Aligning agribusiness and the broader food system with the Paris Agreement

Working Paper

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Executive Summary

A rapid and far-reaching transition of agriculture and the broader food system more broadly is key to achieving the objectives of the Paris Agreement both through minimising direct emissions from agriculture, reducing land use and induced land use change's impact on deforestation, as well as through enhancing carbon sink capacity of lands and soils. Currently, agriculture and the broader food system are not on a pathway compatible with the Paris Agreement: Without ambitious mitigation measures, emissions in the land sector are expected to make up 50% of all emissions by 2050, putting the 1.5ºC temperature goal out of reach even if all emissions from other sources are entirely eliminated (Searchinger *et al.*, 2018; IPCC, 2019a).

Bringing about the required changes calls for a massive shift in where and how our food is produced, processed and transported to consumers. At the same time, this shift needs reinforcing with changes in our eating habits and how much food we waste. Such changes will be a significant challenge considering population growth projections of up to 10 billion people by 2050, meat consumption trends, and the limited options to some of agriculture's most problematic greenhouse gasses: methane and nitrous oxide. In addition to compensating for these emissions, which are not expected to be eliminated completely, the land sector must also shift to serve as an overall net carbon sink to compensate for emissions in other sectors. Considering issues of biodiversity, water, and food security, as well as the importance of the land sector to the livelihoods of billions of people, this sink capacity is limited. This underlines the urgency of implementing rapid transformations in all sectors in order to lower overall emissions.

Agriculture's vulnerability to climate change also means that sustainable development efforts and ending will be impossible without immediate climate action in general and in the food system in particular. On a positive note, reducing agribusinesses' emissions and enhancing sinks can offer a wide variety of co-benefits for sustainable development, including improved food security and nutrition, healthier soil, reduced air and water pollution, and more resilient ecosystem services that can help protect against the wider impacts of climate change while serving as sinks. Abatement costs are often negative, suggesting substantial potential savings and benefits for stakeholders. At the same time, where there are trade-offs – importantly between expanding sink capacity and food security – every effort must be made to ensure that safeguards avoid, minimise, and mitigate negative impacts.

The nature of the food system is however challenging considering the sector's dispersed nature with many (often small) farms, and unique greenhouse gas profile. This complexity calls for targeted measures from policy makers as well as stakeholders all along the food supply chain, from producer to processors, to logistics companies, wholesale, retail, and consumers. In terms of how and where food is produced, it is essential that agricultural activities become more productive to stop encroaching on high carbon stock and conservation value land, including forests, peatbogs and wetland ecosystems. Further, it is essential to reduce methane emissions from livestock and rice production, reduce soil carbon loss, minimise emissions from fertiliser production, stop the overapplication of synthetic fertilisers, reduce waste, and electrify farm equipment. In supply chains, key measures to reduce emissions include fostering transparency and due diligence. Considering the lack of decarbonisation options with current aviation technology, there needs to be a shift away from the use of airfreight for agricultural commodities to reach their key export markets. For the demand side, key measures to reduce emissions include supporting and fostering shifting demand patterns and diets away from meat, dairy and other commodities with a high carbon footprint, and massively reducing food waste.

Although the challenge remains huge and the sector as a whole is not yet on a Paris-aligned path, there are glimmers of a transition towards a more climate friendly food system. Investors and food companies are increasingly making pledges to stop deforestation. Policy makers are calling for due diligence and transparency in supply chains. And start-ups are expanding to meet the growing demand for healthier, more seasonal and locally sourced foods and meat and dairy alternatives.

The sustainable development mandate and Paris alignment commitments of development banks means that they have an important role in mobilising to help policy makers, farmers and agribusinesses, investors, wholesalers, retailers, and consumers bring about this shift. Clear Paris alignment investment

policies and criteria can help decision making and build a promising project pipeline for both the private sector lending arms of DFIs and private investors.

Drawing on academic research, policy papers, market research and exchanges with experts, practitioners, and other stakeholders, we propose a rating system to guide investment decision making by dividing agribusinesses into four categories according to their consistency with mitigation objectives. For each, we propose guidance on when to not finance, opportunities to engage to promote a shift to best practice or scale up finance for climate positive business models.

- A categorisation of "misaligned" would rule out investments in the production of agricultural commodities that expand agricultural production, which drives deforestation or the conversion of vital peatland or coastal wetland ecosystems, and production of commodities dependent on export via air freight.
- A categorisation of "mostly misaligned" would exclude providing working capital to companies engaged in misaligned activities but would allow for project finance for agribusiness interested and willing to shift away from such activities.
- A categorisation of "partially misaligned" would include agribusiness not directly involved in misaligned activities, but not yet in line with best practice – such businesses would be eligible for working capital with conditionality to move towards best practice.
- A categorisation of "aligned" would correspond to agribusinesses that are not only deforestation-free in its activities and supply chains, but that is also in line with best practice in terms of manure management, soil carbon conservation, fertiliser application, and irrigation, as well as transparency and due diligence. Agribusinesses would particularly count as "aligned" if their practices enhance carbon sinks (such as agroforestry) or specialize in plant-based protein foods that serve as meat and dairy alternatives.

Further important opportunities can be found in establishing facilities and capacity building programmes to help farmers overcome the upfront costs for targeted investments that can help realise important development, climate, resilience, and health objectives.

A conservative risk based approached for agribusiness finance

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Abbreviations

AFOLU	Agriculture, Forestry and Other Land Use
CAGR	Compound Annual Growth Rate
CO_2	Carbon Dioxide
DFI	Development Finance Institution
DRC	Democratic Republic of Congo
ESG	Environment Social Governance
EU	European Union
FAO	Food and Agriculture Organization
FSC	Forest Stewardship Council
GHG	Greenhouse Gas
HCS	High Carbon Stock
HCV	High Conservation Value
IDFC	International Development Finance Club
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land Use, Land-Use Change, and Forestry
MDB	Multilateral Development Bank
NDC	Nationally Determined Contribution
NYDC	New York Declaration on Forests
NGO	Non-Governmental Organisation
PEFC	Programme for the Endorsement of Forest Certification
RSPO	Roundtable on Sustainable Palm Oil
SDG	Sustainable Development Goals
SFM	Sustainable Forest Management
SME	Small and Medium-sized Enterprises
TCFD	Task Force on Climate-related Financial Disclosures
US	United States
USD	United States Dollar

1 Introduction

The agribusiness and the broader food system are key to achieving the goals of the Paris Agreement through both reductions of greenhouse gases (GHGs) emissions and enhancement of the land carbon sink. This must be accomplished while sustainably producing food, fibre, and other resources for a growing population – global food demand is projected to further increase by more than 50% to feed around 10 billion people in 2050. Failure to meet mitigation goals greatly increases the risk of crop production losses from more frequent and intense extreme weather events such as heatwaves, droughts, and floods. The vulnerability of the sector to climate change is especially high in developing countries where climate change has already contributed to increased food insecurity (FAO *et al.*, 2018).

The broader food system, including agricultural input producers, farmers, processors, logistics, wholesalers, retailers and consumers, is responsible for between 26% and 37% of total GHG emissions (Poore and Nemecek, 2018; IPCC, 2019a). While emissions from agriculture cannot be eliminated completely, they must be reduced as much as possible. This is especially important because in order to avoid overshooting the 1.5°C temperature threshold to limit the risk of dangerous climate change, the emissions from Land Use, Land Use Change, and Forestry (LULUCF) must reach net-zero by 2030; before 2050 the sector must turn into a significant net-sink in order to compensate for remaining emissions in other sectors (Roe *et al.*, 2019). This calls for rapid and far-reaching changes in what we eat, how food is produced and gets to consumers, how much food is wasted, and our related management of forests and other carbon sinks.

Development finance institutions (DFIs), including their private sector lending arms, play an important role in mobilising and channelling climate finance and helping in the realisation of the sustainable development goals (SDGs), including to end poverty, ensure global food security, protect biodiversity, and mitigate climate change. Climate considerations for agribusiness and the broader food system relate to multiple sectors, including chemical processes for fertilisers, on farm energy use, land use change and deforestation, direct emissions from agricultural activities, energy use for processing, transport, and retail distribution. For DFIs, a holistic understanding of this system and approach is important to inform investment decision making in an effort to align with the Paris Agreement. This includes playing an active role in eliminating deforestation from agricultural supply chains, supporting behavioural change towards healthier diets, reducing food waste, and helping the agricultural sector to minimize agricultural emissions trough improved, sustainable farming practices.

This report aims to help development finance practitioners, as well as other investors, mainstream climate considerations in their lending to agribusiness and broader food system while maximising multiple co-benefits in line with the SDGs. We first provide an overview of agricultural emissions as part of the land sector, what models suggest Paris-aligned emissions benchmarks on the sectoral level may be, as well as a discussion of potential sustainable development co-benefits. We then discuss how transition risks represent a threat to misaligned investments and how they should be considered in Paris-aligned decision making. Based on these considerations, we propose four investment categories – misaligned, mostly misaligned, partially misaligned and aligned agribusinesses – according to clear criteria, as well as how to engage with each.

2 Current status, benchmarks, and mitigation options

How food and land use drive climate change

After energy, the land sector is the second largest source of GHGs and accounts for just under a quarter of global GHGs emissions (~10-12 gigatonnes (or billion tonnes) of carbon dioxide (CO_2) equivalent[1] per year $GtCO_2e$/yr). These result mainly from deforestation, soil and nutrient management on cropland and livestock production (Smith *et al.*, 2014; IPCC, 2019a). A significant proportion of agricultural emissions are from methane and nitrous oxide, which have particularly high global warming impact compared to CO_2 (IPCC, 2019a).

Without significant and rapid change in land management, farming practices, and livestock production and consumption, these emissions are expected to grow steadily. The global population is expected to reach 10 billion by 2050, mostly due to high demographic growth in developing and emerging countries. As income levels in these countries rise, so does their demand for animal protein.

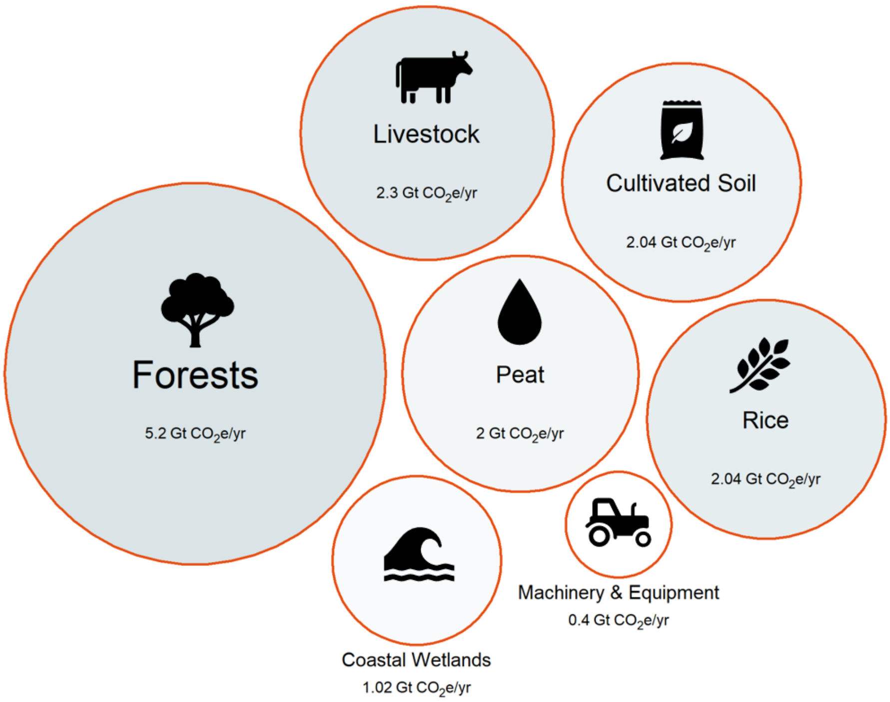

Figure 1: Emissions from agriculture, forestry, and other land use (Global Peatlands Initiative, 2016; IPCC, 2019a; IEA, 2020a)

Deforestation and forest degradation are responsible for 11% of total emissions, making it by far the largest source of emissions in the land sector and food system. Peatland drainage and burning, by which the stored carbon is released into the atmosphere, produces as much as 5% of anthropogenic GHGs (Global Peatlands Initiative, 2016).

After deforestation and land degradation in general, livestock are the next largest source of emissions directly through their digestive systems[2] which produce methane (5% of total emissions), a highly potent GHG as mentioned above, and through animal excretion of manure (6% of total emissions) (FAO, 2006).

[1] Carbon dioxide equivalent (CO_2e) is a unit used to compare the warming potential of different GHGs such as methane and nitrous oxide, using CO_2 as the gas of reference.
[2] Digestion in ruminant animals such as cattle, sheep, goats, and buffalo, occurs via enteric fermentation, a fermentation process that decomposes ingested plant tissues and releases methane.

In addition, pasture and cropland expansion to feed livestock drives deforestation and land use change, contributing to 7% of total emissions.

After livestock production and deforestation, farming management practices such as tillage, nitrogen fertilizer use, and crop residue management make up the third biggest sources of land-based emissions (4% of total emissions) (FAO, 2015).

Additionally, rice cultivation, specifically the release of methane through the decomposition of organic matter on paddy fields, represents 1% of global emissions (FAO, 2015).

Although often not thought of as agribusiness or agricultural emissions, further emissions are associated with the production of agricultural inputs, such as the production of synthetic fertilisers, herbicides, and pesticides.

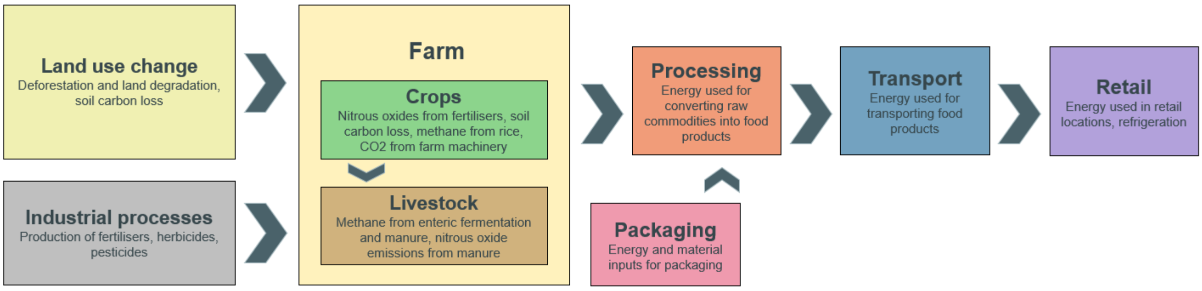

Figure 2: Emissions in the food and agricultural supply chain

Estimates for the entire food supply chain, including the aforementioned production-side as well as food processing, transportation, retail, and packaging, range from about 28 to 37% of total global GHG emissions (Poore and Nemecek, 2018; IPCC, 2019a). A significant amount of food produced is lost throughout the supply chain and wasted by consumers, which together make up for 6% of global GHG emissions (Poore and Nemecek, 2018).

Agriculture, land use, and the broader food system in a Paris aligned pathway

According to the IPCC, mitigation pathways that stabilise global mean temperature rise to 1.5ºC by 2100, while minimising temperature overshoot, generally converge around three key milestones: (1) peak global emissions around 2020; (2) reach net-zero CO_2 emissions (balance between overall GHG sources and sinks) between 2040 and 2060 while minimizing but not eliminating other emissions; and (3) net-negative emissions thereafter (IPCC, 2018; Roe *et al.*, 2019).

This requires rapid and far-reaching transitions in energy, industry, buildings, transport, and notably agriculture and land use, to significantly enhance the land sink before 2050 in order to help compensate for continued emissions in other sectors through CO_2 removal (see Figure 1). The IPCC finds that the feasibility of large-scale CO_2 removal is subject to multiple technical, economic and environmental constraints, notably when it comes to bioenergy carbon capture and storage (BECCS). However, significant near-term reduction in energy and land demand can reduce dependency on future negative emissions (IPCC, 2018).

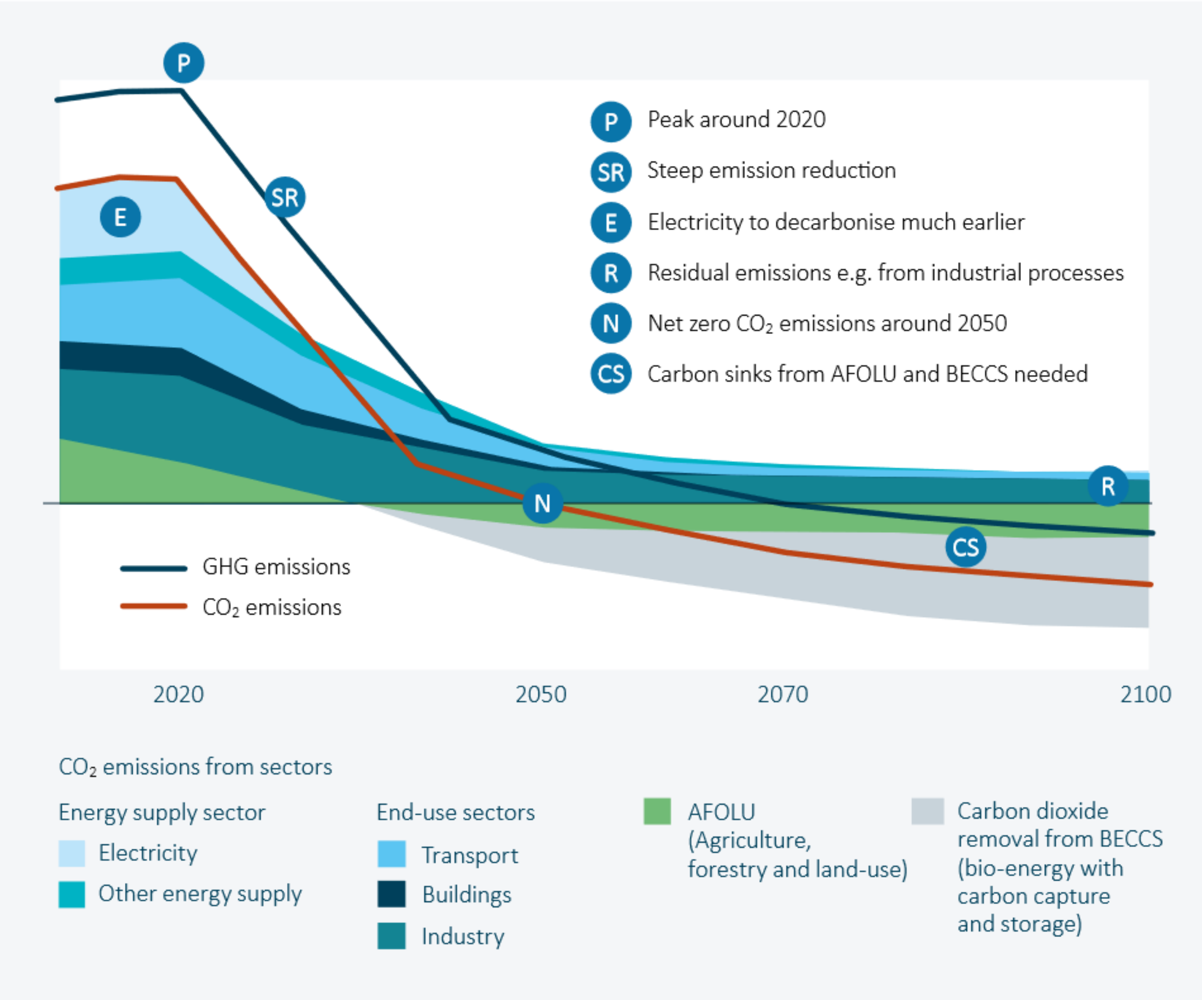

Figure 3: Visualisation of a Paris Agreement (1.5°C) compatible pathway adapted from the IPCC special report on 1.5°C (2018a). (Roeser et al., 2019)

Specifically for agriculture and land use, 1.5°C pathways call for significant reductions in agricultural emissions, in particular nitrous oxide and methane emissions. At the same time, all 1.5°C pathways foresee net-zero CO_2 emissions in land use, land use change, and forestry by around 2030 (Roe *et al.*, 2019). A number of benchmarks can help to guide progress in the sector in the short, medium and long term (see Table 1). In the short term (by 2025), it is a priority to eliminate net deforestation and set the basis for a larger scale transition. In the medium term (to 2030), priorities include emissions reductions, sink enhancement through the significant restoration of tree cover, productivity improvement, and waste reduction. In the long term (to 2050), these trends need to continue and grow in scale.

Table 1: Selected benchmarks in the land sector underlying the 1.5ºC pathways (Griscom *et al.*, 2017; IPCC, 2018; Kuramochi *et al.*, 2018; Harwatt *et al.*, 2020; Lebling *et al.*, 2020).

	By 2025	By 2030	By 2050
Forests and land use	• Stop net deforestation	• Net zero CO_2 emissions in forestry and other land use • Restore tree cover on 350 million hectares of land	• Increase in global forest cover of up to ~950 Mha (678 Mha is estimated to be feasible with a reduction of livestock production).
Livestock		• Limit increase to 5% from 2017 level • 27% increase in productivity of meat production from 2017 levels	• Global reduction (0.5-11 million km^2) of livestock production in order to enable a substantial reduction in order enable increase of global forest cover • 58% increase in productivity of meat production from 2017 levels • 40% reduction in non-CO_2 agricultural emissions
Food loss and waste		• 25% reduction from 2017 levels	• 50% reduction from 2017 level

Without ambitious mitigation measures, emissions in the land sector are expected to make up 50% of all emissions by 2050, putting the 1.5ºC temperature goal out of reach even if all emissions from other sources are eliminated entirely (Searchinger *et al.*, 2018; IPCC, 2019a).

Mitigation options and their potential

Emissions in the agribusiness and broader food system can be divided by their source in the value chain: emissions from deforestation and other ecosystems; direct emissions from agricultural activities; other emissions in the supply chain; and demand measures, notably consumer behaviour. An overview of mitigation options according to these sources can help inform investment criteria for the broader agriculture and food sector (see Table 2).

Table 2: Selected mitigation measures and potential in the land sector based on IPCC. Estimates are for both maximum potential (based on (IPCC, 2019a) and (Roe *et al.*, 2019) for rice and fertiliser production) and accounting for economic, technical and sustainability constraints when available (numbers in brackets based on (Roe *et al.*, 2019)).

	Measures	Mitigation Potential ($GtCO_2e/yr$)	Regional focus
Forests and other ecosystems	Reduced deforestation and forest degradation	5.8 (3.6)	Brazil, Indonesia, DRC, Myanmar, Bolivia, Malaysia, Paraguay, Colombia, Peru and Madagascar
	Reforestation and forest restoration	10.1 (3)	Brazil, Indonesia, China, EU, India, Mexico, Australia, US, Russia, Colombia, Malaysia
	Afforestation	8.9 (0.6)	Brazil, Indonesia, China, EU, India, Mexico, Australia, US, Russia, Colombia, Malaysia
	Forest management	2.1 (1.2)	Global
	Fire management	8.1	Russia, Brazil, Indonesia, US, EU, Australia, Tropical countries
	Restoration and reduced conversion of coastal wetlands	3.1 (0.3)	Brazil, Indonesia, DRC, Myanmar, Bolivia, Malaysia, Paraguay, Colombia, Peru, Madagascar, China, India, Mexico, Australia, US, Russia
	Restoration and reduced conversion of peatlands	2.0 (0.7)	Brazil, Indonesia, DRC, Myanmar, Bolivia, Malaysia, Paraguay, Colombia, Peru, Madagascar, China, EU, India, Mexico, Australia, US, Russia
Agriculture and soils	Increased food productivity	13	Global
	Agroforestry	5.7 (0.4)	Russia, Canada, Brazil, Indonesia, US, EU, Australia, Tropical countries
	Improved livestock management	2.4	China, India, Brazil, EU, US, Australia, Russia, Argentina, Mexico, Colombia, Paraguay, Bolivia
	Improved cropland management	2.3	Developed and emerging countries (China, India, Brazil, EU, US, Australia, Russia)
	Improved grazing land management	1.8	EU, US, Australia, Russia, India, China, Indonesia, Thailand, Bangladesh, Vietnam, Philippines, Brazil, Argentina, Mexico, Colombia, Paraguay, Bolivia
	Increased soil organic carbon content	8.6 (0.8)	China, EU, US, Australia, Brazil, Argentina, India, Indonesia, Mexico, Sub-Saharan Africa
	Reduced soil erosion	3.7	Global
	Improved rice cultivation	0.9 (0.1)	China, India, Indonesia, Bangladesh, Vietnam, Thailand, the Philippines
	Biochar addition to soil	6.6 (0.5)	China, EU, US, Australia, Brazil, Argentina, India, Indonesia, Mexico, Sub-Saharan Africa
Other emissions in the supply chain	Improved energy use in food systems	0.4	Global
	Improved synthetic fertiliser production	0.4	Global
Demand	Dietary change	8 (0.9)	Developed and emerging countries (US, EU, China, Brazil, Argentina, Russia, Australia)
	Reduced post-harvest losses	4.5 (0.5)	Southeast Asia, Sub-Saharan Africa
	Reduced food waste (consumer or retailer)	4.5 (0.5)	China, Europe, North America, Latin America

Stabilising global mean temperature rise to 1.5ºC requires extensive deployment of mitigation measures in all land-based activities, which could reduce emissions by up to 120 $GtCO_2e$/yr (IPCC, 2019a). Taking into account technical, economic and sustainability constraints, at least 14 $GtCO_2e$/yr could be sequestered by 2050, which would bring the land sector towards a 1.5ºC pathway (Roe *et al.*, 2019).

Sustainable development and co-benefits

Climate action and sustainable development are often portrayed as trade-offs, but this represents a false dichotomy – indeed climate change impact is already one of the largest single threats to global food security and broader poverty alleviation efforts. At the same time, most sustainable agricultural practices that reduce emissions also have co-benefits in terms of resilience, productivity, public health, and food security. More broadly, the land sector plays a key role in achieving many of the UN's 17 SDGs. The IPCC (2019) finds that near-term climate change action can bring social, ecological, economic and development co-benefits and that rapid GHG emission reductions reduce negative climate change impacts on agriculture and land ecosystems. Still, land-based mitigation measures need to carefully consider multiple factors beyond GHG emissions reduction and/or sequestration to maximise synergies in achieving other SDGs and avoid, minimise and mitigate what other trade-offs there may be.

Stopping cropland expansion in high-carbon landscapes, such as tropical forests and peatlands, can rapidly reduce emissions from these ecosystems (Steiner *et al.*, 2020). Such measures have limited downsides in terms of sustainable development, as most agricultural expansion occurring on these landscapes is driven by a few cash-crops that may play minimum role for food security (Steiner *et al.*, 2020) but are challenging considering market failures and political economy barriers. As these landscapes are home to rich and diverse ecosystems, overcoming barriers and promoting their conservation and restoration can help sustainably, provide essential commodities and services, and benefit biodiversity.

Table 3 presents links between mitigation activities in the land sector and potential positive and negative impacts in terms of adaptation, desertification, land degradation, food security and cost based on IPCC (2019).

Table 3: Summary of select positive and negative impacts of land response options based on IPCC (2019).

	Measures	Adaptation	Desertification	Land degradation	Food security	Cost
Forests and other ecosystems	Reduced deforestation and forest degradation	Moderate benefits	Significant benefits	Significant benefits	Moderate benefits	$$
	Reforestation and forest restoration	Significant benefits	Significant benefits	Significant benefits	Moderate risks	$$
	Afforestation	Significant benefits	Significant benefits	Significant benefits	Higher risks	$$
	Forest management	Significant benefits	Significant benefits	Significant benefits	Moderate benefits	$$
	Fire management	Moderate benefits	Significant benefits	Significant benefits	Moderate benefits	$$
	Restoration and reduced conversion of coastal wetlands	Significant benefits	Negligible benefits / risks	Minor benefits	Negligible benefits / risks	-
	Restoration and reduced conversion of peatlands	Negligible benefits / risks	Negligible benefits / risks	Moderate benefits	Moderate risks	$
Agriculture and soils	Increased food productivity	Significant benefits	Significant benefits	Significant benefits	Significant benefits	-
	Agroforestry	Significant benefits	Significant benefits	Significant benefits	Significant benefits	$
	Improved livestock management	Moderate benefits	Moderate benefits	Significant benefits	Significant benefits	$$$
	Improved cropland management	Significant benefits	Significant benefits	Significant benefits	Significant benefits	$$
	Improved grazing land management	Moderate benefits	Moderate benefits	Significant benefits	Significant benefits	-
	Increased soil organic carbon content	Significant benefits	Significant benefits	Significant benefits	Significant benefits	$$
	Reduced soil erosion	Significant benefits	Significant benefits	Significant benefits	Significant benefits	$$
	Improved rice cultivation CH4	Negligible benefits / risks	Negligible benefits / risks	Negligible benefits / risks	Negligible benefits / risks	
	Biochar addition to soil	Negligible benefits / risks	Negligible benefits / risks	Minor benefits	Higher risks	$$$
Other emissions in the supply chain	Improved energy use in food systems	Significant benefits	Negligible benefits / risks	Negligible benefits / risks	Significant benefits	-
	Improved synthetic fertiliser production	Negligible benefits / risks	Negligible benefits / risks	Negligible benefits / risks	Negligible benefits / risks	
Demand	Dietary change	Negligible benefits / risks	Moderate benefits	Significant benefits	Significant benefits	-
	Reduced post-harvest losses	Significant benefits	Negligible benefits / risks	Negligible benefits / risks	Negligible benefits / risks	-
	Reduced food waste (consumer or retailer)	Negligible benefits / risks	Moderate benefits	Significant benefits	Significant benefits	-

Key	Significant benefits	Moderate benefits	Minor benefits	Negligible benefits / risks	Moderate risks	Higher risks	Low costs	Medium costs	High costs	No data
							$	$$	$$$	-

3 Investment guidance

The development of concrete benchmarks and criteria to inform Paris-aligned investment decision making for agriculture, land use, and broader food system is particularly challenging. This is in part because sources are widely dispersed, interactions and interrelations between different investments, subsectors and activities are complex, and interventions in one area may have significant impacts on another. More specifically, three aspects constitute complicating factors:

- Agricultural practices and other actors in agricultural value chain differ considerably at the regional, national and local level in terms of structure, social and economic relevance, mitigation options and their interlinkages with other development objectives.
- Agriculture, land use, and the broader food system cover a whole range of subsectors and activities with implications for managed and unmanaged land, agricultural inputs, food production, processing, transport, retail and distribution to the consumer. Within these broad categories, activities extend into many other sectors including energy, chemicals, refrigeration, and larger industry – each can have an effect on the emissions of the broader agriculture and forest value chain.
- Key actors in the land sector and broader food system are typically dispersed across many different smaller investment activities rather than large scale investments into physical assets or

infrastructure. In addition, value chains in the sector are complicated, involving many different actors, which often translates into reduced traceability and transparency.

The breadth of MDB financing instruments as well as advisory services and analytics do however have an impact on and can broadly influence investments in the land sector. They have impacts on land use change and agricultural practices through their influence on rural development, as well as local and international markets for agricultural and forest products. Important financing instruments include policy-based lending, private sector lending, and advisory services which are important for capacity building and technology transfer.

MDB strategies with regard to the agricultural sector and rural development vary somewhat, but have stated priorities including infrastructure expansion, food security, strengthening the private sector and agricultural value chains, often through regional integration and have a strategic aim to support smallholders and SMEs (AfDB, 2000; ADB, 2020; World Bank, 2020). The private sector lending activities work both with individual agribusiness companies as well as financial intermediaries that are expected to help expand agribusiness access to finance (World Bank, 2020). In addition, analysis and advisory services of some banks also work to help improve the policy and legal environment as well as build capacity in both the public and private sectors. Some banks, notably the World Bank, have additional specific programmes to support “Climate Smart Agriculture” and forestry protection, but climate considerations and particularly emissions mitigation options are not yet completely mainstreamed throughout activities, although they intersect with a number of the MDB activities, notably Building Block 1 Mitigation; Building Block 2 Adaptation and resiliency; Building Block 3 Climate Finance; and Building Block 4 Strategy, Engagement and Policy Development.

Table 4 provides an overview of potential interventions by MDBs in the different areas and subsectors discussed in previous sections of the report. These are distinguished along two main types of interventions: policy-based lending and private sector lending. Each is discussed in more detail below.

Table 4: Overview of potential response options and relevant MDB interventions

	Measures	Public and Policy Based Lending	Private Sector Lending
Forests and other ecosystems	Reduced deforestation and forest degradation	✓	✓
	Reforestation and forest restoration	✓	
	Afforestation	✓	
	Forest management	✓	✓
	Fire management	✓	✓
	Restoration and reduced conversion of coastal wetlands	✓	✓
	Restoration and reduced conversion of peatlands	✓	✓
Agriculture and soils	Increased food productivity	✓	✓
	Agroforestry	✓	✓
	Improved livestock management	✓	✓
	Improved cropland management	✓	✓
	Improved grazing land management	✓	✓
	Increased soil organic carbon content	✓	✓
	Reduced soil erosion	✓	✓
	Improved rice cultivation	✓	✓
	Biochar addition to soil	✓	✓
Other emissions in the supply chain	Improved energy use in food systems	✓	✓
	Improved synthetic fertiliser production	✓	✓
Demand	Dietary change	✓	✓
	Reduced post-harvest losses	✓	✓
	Reduced food waste (consumer or retailer)	✓	✓

3.1 Policy engagement

Of the MDBs' six building blocks for Paris alignment, building block four refers to "engagement and policy development support". Similarly, members of the International Development Finance Club (IDFC) have identified the support of country-led climate policies as their second principle in their Paris alignment position paper. Almost 89% (168 of 189) of NDCs mention agriculture, land use, and/or forestry (Strohmaier *et al.*, 2016), but most do not explicitly lay out specific activities or policies to achieve these targets. Supporting partner countries in developing, updating, and implementing long-term strategies and future NDCs with technical support and capacity building will play an important role in supporting a sustainable transition in the land sector and broader food system. Depending on the intervention, there are various options for DFIs to help countries implement mitigation measures in the land and food system.

Policy-based lending or development policy lending are terms used for budgetary support when associated with structural reforms. This kind of assistance in particular has significant potential to help address emissions from land use change and agriculture by empowering countries to enact, implement, and enforce regulations in order to achieve mitigation commitments, address market failures, and improve efficiencies to achieve sustainable development goals. Policy-based lending can have far- and wide-reaching impact, far beyond direct finance options that MDBs have at their disposal, which face challenges reaching dispersed small land holders. Important priorities for such reforms include land tenure reforms, incentive structures created by agricultural subsidies, and opportunities for governments to mandate, protect, and support ecosystem services.

Although policy-based lending has significant potential to help developing countries reduce emissions, climate and environmental considerations have not yet played a large role in policy-based lending. This is in part because strong country ownership and willingness and commitment to reform are prerequisites to ensure lasting impact but may also be a result of historical controversies and resistance surrounding the influence of MDB on countries' policies, in particular privatization and market reforms. Outreach programmes from MDBs with strong and engaged stakeholder-driven dialogue can help foster awareness among developing country policy makers about the importance of such reforms and the important benefits that they can bring, foster country ownership for policy reform, as well as identify the most appropriate policy reform options, including how they should be implemented. Important priorities for budgetary support and policy-based lending to shift the land sector toward a Paris-compatible pathway can be found below. Such measures cannot be implemented on their own; rather, they will often require significant advisory services in the form of technical assistance and capacity building in order to help increase the likelihood that the reforms lead to the desired impact.

- **Forest governance, regulatory frameworks, and land tenure reform:** Lack of clarified ownership frameworks, as well as a lack of enforcement of forest governance laws often are contributing factors that drive deforestation in tropical countries. Increased protected area zoning and land sparing only function with improved forest governance (IPCC, 2019; Roe *et al.*, 2019). Policy based loans to foster improved governance, regulatory frameworks and support for regulatory enforcement are key to help counter deforestation drivers. These can be complemented by stronger land tenure security and indigenous land rights, and improved monitoring capacities (IPCC, 2019, pp. 709).
- **Agricultural subsidy reform for livestock**: Especially in Latin America, subsidies supporting livestock production could be reformed to shift away from production growth incentives towards more support for conservation measures, including more sustainable livestock raising practices such as recoupling of crops and livestock production. This in turn helps reduce drivers of deforestation and reduce methane emissions from enteric fermentation.
- **Water subsidy reform for rice irrigation:** Irrigation water for rice farming is currently often subsidised which does not provide an incentive for water conservation. It also contributes to excessive flooding of rice paddies, which increases methane emissions and is not optimal in terms of productivity and yield. Reform of such subsidies, and a shift towards efficient pricing for water

use, in conjunction with capacity building for alternate wetting and drying can help to significantly reduce methane emissions and improve yields. Such subsidy reform would also help farmers better adapt to climate change and less regular precipitation patterns.

- **Fertiliser subsidy reform**: In many countries, notably China and India, fertiliser subsidies, originally meant to help farmers increase fertiliser use, have led to a large overapplication of synthetic nitrogen fertilisers leading to high nitrous oxide emissions, as well as soil and water pollution far beyond any benefit for agricultural yields. Reforms of these subsidy schemes can contribute greatly to reducing nitrous oxide emissions, increase efficiency, reduce waste, and reduce soil and water pollution.
- **Diesel subsidy reform for on-farm equipment**: In many countries, fossil fuels used on the farm for farm equipment including pumping irrigation water are highly subsidised. Fuel subsidy reform in the sector could be paired with programs to support on farm renewable electricity generation and the electrification of farm equipment.
- **Fiscal reform / incentives**: Tax reforms from adjusting sales or value added taxes based on the carbon footprint of commodities to fuel taxes can help set broad market incentives to shift to lower carbon agricultural practices. In combination with the price incentives set by the taxes, revenue generated can also go to help government efforts to promote sustainable agricultural practices, or for example create systems to support farmers with payments for ecosystem services. Payments to farmers and landowners for providing ecosystem services on their land is a key financial mechanism to incentivize afforestation and forest restoration (IPCC, 2019; Roe et al., 2019, pp. 287).

3.2 Private sector agribusiness lending and engagement

Development banks lend to a number of different private sector agribusiness companies up and down the supply chain, in both developing and developed countries (Rutaagi, 2020). After supporting governments with policy reform measures, including associated technical advisory services, setting robust criteria for lending to the private sector and associated capacity building is probably the most important way development banks can influence agricultural practices and reduce agriculture, land use, and food system emissions. Most importantly, it is essential that banks conduct due diligence, promote transparency and traceability, and mainstream systems of sustainability certifications to help enable investors, other companies in the value chain, as well as consumers make informed choices and facilitate policies to better target unsustainable practices.

Transition risk in the agricultural, land use, and broader food system

Climate related risks should play an important role in development bank decision making. Although climate risk in the land sector is generally discussed in relation to physical risk of climate change (extreme weather events, drought) and context specific measures should be taken to address the specific case and situation to promote adaptation and resilience, transition risk is a growing and often underestimated issue for investments in the agribusiness sector. In keeping with their development mandate, it is important that DFIs, working with agribusinesses, help them understand transition risk and shift to business models that minimise the climate impact of their activities so as to address such risk. Box 4 explores transition risk in agriculture, land use, and broader food system according to the Task Force on Climate-related Financial Disclosures (TCFD) approach.

Box 1: Transition Risks in the agriculture, land use, and broader food system

Although often associated with energy supply and demand sectors, climate transition risk is increasingly important for investments in the agricultural, land use, and broader food system. The radical changes that must occur to achieve the overall climate objectives mean that DFIs, governments, public and private investors, as well as agribusinesses must take the risks associated with a Paris-consistent transition into consideration in their investment decision making.

- **Policy and legal risk:** Although carbon pricing in the agricultural, land use, and broader food system plays a small role in most countries, a number of countries have started to integrate them in carbon pricing schemes and may expand this to imports through carbon border tax adjustments. To the extent that the export of agricultural products is dependent on air-freight, carbon pricing affects market access not primarily through their direct emissions in production, but rather through their delivery to the consumer. Some companies have already started to include carbon footprinting information on food product labels, and enhanced emissions-reporting obligations may bring this into the mainstream. Further, a number of countries are discussing holding downstream actors in the agricultural supply chain legally liable for conducting due diligence to ensure that they avoid deforestation (Heflich, 2020; Hughes and Terazono, 2020). Negative impacts on biodiversity and other environmental considerations in supply chains are also likely to be subject to more scrutiny and related policy measures.
- **Market risk:** Changing consumer behaviour is also an important risk consideration for agribusiness, especially for meat and dairy products. Milk demand has already peaked in some markets, and Asia is likely one of the largest growth markets for milk alternatives. Restrictions on key commodities in terms of their impact on deforestation and other emissions intensive inputs such as synthetic fertilisers may increase costs for inputs including feed for livestock.
- **Technology risk:** Corresponding and responding to shifts in consumer preferences, technological advances in lab grown meat and food processing for plant-based meat alternatives have gained increasing market attention and may threaten markets for high emitting products as competitors shift to substitute existing products with lower emission options.
- **Reputational risk:** Changing consumer behaviour and preferences are not only a market risk to emissions intensive agribusiness such as in the livestock sector; it is also a reputational risk for companies and their investors (including public development banks). Consumer awareness campaigns are increasingly leading to a stigmatization of the high emitting agribusiness sector. This broader investment community, increasingly aware of Environment Social Governance issues, has also started to take notice. A recent assessment of the New York Declaration on Forests finds that “companies have been slow to implement commitments” and “reporting remains inadequate to assess the adequacy of supply chain zero-deforestation approaches” (NYDF Assessment Partners, 2019).

Agribusinesses working with DFIs range from upstream companies supplying fertilisers, herbicides, pesticides, seeds, and farm equipment, to companies that are directly engaged in the production of agricultural and related land use commodities, wholesale companies, food processing companies, transport logistics, as well as retail (see Figure 1). Accordingly, lending to agribusiness companies should consider the role they play in commodity supply chains. Such companies can broadly be divided into two categories: companies that are directly involved with the actual production of agricultural commodities on the farm, and other companies that engage in food processing, transport, wholesale and retail.

Agribusiness directly engaged with production of agricultural commodities

Lending to companies that are directly engaged in growing crops or raising livestock requires a number of considerations including: (in)direct association with deforestation and forest degradation; the nature of the crop and how it will be transported to its destination, and consistency with best practice to minimise emissions on the farm. In many cases, finance provided for such agribusiness companies may not be associated with a particular farm facility or location, but rather related to working capital or other non-tangible investments for the company. In such cases, the agricultural and climate alignment of the company as a whole must be taken into consideration. Each is described in more detail below.
First and foremost, before a lending decision is made, it is important for a development bank to understand if the proposed project would directly or indirectly contribute to deforestation or forest degradation with particular risks for land of high carbon stock (HCS) or high conservation value (HCV) (see Table 5). The risks associated with lending in this sector depend greatly on the company, commodity, and the geographic location of the company's production. The primary forest risk commodities (FRC) include palm oil, biofuels, shrimp, meat and dairy (including livestock feed sources), soy, paper/timber, sugar cane, maize, rapeseeds, rubber, chocolate, and, coffee (Boucher *et al.*, 2011; Kissinger, Herold and De Sy, 2012; Austin *et al.*, 2019; Heflich, 2020).

Accordingly, finance for companies engaged in the production of these commodities should be subject to particularly close scrutiny. Here, it should be noted that with regard to livestock, even if the livestock is raised in an area that is not directly in danger of driving deforestation and conversion of HCS or HCV land, the sources of the livestock feed should also be considered. Disclosure and due diligence requirements can reflect the risk associated with a particular commodity in a particular region. In some instances, there may be no clear cause and effect relationship between clearing of the land and an agricultural activity that may then take place on the land a number of years later. For example, in the Amazon basin, forests are often cleared first to ranch cattle, and then later sold to soy farmers as cattle ranchers move further into former forest areas with cheaper land (Barona *et al.*, 2010). If the land is currently forested or was forested in the past ten years, in a region that is a deforestation hot spot, it may be at least an indirect driver of deforestation. Such regions in developing countries include: Chocó Darién, the Amazon, the Cerrado, and Gran Chaco in South America, the Congo Basin and large areas of East Africa, the Greater Mekong, Borneo, Sumatra, and New Guinea (WWF, 2015). Funding for activities directly, or indirectly by providing financial services to companies engaged in activities driving destruction of HCS or HCV should be clearly placed on development banks' exclusion lists. The EU Taxonomy for Sustainable Finance, and lending policies from private banks such as HSBC have set precedents for what can be considered land where agricultural activity should be avoided (see Table 7).

Depending on the commodity, various certification schemes are available that can facilitate both agribusinesses in demonstrating their avoidance of deforestation, as well as due diligence on behalf of DFIs when making an investment decision. Because of the proliferation of standards, financial institutions should select best-in-class standards that exclude both legal and illegal deforestation (Kusumantingtyas and van Gelder, 2019). Comparable certifications however do not yet exist for all deforestation risk commodities or are not internationally established to the same extent. In cases where there is no established international standard, or where such certifications are not sufficiently comprehensive, DFI's will need to conduct their own due diligence when engaging with their agribusiness clients.

Table 5: High Carbon Stock and High Conservation Value exclusion list

Category	Further details
Wetland conversion	Exclusion for wetlands, namely land that is covered with or saturated by water permanently or for a significant part of the year.
Forests conversion	Exclusion for continuously forested areas, namely land spanning more than one hectare with trees higher than five metres and a canopy cover of more than 30 %, or trees able to reach those thresholds on site.
	Exclusion for land spanning more than one hectare with trees higher than five metres and a canopy cover of between 10 % and 30 %, or trees able to reach those thresholds in situ.
Peat conversion	Exclusion for peatland, unless evidence is provided that the cultivation and harvesting of that raw material does not involve drainage of previously undrained soil.
HCS Land Conversion (specifically for palm oil)	Exclusion for high density forest, medium density forest, low density forest, or young regenerating forest based on light detection and ranging (LiDAR), satellite data, and ground survey measurements.

Sources: HCS Working Group, 2016; EU Technical Working Group on Sustainable Finance, 2020

The next consideration is the overall carbon footprint of the agricultural commodity at the point of consumption. Considering the lack of currently available technologies to decarbonise air freight, and the fact that they represent only a very small proportion of the overall food system that is not a factor in guaranteeing food security, **perishable agricultural products transported by air freight should also be placed on an exclusion list.**[3]

To the extent that potential investment opportunities in the agribusiness sector have to do with actors directly involved in on farm activities – either livestock or crop production, there are a number of measures that can be taken to reduce soil carbon loss, nitrous oxide emissions from soil and fertiliser, as well as reducing methane emissions on farms from enteric fermentation and manure management as outlined in Section 3. An EU Technical Expert Group made recommendations to the European Commission with regard to the design of an EU Taxonomy on Sustainable Finance which includes a framework with an overview of best practices to reduce emissions in various economic sectors including agriculture, an overview of which can be found in Table 6**.** The EU Taxonomy represents a classification system to establish a standard for economic activities to be considered in the EU. Though not binding for countries outside of the EU, the EU Taxonomy provides a solid basis and standard for best practice and sustainability in agricultural practice with global relevance. However, because of the dispersed nature of emissions sources and actors in agriculture, particularly in developing countries, these are not individual measures that development banks would, in general, specifically invest in, but should rather be something that development banks screen for when considering loans to agribusiness.

[3] Such an exclusion precedent has already been set by the European Investment Bank (EIB, 2020)

Table 6: Proposed EU Taxonomy criteria for Agriculture (summarized overview of selected measures)[4]

	Sustainable agricultural measures
Perennial crops	**Crop choice and cover**: Sowing of cover crops using a locally appropriate species mixture and reducing bare soil to cover at least 75% at farm level per year.
	Soil management: • Prevent soil compaction • Management of carbon-rich soils (Avoiding deep ploughing on carbon-rich soils; Avoiding row crops; Maintaining a shallower water table –peat and arable land) • Avoid water logging and compaction where land is drained • Maintain permanent grassland • No burning of arable stubble except where authority has granted an exemption for plant health reasons
	Nutrient management: Nutrient management plan to optimize fertilization and improve nitrogen use efficiency.
	Structural elements with mitigation benefit: Conversion of low productivity land (e.g. along field edges) into woodland to increase carbon sequestration and protect against soil erosion
Non-perennial crops	**Crop choice and rotation**: • At least a five crop rotation • Sowing of cover crops using a locally appropriate species mixture and reducing bare soil to cover at least 75% at farm level per year. • Residue management
	Soil management: • Prevent soil compaction • Management of carbon-rich soils (Avoiding deep ploughing on carbon-rich soils; Avoiding row crops and tubers; Maintaining a shallower water table –peat and arable land) • Avoid waterlogging and compaction on drained soils • Maintain permanent grassland • No burning of arable stubble except where authority has granted an exemption for plant health.
	Nutrient management: Nutrient management plan to optimize fertilization and improve nitrogen use efficiency.
Rice	**Paddy rice management:** Shallow flooding, mid-season drying event, off season straw
	Structural elements with mitigation potential: Conversion of low productivity land (e.g. along field edges) into woodland to increase carbon sequestration and protect against soil erosion
Livestock	**Animal health planning** Better health planning and management (develop a health management plan, improve hygiene & supervision at parturition, improve maternal nutrition in late gestation to increase offspring survival, improve fertility management, selection for improving both methane and ammonia emission efficiency).
	Animal feeding: • Feed additives: to reduce enteric methane emissions of ruminants. • Precision and multi-phase feeding techniques, where the nutrient requirements of groups of animals (or individual animals) are targeted in feed formulation. • Feed imported to the farm must be sourced responsibly and must demonstrate that the production of feed did not take place in deforested areas with high carbon stock or high biodiversity value.
	Manure management: • Cooling of liquid manure. • Covering and sealing slurry and farm-yard manure storage to reduce gaseous losses of ammonia and methane emissions. • Separating solids from slurry: via mechanical or chemical ways the liquid part of the slurry can be separated from solids. • Composting and applying solid manure • Slurry acidification by adding strong acids to the slurry to achieve a pH of 4.5-6.8 to reduce methane and NH3 emissions. • Apply low-emission application technology for slurry and manure
	Permanent grassland management: • Pasture renovation (when productivity declines, reseed the pasture) • Remove animals from very wet fields to reduce compaction • Maintain permanent grassland • No ploughing of permanent grassland
	Soil management: No burning of arable stubble except where authority has granted an exemption for plant health reasons.

[4] For full details see https://ec.europa.eu/info/sites/info/files/business_economy_euro/banking_and_finance/documents/200309-sustainable-finance-teg-final-report-taxonomy_en.pdf

With regard to a general approach to agribusiness lending, we propose a decision tree for agribusinesses involved with the actual farm production activity (see Figure 4). A DFI would first evaluate any potential impact on HCS or HCV deforestation, or peat or wetland conversion. If the agricultural activity is not linked to land use conversion, a determination could be made if the commodity's main target consumer would necessitate air freight transport. If this is not the case, an investment officer could consider to what extent the agribusiness is in line with best practice based on the EU Taxonomy in terms of minimising soil carbon loss, nitrous oxide emissions, and methane emissions depending on the commodity in question. For livestock, it is important to not only consider the practices associated with how the livestock is raised, but also the origin and circumstances of the livestock feed and to ensure that the feed, is not a driver of HCS or HCV land conversion and is grown according to best practice to minimise carbon dioxide, nitrous oxide, and methane emissions. In instances where agribusiness do not produce feed for themselves, lending decisions should be made conditional on the agribusiness conducting due diligence with regard to the circumstances of the production of the source of the feed – this is similar to working with agribusinesses lower down in the supply chain (see next section).

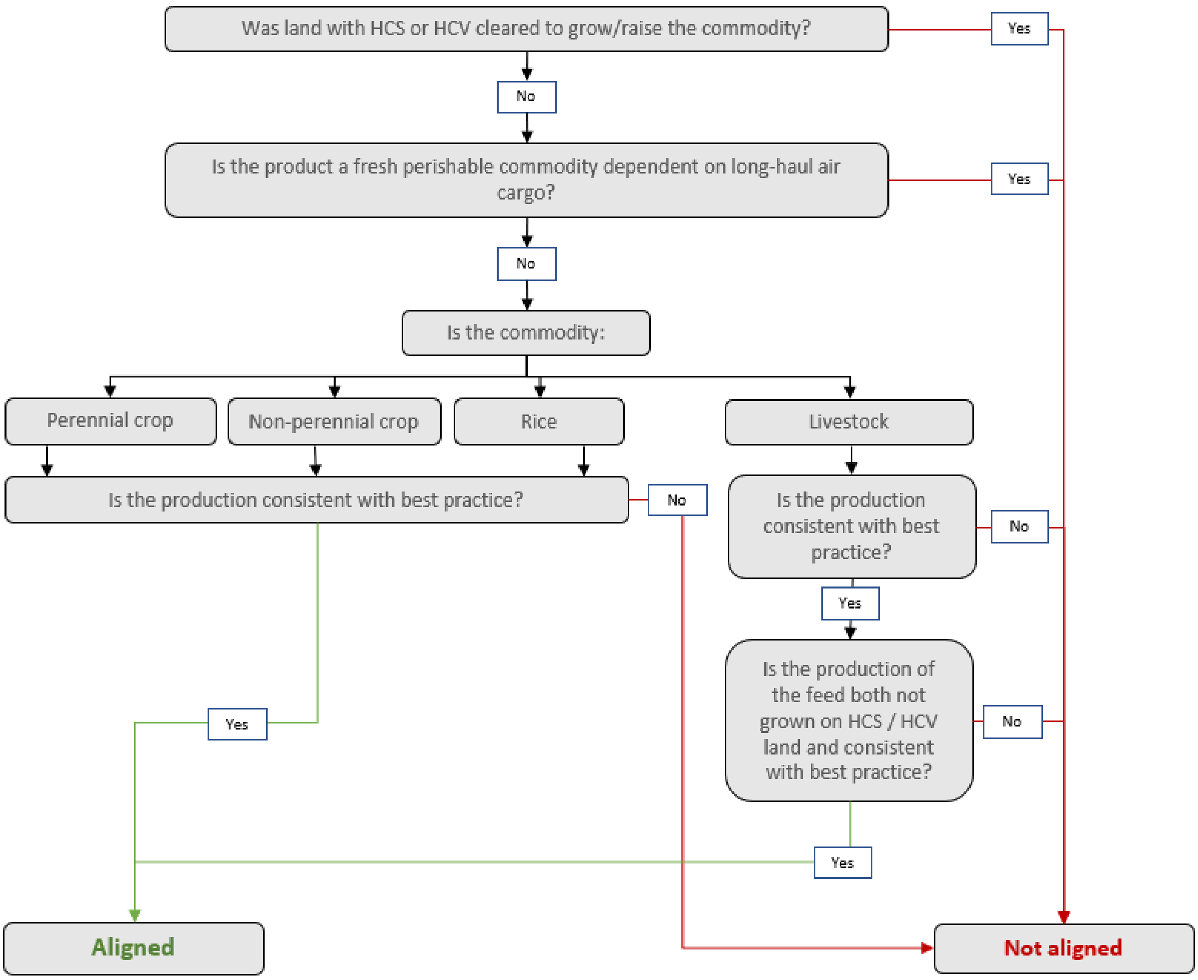

Figure 4: Decision tree for agribusiness directly engaged in production of commodities

To the extent that an agribusiness is engaged in the production of perennial crops, non-perennial crops, or rice that are not associated with the conversion of HCS or HCV land and will not be transported by air freight, MDBs should consider finance for agribusinesses, farmers and others in the supply chain associated with technical assistance and training to adopt best practice (see Table 6).

Box 2: Biofuels

Biofuels, made from various biomass feedstocks, pose a number of challenges to global food security and Paris alignment. Currently, most biofuel comes from starch and sugar crops, corn/maize, and vegetable oils known as first generation biofuels. Though still marginal, various feedstock alternatives are under development using cellulosic biomass, agricultural residues and waste (second generation biofuel), or algae (third generation biofuel).

In theory, biofuels are carbon neutral because all the carbon released into the atmosphere when they are burned was originally absorbed from the atmosphere through photosynthesis during the growth of the plant. However, on a life cycle basis – including induced land use change, planting, harvesting, processing, storage, and transport – the GHG reduction benefit of biofuel is often either much smaller or in some cases detrimental to climate mitigation objectives. Large-scale deployment of first-generation biofuels adds pressure on environmental resources (land, water, soil nutrients, fertilizers), drives deforestation, and competes with food production threatening food security. In contrast, in the future, second generation biomass although less efficient and relatively small market feedstocks such as miscanthus or poplar, as well as agricultural and forest residues could theoretically be scaled up without directly competing with food production (IPCC, 2018). Algae used to produce third generation biofuels is also not a mature technology but could in theory be grown in wastewater treatment plants and at sea.

The following criteria should be considered when investing in sustainable bioenergy production:

- 1st and 2nd generation bioenergy crops should not result in cropland expansion on forest land;
- 1st and 2nd generation bioenergy crops should not compete with food crops to avoid increases in food prices;
- 1st and 2nd generation bioenergy crops should not compete with food and fibre crops for land, water and fertiliser resources.

Considering the climate impact of livestock rearing for meat and dairy – and associated feed production – as a driver for deforestation, nitrous oxide emissions, and methane emissions from enteric fermentation and manure, development finance should focus on sustainable plant-based meat and dairy alternatives instead of expansion of livestock production facilities in most developed and emerging economies. Where finance for livestock production is provided, it should focus on shifting agribusiness towards more sustainable activities in line with best practice recoupling livestock and feed production on the same land to improve transparency and sustainability of feed sourcing and reduce deforestation pressure. Financing of livestock production expansion should to restricted to countries where agropastoral livelihoods are dependent on animal protein from livestock; instances where significant burdens of under nutrition where obtaining adequate quantities of micronutrients from plant sources alone is difficult – areas suggested by the EAT–Lancet Commission on healthy diets from sustainable food systems (Willett *et al.*, 2019).

In cases where the agribusiness in question is involved in a variety of agricultural activities, or in multiple locations, DFIs could apply a conservative risk tailored approach to consider the overall sustainability of the practices of the company's activities. If livestock or crop production activities of the company are conducted on HCS or HCV land and or exports via air freight are central to the business model of the company, investment should be withheld. If such activities are significant, but are not core to the business, a financial institution could consider project finance or investment loans with the specific objective to shift away from misaligned activities on the condition of commitment and plan with monitored implementation to phase out misaligned activities. In cases where agricultural activities do not drive conversion of HCS/HCV land, but are not yet in line with best practice, working capital could be considered with conditionality of improvement in practice. For aligned agribusiness, development finance should support expansion (see Figure 5).

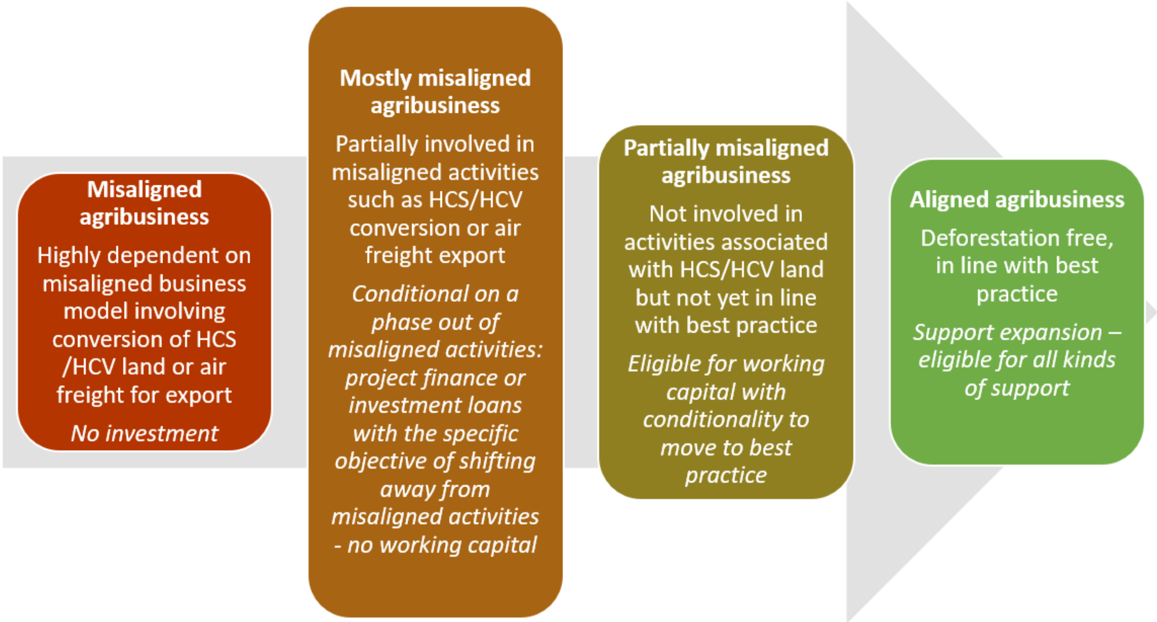

Figure 5: Conservative risk tailored approach for agribusiness finance

Agribusiness not directly involved with production of agricultural commodities

For agribusinesses involved only in the supply chain of agricultural commodities, but not in on-farm production, it is important that development banks ensure that the agribusiness companies they invest in know their suppliers and conduct due diligence in terms of the traceability of their supply chains to ensure that its suppliers are not engaged in practices that lead to deforestation or the loss of peatlands or coastal wetlands, and are taking measures to minimise on-farm emissions in line with best practice. Here, transparency in the carbon footprint of traded commodities is a critical factor in connecting producers with climate friendly, sustainable agricultural practices and consumers that increasingly demand sustainably sourced products. Further, such transparency will be increasingly important with expanded liability for companies lower down in the supply chain to prove that the inputs into the products they sell do not contribute to deforestation (Hughes and Terazono, 2020). In addition to the Paris alignment considerations of banks, it is in the interest of the companies themselves to actually implement the various zero deforestation commitments that especially large agribusiness have made (New York Declaration on Forests, 2014) and to minimize reputational risks arising from association with commodity value chains driving deforestation (Climate Advisers and Ceres 2017). Sustainability certifications can play an important role in doing so – though it is important that any such certification scheme address both legal and illegal deforestation with special attention to HCS and HCV land.

To guide decision making with regard to investments in agribusiness companies in the supply chain, but not directly in on-farm activities, we propose a decision tree that considers a number of factors, based on current sustainability certifications, type of commodity, traceability, and willingness to gain certifications in the future (see Figure 6).

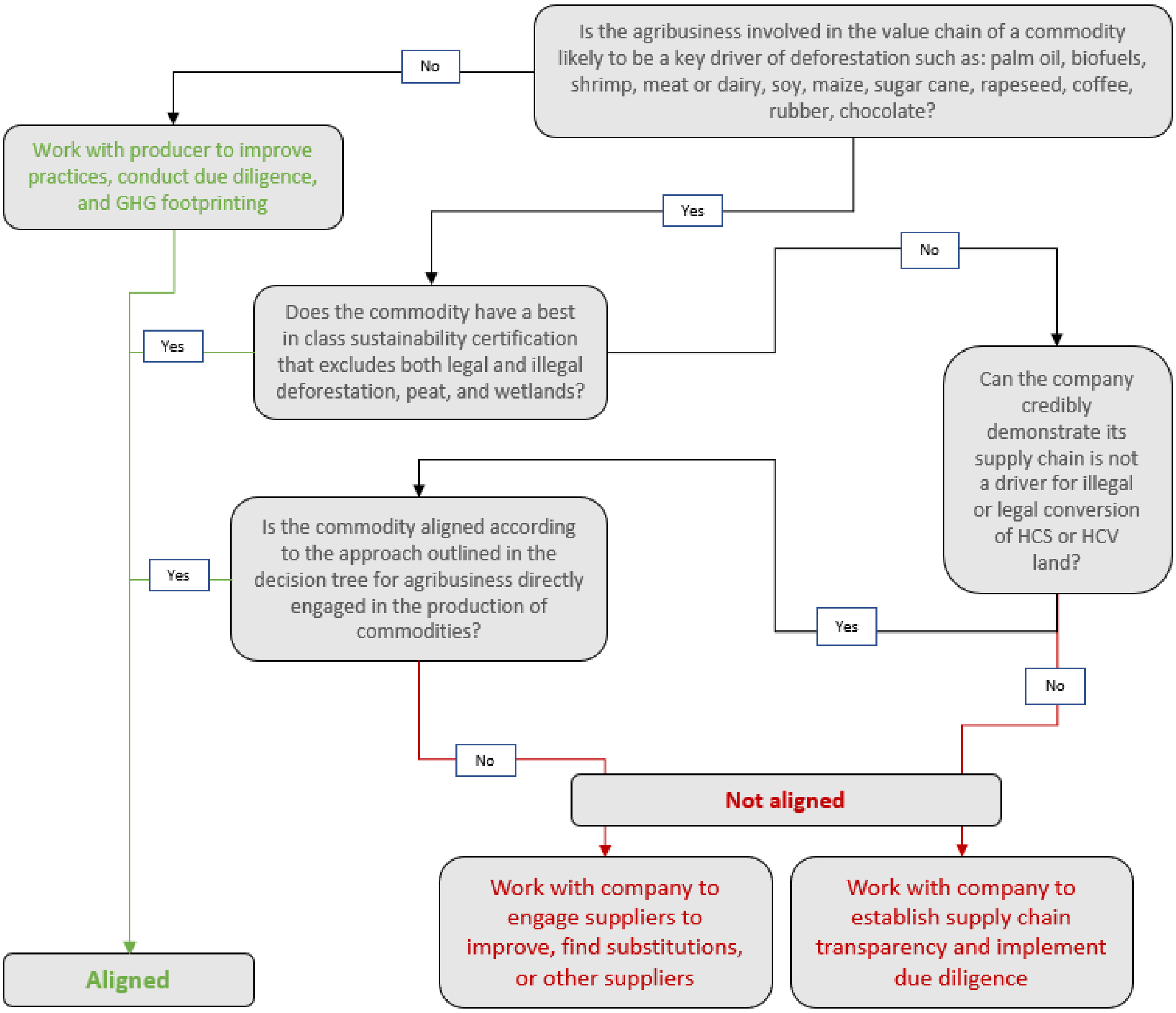

Figure 6: Decision tree for agribusinesses in the supply chain

Similarly to the considerations for agribusinesses directly involved in the production of a commodity, for agribusinesses lower down in the supply chain, it is important to avoid commodities that are linked to deforestation or conversion of peat or wetlands. As mentioned, a comparatively small number of commodities pose a significantly higher risk of driving land conversion than others and require increased scrutiny. If the agribusiness is not involved in supply chains for these products, they can be considered lower risk and although DFI's should work with the agribusiness to engage their suppliers to increase supply chain GHG transparency and work towards best practice.

If the agribusiness is involved in the supply chain for these commodities, it is important to ensure that the company conducts due diligence and ensures that it is not supporting destruction of HCS/HCV land. This can be done by ensuring that it only sources commodities that are certified by a leading standard that excludes both legal and illegal deforestation. If there is not sufficient transparency in the supply chain with regard to HCS and HCV safeguards, investments in companies in that supply chain cannot be considered aligned. In such a case, a DFI could consider working with the company to establish supply chain transparency and implement due diligence but should not provide finance for business expansion.

If, however, the company can demonstrate that its supply chains do not drive HCV/HCV land conversion, and are aligned with best practice, an investment could be considered aligned – but it would be in the company's own interest to seek certification. On the other hand, if best agricultural practice has not yet been mainstreamed among suppliers, it would be important to work with the company to engage with suppliers to improve, find substitutions, or find other suppliers.

A coalition of a number of research organisations and NGOs have recently published an Accountability Framework[5] to provide guidance on how to implement credible supply chain commitments. The guidance on transparency can help DFI's engage with agribusiness clients at least until clearer legal frameworks for disclosure and due diligence are established through emerging legislation such as in the EU and the UK.

3.2.1 Investments targeted at specific technologies and measures

While individual interventions are worthy endeavours and can reduce greenhouse gas emissions, improve the lives of farmers, and reduce soil, water and air pollution, their local level impact is insufficient to transition the world's agriculture and forest sectors to a Paris-compatible pathway. With regard to deforestation and high carbon stock landscape conversion, depending on the activity in question, there is a high probability that an intervention in one place, such as protecting a certain section of forest, will only shift emitting activity to elsewhere in the region or to a different country on the other side of the world (Aukland, Costa and Brown, 2003; Richards and Stokes, 2004). This does not mean that such interventions are not important, but it is clear that a low carbon transition for the agricultural, land use, and broader food system must not only dramatically scale up local interventions to shift farming and land use practices but also consumer behaviour and markets on a large scale. Targeted investments in technological advances in computing, biotechnology, crop and food science, combined with evolving consumer preferences and sound policy making can shift both international and local markets towards a more sustainable food system, healthier diets, and improve food security.

In addition to the investment guidance outlined above, specific loan facilities for particular technologies could also help play a role in helping to scale technologies which may generate positive cashflows or savings for farmers and agribusiness in the short to medium term. Such opportunities may represent an opportunity for MDBs to engage with local banks and other financial intermediaries that already presently have existing lending relationships with local farmers. Examples of such opportunities include the electrification of farm machinery and equipment, replacing diesel irrigation pumps with solar powered electric pumps, laser land levelling, and biogas digesters. An additional option may be loans to help agribusiness implement measures to foster transparency in supply chains and improved carbon footprinting such as blockchain solutions to guarantee the deforestation free provenance of key agricultural commodities that are likely to be drivers of deforestation. Further important investment priorities include investments in plant-based meat and dairy alternatives and agroforestry. Each option is briefly described below.

Electrification of farm machinery and equipment

Shifting from fossil fuel-based equipment and machinery to zero-emissions alternatives offers significant on-farm mitigation potential, and large cost savings of \$229 per tCO_2e (Ahmed et al., 2020) – largely thanks to the elimination of diesel fuel costs, especially when renewable energy can be generated on site. Although zero-emissions equipment and machinery adoption in agriculture is currently low, this transition could be accelerated by investments in battery electric power, leading to reduced battery costs and more competitive prices versus traditional internal combustion engines. Revised emissions regulations and better research and development investment in the private sector may accelerate the adoption of alternatives, addressing the challenge of the slow turnover of farm equipment (Ahmed et al., 2020).

Solar water pumps

Shifting to solar-powered water pumps reduces direct GHG emissions by up to 98% compared to diesel-based pumps, and indirectly reduces emissions via the accompanying modernization of infrastructure, as this leads to reduced pollution, better fertilizer use and more precise irrigation (Schnetzer and

[5] See Accountability Framework: https://accountability-framework.org/

Pluschke, 2017). Solar pumps are also associated with improved energy efficiency and water access in developing countries such as India. To avoid the potential overuse of water resources resulting from the elimination of fuel costs, water pumps should remain connected to the power grid, allowing farmers to sell back excess electricity instead of using this surplus to pump more water (Walton, 2019) . The capital-intensive nature of the shift to solar-powered pumps is one of the main barriers facing subsistence and smallholder farmers (IRENA, 2016), and is an important opportunity for development finance to support both mitigation and adaptation effort.

Laser land levelling for rice paddies

Especially for rice paddies, but also for other crops, uneven land poses an important barrier to improved irrigation water management. Laser land levelling is a highly accurate technology to flatten cropland to an even plane which can allow the farmer to better manage water levels, improve water absorption, avoid run-off and water logging. Together with alternative wetting techniques for rice, this can reduce methane emissions from rice fields, reduce energy needed to pump irrigation water, enhance farmers' resilience to changing precipitation patterns, and improve yields.

Biogas digesters

Capturing and using methane from manure through anaerobic digesters can significantly reduce GHG emissions from dairy cow and hog manure systems, and produce biogas which, when combusted, converts methane into CO_2. Small scale digesters have significant potential for low-income farming regions and significant scope for expanded generation of biogas. Other co-benefits include reduction in odours and local air pollution, as well as generation of renewable fuel that can reduce demand for biomass for cooking, therefore relieving pressure on local forests (Grossi *et al.*, 2019) and improving household incomes.

Due diligence, transparency, and GHG footprinting

An analysis of the effect that food labelling has on consumer behaviours and industry practices found that additional information led to a reduced calorie consumption of almost 7%, a reduction of fat consumption by over 10%, and other unhealthy options by 13% (Shangguan *et al.*, 2018). As awareness of climate change grows, a growing body of evidence shows that carbon footprint labels also affects consumer behaviour, nudging them towards more climate friendly choices (Vlaeminck, Jiang and Vranken, 2014; Fischdick, 2020). Accordingly, a growing number of businesses, mostly plant-based purveyors of meat and dairy alternatives, have started to estimate and label food and beverages with the carbon footprint of their related value chain (Kateman, 2020). While direct investments in helping foster due diligence, transparency and GHG footprinting may not generate an immediate cashflow improvement for agribusiness, it can help open up new markets and protect against future reputational and legal liability risks. Parallel innovations enabled by blockchain technology are providing increased transparency on the provenance of commodities that have historically driven deforestation such as coffee – including a Starbuck's pilot sourcing coffee from Costa Rica, Colombia, and Rwanda (Rajamanickam, 2019; Sokolowsky, 2019).

Targeted support for plant-based protein alternative value chains

As discussed above, dietary change is an important mitigation measure that goes beyond reducing deforestation, nitrous oxide emissions, and methane. The market for plant-based meat and dairy alternatives is growing rapidly. Barclays Investment Bank expects the global alternative meat[6] market share in the overall meat industry to grow from about $14 billion USD or 1% today to 10% in 2029 ($140 billion USD) (Barclays, 2019). Milk consumption in the US has already peaked and is in decline – in 2018 it is estimated to have shrunk by $1.1 billion in 2018 (Raphael, 2019), while the market for plant-based dairy alternatives (including soy, almond, coconut, rice, oats, and hemp) is projected to grow at

[6] Alternative meat products include plant based "mock meats" as well as "lab-grown real meat".

a Compound Annual Growth Rate (CAGR) of 11.4% to $26 billion by 2024, with the fastest growth in the Asia Pacific region (Markets and Markets, 2020). Consumer demand for oat milk has grown especially fast: Swedish company Oatly recently had problems keeping up with demand (Makalintal, 2018). MDBs can support this shift through supporting alternative meat and dairy small and medium companies, and encouraging trade finance for these products. Investments promoting this growing sector have the potential to improve health, reduce emissions, and foster sustainable economic growth.

Agroforestry

As outlined above, agroforestry can also benefit crop yields, may be well suited for multiple crops and help diversify income streams for farmers. Successful examples include cocoa production, where agroforestry practices with mixed forest canopies can improve cocoa yields (Asare et al., 2018), and provide higher yields for the same input of labour (Armengot et al., 2016). Similar positive results have been found with various approaches mixing coffee, banana, and other crops on the same plot of land in Costa Rica (Birkenberg and Birner, 2018). While agroforestry projects may face challenges in terms of increased revenues taking a long time to repay initial investments as trees grow and soil regenerates, agroforestry opportunities for agrobusiness are a ripe candidate for increased concessionality given its multitudes of benefits.

4 Conclusions

Although the land sector and specifically agriculture is not currently on a path towards reaching the objectives of the Paris Agreement, there are glimmers of change that are worth supporting and mainstreaming. DFIs and agribusiness investors, together with policy makers, experts and local stakeholders working toward robust Paris-aligned investment criteria, have the potential to dramatically scale up local interventions to shift farming and land use practices to best practice, as well as bring about shifts in commodity markets on a global scale. To do so, DFI lending must help policy makers and stakeholders set the right kinds of policy incentives and mobilise significant amounts of capital to support climate friendly business models, help shift companies that are willing to change, and cease financing fundamentally incompatible companies according to robust safeguards to preserve areas of high carbon stock and high conservation value.

A concerted, coordinated effort will be required. Here, outreach, dialogue and engagement will be key to build ownership and ensure that policy reform and capacity building is conducted in a way that is responsive to the values and needs of the local, national context. This is not only the case for national and local policy makers and larger agribusiness, but also and especially relevant for smallholders and indigenous peoples. For lending further down in the value chain not directly engaged in on-farm activities, it is essential that policy support and financing is associated with conditionality to ensure that they demand transparency in their value chains and practice due diligence to avoid and shift away from suppliers driving deforestation and unsustainable agriculture. On a broader level, robust standards, due diligence, and enhanced transparency combined with consumer awareness campaigns can help shift both international and local markets towards a more sustainable food system, healthier diets, improve food security and make an essential contribution towards the achievement of the Paris Agreement.

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1 Annex: Emission sources and mitigation measures in the agriculture and food sector

1.1 Forests and other ecosystems

Deforestation

Deforestation, especially tropical deforestation is a leading source of GHG emissions. Tropical deforestation is responsible for 4.8 $GtCO_2e$/yr (8% of global emissions) (Seymour and Busch, 2016). Commercial agriculture to produce palm oil, beef, soybeans, timber, and wood pulp to supply the EU China and India is the main driver of tropical deforestation, which occurs primarily in the Amazon basin, the Congo basin and in South-East Asia (Seymour and Busch, 2016; Pendrill *et al.*, 2019) (Table 3). Ending deforestation is the cheapest and hence the most cost effective mitigation measure (Roe *et al.*, 2019).

Table 7: Drivers of tropical deforestation

Region	Main drivers
Amazon	Commercial soybean and cattle production Mining and oil extraction Expanding regional road networks Permanent flooding via large hydroelectric dams Subsistence agriculture (largely in Bolivia) Logging (both legal and illegal)
South East Asia (mainly Indonesia)	Commercial production of palm oil Conversion to grassland via forest fires
Congo Basin	Smallholders Logging (both legal and illegal) Mining and oil development (in Democratic Republic of the Congo (DRC)

Sources: Steinweg, Kuepper, and Thoumi 2016, R., P., and J.C. 2014, Austin et al. 2019

Afforestation, reforestation and forest management

Afforestation and reforestation could sequester up to 19 $GtCO_2e$/year. However, upper estimates of this potential would require more land that may currently be used for other purposes. To the extent that this may conflict with food production, afforestation should be concentrated on fallow or degraded land not used for other purposes. Reforestation provides the opportunity to restore the historical biodiversity in many regions or enhance existing biodiversity and ecosystem services of natural ecosystems (Pettorelli *et al.*, 2018).

Combining reforestation with ecosystem restoration initiatives such as the reintroduction of historically-present animal species further enhances ecosystem biodiversity, resilience, and services (Perino *et al.*, 2019). Ecosystem restoration can be made more cost-effective by identifying priority areas based on mitigation potential and biodiversity. Consideration for tree species and local context is however important as afforestation with certain species may increase soil carbon emissions by encouraging organic carbon release over decades and thus reduce carbon sequestration benefits (Friggens *et al.*, 2020). Chiefly, native-species and biodiverse forests are more resilient to climate change and therefore serve as more resilient sinks (Thompson *et al.*, 2009; Xu, 2011; Pawson *et al.*, 2013; Liu, Kuchma and Krutovsky, 2018).

Peatland preservation and restoration

Peatlands consist of partially decayed vegetation that forms in water-logged conditions and are the largest terrestrial organic carbon stocks. The largest peatland areas are found in Russia and Canada, but most peatland emissions come from Indonesia, where peatlands are drained for palm oil production

(Conchedda and Tubiello, 2020). Peatland drainage and burning, by which the stored carbon is released into the atmosphere, produces around 2 $GtCO_2e$/yr (Global Peatlands Initiative, 2016). Peatland conservation and restoration could mitigate emissions by 2 $GtCO_2e$/yr (Table 2). An integrated approach simultaneously targeting drivers of peat loss, such as agricultural expansion, and restoring degraded peatlands is necessary to reduce emissions from peat.

Coastal wetland preservation and restoration

Global conversion of coastal wetlands contribute to 1 $GtCO_2e$/yr (Pendleton *et al.*, 2012). The total mitigation potential from coastal wetland interventions is 3.1 $GtCO_2e$/yr (Table 2). Similarly to forests, coastal wetland conversion can be reduced by increasing the proportion of wetlands under protection and better enforcement of conservation policies, deforestation or wetland conversion-free commodity certification, and improved commodity supply chain regulation and transparency (Roe *et al.*, 2019). A leading driver of mangrove conversion are shrimp farms in South East Asia, which in addition to releasing huge amounts of CO_2, also undermines ecosystem health and their services, and increases the vulnerability of coastal communities to coastal erosion and tsunamis (Smith *et al.*, 2020).

1.2 Agriculture

Current crop and livestock production practices not only produce significant direct emissions, but also lead to drastic degradation of the global soil carbon reservoir. Cropland and pastureland expansion to increase agricultural production are also a leading driver of deforestation. In addition to avoiding conversion of forests for agricultural purposes, options to reduce emissions from agriculture include improved livestock management, conservation agriculture, improved grassland management, improved fertiliser management, biochar, improved water management in rice cropping systems, and agroforestry. Each is discussed in further detail below.

Livestock management

Enteric fermentation from livestock production and resulting manure production contribute to 65% of total emissions from agriculture activities, mostly in the form of methane. While technological and breeding developments such as the use of methane inhibitors for dairy cows and selective breeding can help reduce emissions from livestock (Kuramochi *et al.*, 2018), drastic emission reductions needed to achieve the 1.5º target call for substantial reductions in demand for meat and dairy products (see section 3.4.1), as well as reduction in emission intensity from the livestock supply chain. Improvement in livestock management could mitigate up to 2.4 $GtCO_2e$/yr (Table 2).

Capturing and using methane from manure through anaerobic digesters can significantly reduce GHG emissions from dairy cow and hog manure systems and produce biogas which, when combusted, converts methane into CO_2. Small scale digesters have significant potential for low-income farming regions and significant scope for expanded generation of biogas. Other co-benefits include reduction in odours and local air pollution, as well as generation of renewable fuel that can reduce demand for biomass for cooking, therefore relieving pressure on local forests (Grossi et al., 2019) and improving household incomes.

Reduction in livestock emission intensity can be achieved through animal breeding and feed improvement. Another key measure to reduce competition for land is to promote livestock feed from leftovers on arable land (e.g., co-products from cropland, food waste, grassland, crop residues) (Van Zanten *et al.*, 2018).

Conservation agriculture & Improved grassland management

With between 1,500 to 2,400 Gt of organic carbon, the soil carbon reservoir exceeds the total mass of carbon in vegetation and the atmosphere combined (Ciais *et al.*, 2013). The FAO estimates that one third of the world's soil is already degraded through erosion, compaction, nutrient imbalance, pollution, acidification, water logging, loss of soil biodiversity and increasing salinity (FAO and ITPS, 2015). Conservation agriculture is a farming system that focuses on protecting and restoring soil health via minimum disturbance such as tillage, use of permanent cover crops and crop residues, intercropping and crop rotation (FAO, 2016). Further mitigation measures include multicropping with nitrogen-fixing crops, improved fertiliser management, and biochar application. These practices preserve soil organic matter, enhance soil moisture, reduce soil compaction and erosion, improve soil structure and increase soil nutrient contents (FAO, 2016). Such approaches also bring important co-benefits such as improved soil fertility, increased biodiversity, better water retention water, making crops more resilient to long droughts and flooding from heavy downpours (Hawken, 2017). The use of nitrogen-fixing crops, such as soybeans in crop rotation systems, sequesters nitrogen from the atmosphere and reduces the need for inorganic fertilisers, thus reducing nitrous oxide emissions.

Improved fertiliser management

Synthetic fertiliser use in agriculture is the largest source of human induced nitrous oxide emissions. More than 50% of nitrogen fertilisers applied to soils are not absorbed by crops due to overuse and poor soil water management which, in addition to nitrous oxide emissions, increases risks of nitrogen pollution in surounding freshwater sources (Lassaletta *et al.*, 2014). Improving fertiliser management on cropland could reduce emissions by up to 0.7 GtCO2eq /year by 2050. For example, shifting from traditional quick release fertilisers to controlled release stabilised fertilisers offers great potential for boosting crop yields whilst reducing emissions (EU Technical Working Group on Sustainable Finance, 2020, pp. 116-117).

Biochar application

Biochar is a type of charcoal extremely high in carbon content, produced from the burning of biomass in the absence of oxygen; its application to soil contributes to soil carbon, improves soil water holding capacity and soil fertility, reduces nutrient leaching, and has been shown to benefit crop yield in tropical soils (IPCC, 2019a). Global mitigation potential estimates of biochar could reach 6.6 $GtCO_2e$/yr (IPCC, 2019a). Despite its benefits for soil fertility, biochar as a mitigation option needs safeguards to ensure that the source of the biomass does not pose risks to land for food production. Ideally, sustainable biomass sources should come from agricultural waste such as peanut shells or rice straw, though limiting biomass sourcing to only crop residue significantly reduces its mitigation potential down to 0.8 $GtCO_2e$/yr (Roe *et al.*, 2019).

Rice methane minimisation

The majority of rice cultivation comes from rice paddies that are continuously flooded. This provides ideal conditions for anaerobic bacteria that produce large amounts of methane. Microbial transformation of nitrogen in soils and manures produces nitrous oxide emissions. Often much more fertilizer is applied than needed in wet conditions leading to additional emissions with no added benefit to productivity. Together, rice cultivation is responsible for 30% of agricultural methane emissions and 11% of agricultural nitrous oxide emissions (Hussain *et al.*, 2015). Various farm management techniques can help GHG emissions from rice cultivation, while maintaining high crop yield. These include soil management (e.g., conservation tillage or no till), water management (such as drainage, irrigation as well as alternate wetting and drying techniques) or improved fertiliser application (such as change in application rate and timing). In addition, the use of rice cultivars that emit less methane and better assimilate nitrogen could reduce methane and nitrous oxide emissions (Yagi, Tsuruta and Minami, 1997; Hussain *et al.*, 2015).

Especially for rice paddies, but also for other crops, uneven land poses an important barrier to improved irrigation water management. Laser land levelling is a highly accurate technology to flatten cropland to an even plane which can allow the farmer to better manage water levels, improve water absorption, avoid run-off and water logging. Together with alternative wetting techniques for rice, this can reduce methane emissions from rice fields, reduce energy needed to pump irrigation water, enhances farmers' resilience to changing precipitation patterns, and improves yields.

The global mitigation potential for rice production systems ranges between 0.08-0.9 $GtCO_2e$/yr (Roe *et al.*, 2019).

Agroforestry

Agroforestry refers to the practice of integrating trees to cropland and/or pastureland lands, and is generally recognised as having multiple benefits such as carbon sequestration (up to 5.7 $GtCO_2e$/yr, Table 2), biodiversity conservation, soil enrichment, and air and water quality improvement, as well as agricultural productivity and poverty alleviation (Jose, 2009; IPCC, 2019a). Agroforestry can also benefit crop yields and may be well suited for multiple crops including nuts, fruit, medicinal products and wood, which help diversify farmers' income streams.

Successful examples include cocoa production, where agroforestry practices with mixed forest canopies can improve cocoa yields (Asare et al., 2018) and provide higher yields for the same input of labour (Armengot et al., 2016). Similar positive results have been found with various approaches mixing coffee, banana, and other crops on the same plot of land in Costa Rica (Birkenberg and Birner, 2018).

1.3 Other emissions in the supply chain

On farm energy use

Fossil fuel CO_2 from machinery and equipment on farms accounted for 0.4 tCO2e in 2017 (IEA, 2020).There are two important options to reduce emissions, improve air quality, and save farmers money. Shifting from fossil fuel-based equipment and machinery to zero-emissions alternatives has the biggest on-farm mitigation potential, and large cost savings of $229 per tCO_2e. In addition, shifting to solar-powered water pumps reduces direct GHG emissions by up to 98% compared to diesel-based pumps (Schnetzer and Pluschke, 2017).

Shifting from fossil fuel-based equipment and machinery to zero-emissions alternatives offers significant on-farm mitigation potential, and large cost savings of $229 per tCO_2e (Ahmed et al., 2020) – largely thanks to the elimination of diesel fuel costs, especially when renewable energy can be generated on site. Although zero-emissions equipment and machinery adoption in agriculture is currently low, this transition could be accelerated by investments in battery electric power, leading to reduced battery costs and more competitive prices versus traditional internal combustion engines. Revised emissions regulations and better research and development investment in the private sector may accelerate the adoption of alternatives, addressing the challenge of the slow turnover of farm equipment (Ahmed et al., 2020).

Shifting to solar-powered water pumps reduces direct GHG emissions by up to 98% compared to diesel-based pumps, and indirectly reduces emissions via the accompanying modernization of infrastructure, as this leads to reduced pollution, better fertilizer use and more precise irrigation (Schnetzer and Pluschke, 2017). Solar pumps are also associated with improved energy efficiency and water access in developing countries such as India. To avoid the potential overuse of water resources resulting from the elimination of fuel costs, water pumps should remain connected to the power grid, allowing farmers to sell back excess electricity instead of using this surplus to pump more water (Walton, 2019). The capital-intensive nature of the shift to solar-powered pumps is one of the main barriers facing subsistence and smallholder farmers (IRENA, 2016), and is an important opportunity for development finance to support both mitigation and adaptation effort.

Improved synthetic fertiliser production

In addition to the climate impact of nitrous oxide emissions from the use of fertilisers on fields, its production also requires significant amounts of energy, primarily from fossil fuels both to produce the input hydrogen gas, as well as the temperature and pressure to make it react with atmospheric nitrogen. These fossil fuels are responsible for 1.8% of global CO_2 emissions (The Royal Society, 2020). Efforts to reduce the climate impact of fertiliser production mainly target alternative production of hydrogen through electrolysis using renewable energy (The Royal Society, 2020). Improved synthetic fertiliser production has a mitigation potential of up to 0.4 $GtCO_2e$ from 2020-2050.

Agricultural commodity transport emissions

Because of the comparative expense, very little food is transported by air freight compared to other transport modes. The associated cost means that only higher margin perishable products are transported by air freight, for example berries and asparagus when they are off season in the target market. Measured in overall food miles[7], only 0.16% of all food is transported by air – the vast majority of food is transported by water (59%), road (31%), and rail (10%) (Poore and Nemecek, 2018). When food is transported by air however, this leads to a significantly higher carbon footprint of 6-113 times more than alternative modes of transport (Ritchie and Roser, 2020).

1.4 Demand measures and consumer behaviour

Dietary change

Reducing meat and dairy consumption and substituting it with plant-based protein sources and other animal protein with a lower carbon footprint, is the single most important mitigation measure in the food sector with a total potential of up to 8 GtCO2e/year between 2020 and 2050. This would not only reduce methane emissions from enteric fermentation and manure, but also reduce soil carbon loss, nitrous oxide emissions from fertilizers used to grow feed, and reduce deforestation (IPCC, 2019a; Harwatt *et al.*, 2020).

In addition to environmental benefits, reduced red meat consumption (below 50 g per day) could have large health benefits and reduce the number of deaths from heart disease, stroke, cancer and type II diabetes (Springmann *et al.*, 2018). In high-income countries such as Europe, the USA, Canada, and Australia, increased health and environmental awareness together with improved transparency and food labelling is driving rising demand for meat alternatives (Caro, Kebreab and Mitloehner, 2016).

The market for plant-based meat and dairy alternatives is growing rapidly. Barclays Investment Bank expects the global alternative meat[8] market share in the overall meat industry to grow from about $14 billion USD or 1% today to 10% in 2029 ($140 billion USD) (Barclays, 2019). Milk consumption in the US has already peaked and is in decline, shrinking the market by $1.1 billion in 2018 (Raphael, 2019), while the market for plant based dairy alternatives (including soy, almond, coconut, rice, oats, and hemp) is projected to grow at a Compound Annual Growth Rate (CAGR) of 11.4% to $26 billion by 2024 with the fastest growth in the Asia Pacific region (Markets and Markets, 2020). Consumer demand for oat milk has grown especially fast, with Swedish company Oatly experiencing problems keeping up with demand (Makalintal, 2018). DFIs and ESG investors can support this shift through supporting alternative meat and dairy small and companies and encouraging trade finance for these products. Investments promoting this growing sector have the potential to improve health, reduce emissions, and foster sustainable economic growth.

[7] Distance that the agricultural commodity is transported multiplied by mass.

[8] Alternative meat products include plant based “mock meats” as well as “lab-grown real meat”.

Food and agricultural waste

Over a third of food produced goes to waste —about 1.3 Gt each year (FAO 2013a), and much more in the wake of the COVID 19 pandemic (Yaffe-Bellany and Corkery, 2020). Reduced food losses and waste has a mitigation potential of up to 1.8 $GtCO_2e$/yr (Table 2). Reducing food waste from 33% at present to 20% by 2050 is a key measure to meeting the 1.5°C target (IPCC, 2019a; Roe *et al.*, 2019). Food is wasted at all stages of the food supply chains for a variety of reasons depending on the country. (Scialabba, 2015). Improved storage and transport systems are an important measure to address on-farm and post-harvest losses, especially in developing countries. Better access to markets, improved storage technologies such as evaporative coolers, as well as more heat- and disease-resistant crop varieties and farmer education on best practices in harvest and post-harvest handling, can help reduce food waste especially for perishable foods (Sheahan and Barrett, 2017). In higher income countries, aesthetic preferences and awareness campaigns, sell-by dates, packaging and retail policies have more potential further down in the supply chain (Adam, 2015).

Cooking practices

In South Asia and East Africa, hotspots of wood fuel, deploying approximately 100 million cleaner cookstoves has the potential to mitigate 0.8 $GtCO_2e$/yr by reducing wood fuel demand (Bailis *et al.*, 2015). This also offers benefits for air quality and health (Roe *et al.*, 2019). More broadly, Surendra et al. (2014) estimate a total reduction potential of reduced firewood and kerosene use through the use of anaerobic digesters[9] to produce biogas, a cleaner alternative to wood fuels, and clean cookstoves.

[9] Anaerobic digestion is the breakdown of biodegradable material by microorganisms in an oxygen-free environment. Among other things, this produces biogas.

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