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A SURVEY OF GHG MITIGATION POLICIES FOR THE AGRICULTURE, FORESTRY AND OTHER LAND USE SECTOR

Ben Henderson, Clara Frezal, and Eimear Flynn (OECD)

In light of the urgency for policy action to address climate change, this report provides the first detailed global catalogue of targets and policies for mitigating greenhouse gas emissions in the Agriculture, Forestry and Other Land Use (AFOLU) sector. It covers 20 countries which collectively account for nearly half of the world's AFOLU emissions. Most of these countries have recently set targets within their AFOLU sector as part of national climate mitigation strategies and commitments, although these targets are only legally-binding for two countries. However, policies to incentivise emission reductions and achieve these targets still need to be developed. Consequently, policy efforts will need to intensify for the AFOLU sector to contribute effectively to limiting global temperature increases to well below 2°C, and especially to meet the more ambitious 1.5°C target of the Paris Agreement.

Keywords: LULUCF, Climate Change, NDCs, Paris Agreement

JEL codes: Q15, Q18, Q54, Q58

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Executive Summary

This report provides a survey of targets and policies for mitigating greenhouse gas (GHG) emissions in the Agriculture, Forestry and Other Land Use (AFOLU) sector for twenty countries. These countries cover six global regions: Europe (France, Ireland, the Netherlands, and the European Union), North America (Canada, the United States), South America (Brazil), Oceania (Australia, New Zealand), East and South East Asia (The People's Republic of China – henceforth "China" –, Indonesia), and Sub-Saharan Africa (Ethiopia, Mali, Namibia, Nigeria, Benin, Burundi, Chad, Comoros, Côte d'Ivoire, Gambia). Within each of the global regions, countries were selected based on a combination of their regional contribution to Agriculture, Forestry and Other Land Use (AFOLU) emissions, and the progress they have made in introducing policies or commitments to reduce these emissions. In 2016, these countries accounted for close to half of the world's AFOLU emissions, with 42% of global emissions from agriculture and 50% of global Land Use, Land-Use Change and Forestry (LULUCF) emissions (a GHG emission inventory category that corresponds to the FOLU component of AFOLU).

National ambitions and commitments to mitigate AFOLU emissions vary markedly among the countries surveyed. While all of the countries covered in this report commit to national-level GHG emissions reductions in their Nationally Determined Contributions (NDCs), communicated to the United Nations Framework Convention on Climate Change (UNFCCC) under the Paris Agreement, only Indonesia and the surveyed African countries pledge specific mitigation targets for AFOLU emissions in their NDCs. While the setting of sector specific targets in NDCs is important, most of the surveyed countries have also put mitigation policy frameworks or strategies in place to support their NDCs, many of which set targets for AFOLU emissions. More specifically:

- Mitigation targets in OECD countries are more common for agriculture than LULUCF. Where targets for agriculture have been defined, they are typically lower than the percentage reductions in global emissions needed from the sector to stabilise global temperatures at 2°C, according to findings from multi-sector integrated assessment models. New Zealand and Ireland are presently the only countries with legally binding mitigation targets in agriculture.
- The surveyed non-OECD countries that pledged sector-specific targets, tend to have more ambitious mitigation targets for AFOLU than OECD countries, which are conditional on external financial support. The few unconditional targets pledged by non-OECD countries are, by contrast, small in percentage terms.

Where they have been developed, national mitigation strategies and frameworks provide some details about mitigation policies. Challenges for measuring AFOLU emissions, which are mainly from diffuse heterogeneous sources, have been an obstacle for the implementation of mitigation policies in the sector. Progress is however being made on the measurement, reporting and verification (MRV) of emissions at both sector and landholder scales.

Among the mitigation policies in AFOLU that have been implemented, there are very few examples of national-level market-based instruments to incentivise the mitigation of the major emission sources in the sector. All national policies that apply the "polluter pays principle" via market-based instruments, such as carbon taxes or emission permits, presently exclude AFOLU, with the exception of the New Zealand Emissions Trading Scheme (NZ ETS), which includes the forestry sector. The pricing of farm-level emissions in New Zealand is also scheduled for implementation in 2025. In readiness for this, the reporting of farm-level emissions will become mandatory by 2024. A final decision on the implementation of farm-level pricing on emissions will depend on the outcome of a government study into its feasibility. This transition period allows farmers and government agencies to build capacity on the MRV of farm-level emissions prior to the introduction of carbon pricing. This two-step approach offers a pragmatic template

for other countries seeking to introduce carbon pricing policies for the sector. At the very least, introducing country-wide MRV obligations can help pave the way for any national scale carbon pricing policy in AFOLU.

Ongoing experiences with the use of voluntary market-based instruments to mitigate emissions in the AFOLU sector, such as abatement payments or offset schemes linked to emissions trading schemes that involve paying landholders for mitigating emissions, also provide important policy knowledge and insights. These include Australia's Emission Reduction Fund, which relies on auctions to disburse payments from government to project proponents for GHG abatement in the AFOLU sector. This policy has had considerably more impact delivering emission reductions from LULUCF measures than from agriculture. The scale of impact of voluntary market-based approaches that rely on governments or offset income to pay for emission reductions is inherently limited by government budgetary resources and demand for offset credits. These constraints do not apply to carbon pricing instruments that apply the polluter pays principle. Nevertheless, the experiences gained from designing and using the MRV tools that are necessary to create fungible abatement credits will build important technical and institutional capacity, which is also transferable to other market-based instruments. Dissemination of this capacity and knowledge, which has also been generated in offset schemes by selected Canadian provinces and US states, could be useful for countries planning to implement market-based mitigation instruments in AFOLU.

A more common policy approach compared to market-based based instruments is the use of grant and income support schemes with sustainability objectives that include GHG mitigation as either a core goal or co-benefit. Although these policies are more widespread among the reviewed countries (with examples in all the OECD countries and regions reviewed, along with China and Indonesia), they vary considerably in terms of their scale and effectiveness, and are much less targeted to reducing emissions than the few examples of market-based instruments discussed above. These approaches are more relevant for countries that already provide substantial support to the sector, and which have some flexibility to reconfigure this assistance to improve its environmental performance.

- For agriculture, this includes the European Union's Common Agricultural Policy (CAP), which incorporates sustainability objectives as part of a package of income support measures and investments for rural development. So far the CAP has had a minimal impact on mitigation. Based on model simulations, it was estimated that in 2016, greening measures implemented under Pillar I of the CAP reduced agricultural emissions by 2%, and Rural Development Programme (RDP) measures, with cross-cutting mitigation objectives, reduced emissions by 1.5%. However, the post 2020 EU CAP is expected to devote an increased share of its expenditure to measures that could lower emissions from agriculture.
- For LULUCF, the most common of these policies have been those promoting afforestation, including in China (Grain-for-Green), Ireland (Afforestation Scheme), and New Zealand (One Billion Trees programme). However, the provision of sufficient incentives to enable afforestation to compete with agricultural land uses remains an ongoing challenge for these policies, particularly where agricultural production is supported by governments.

Much more limited use has been made of programmes providing cheap credit to landholders willing to undertake investments to lower emissions from agriculture. These policies provide weaker incentives than those that either price carbon or pay for abatement, because they only assist with uptake of the subset of investments that are profitable in the absence of a carbon price. This approach was employed in the case of Brazil's low emission agriculture programme (ABC Programme).

Improved monitoring of GHG mitigation outcomes from grant, income support and credit policies is needed to assess their effectiveness and generate knowledge to feedback into improved policy design and performance.

Other important enabling policies include R&D and knowledge transfer programmes, which are the most widely used policies in surveyed countries and play a particularly important role in OECD countries. While

these policies are not particularly effective on their own, they are important for supporting and amplifying the impact of policies that provide incentives for reducing emissions.

In parallel to public policies, an increasing number of private industry initiatives are emerging, particularly in livestock sectors, which seek to measure and benchmark GHG emissions and in some cases set ambitious mitigation goals. In addition to their branding and marketing benefits, these initiatives can also support the achievement of national mitigation goals for AFOLU. However, questions remain over how the more ambitious of these initiatives can achieve these goals without stronger supporting policies from governments.

There are environmental regulations in many of the surveyed countries that, in some cases, have large mitigation potential. In fact, much of the AFOLU sector's contribution to global mitigation efforts rests on regulations to safeguard the world's remaining carbon sinks, particularly in Latin America, Sub Saharan Africa, and South East Asia. Among the surveyed countries, Brazil and Indonesia have policies with the potential for large scale protection of these important carbon sinks, however, inadequate enforcement and governance continues to pose a substantial threat to climate change.

Despite the overall slow pace of mitigation policy development in AFOLU, especially with regard to market-based policies, there are reasons for optimism. There is a slow but growing trend in the number of countries establishing AFOLU-specific targets as part of national mitigation frameworks and strategies. Furthermore, should agricultural emissions be priced in the NZ ETS, this could set a precedent and provide a possible roadmap for other countries to follow. Ongoing R&D efforts on cost-effective mitigation and MRV approaches are gradually increasing the feasibility of implementing carbon pricing policies in AFOLU.

Nevertheless, policy efforts will need to intensify if the AFOLU sector is to have an effective contribution to limiting global temperature increases to well below 2°C, and especially to meet the more ambitious 1.5°C target of the Paris Agreement.

1. Surveying mitigation policies in agriculture, forestry and other land use sectors: Approach and summary of progress

In this section, the approach used for conducting the survey report is explained, and a summary of progress on implementing mitigation targets and supporting policies measures is provided. In Sections 2 to 7, more detailed information about these targets and policies is provided for each of the surveyed countries and regions.

1.1. Approach and objectives of the mitigation policy survey

In this report, a survey of targets and policies for mitigating GHG emissions in the AFOLU sector is provided for twenty countries in six global regions. This includes targets pledged in Nationally Determined Contributions (NDC) under the Paris Agreement, along with policies that are specific to GHG mitigation, as well as those with other objectives which can have a more indirect impact on reducing AFOLU emissions. Programmes supporting the research and development (R&D) of mitigation technologies and practices are also described, as well as industry led initiatives to mitigate GHG emissions in the agricultural sector.

The regions and countries covered in this study include Europe (France, Ireland, the Netherlands, and the European Union), North America (Canada, the United States), South America (Brazil), Oceania (Australia, New Zealand), East and South East Asia (China and Indonesia), and Sub-Saharan Africa (Ethiopia, Mali, Namibia, Nigeria, Benin, Burundi, Chad, Comoros, Côte d'Ivoire, Gambia).

The selection of countries and jurisdictions was based on different considerations, including their significance to AFOLU emissions, and their policy progress towards reducing AFOLU emissions. The selected countries and jurisdictions accounted for 42% of global agricultural emissions, and 50% of LULUCF emissions in 2016 (FAOSTAT, 2019[1]; FAOSTAT, 2019[2]).

The scope of this survey includes mitigation policies for reducing GHG emissions from agriculture as well as negative emission practices in the LULUCF sector that increase carbon stocks in soils and above ground biomass. In this survey no judgements are made about the relative effectiveness of the different mitigation practices. However, we do report on the performance of mitigation policies in the small number of cases in which they have been evaluated. With respect to practices in the LULUCF sector, no distinction is made between the importance of mitigation from avoided deforestation and from afforestation. Nevertheless, it is worth noting that most OECD countries have not experienced significant deforestation in recent decades, partly due to deforestation in earlier periods (including that which occurred centuries ago) and partly due the success of policies, which typically do not have climate change mitigation as a central objective. Consequently, the focus of mitigation policies in the forestry sector of the OECD countries in this survey is on afforestation rather than avoided deforestation. By contrast, in non-OECD countries with a substantial proportion of their territory covered by forest, deforestation is an ongoing issue with large global implications for climate change. In such countries LULUCF policies preventing deforestation are included.

The information in this report was compiled from NDC submissions, government policy documents and websites, and a small handful of journal articles. Within each country section, a summary of AFOLU emissions is provided, followed by a description of policies that have the mitigation of these emissions as a main objective. Other environmental policy measures that have an indirect, but potentially strong, impact on mitigating AFOLU emissions are also included. Finally, details about research, development and

knowledge transfer policies and industry initiatives supporting AFOLU emission reductions, are also provided in the region and country sections.[1]

1.2. Summary of the findings on mitigation targets and policies for AFOLU

In this section, a summary of the GHG mitigation targets and main supporting policies is presented, including discussion on their performance, where this information was available. A collated summary of the policy insights and lessons is presented in the Executive Summary.

GHG mitigation targets for AFOLU

Significant GHG mitigation is needed from AFOLU to limit global temperature increases to below 2ºC. Annual reductions in global agricultural emissions of between 14% and 23% in 2030, as part of economy-wide efforts with a common carbon price, are estimated to be consistent with this target (Wollenberg et al., 2016[3]; IPCC, 2019[4]). These estimates provide a highly approximate reference point for gauging the size of the various mitigation targets of countries.

National ambitions and commitments to mitigate AFOLU emissions vary markedly among the countries surveyed. While all countries set overall emissions targets in their NDCs, these pledges typically provide broad national level targets. Most of the surveyed countries have put mitigation policy frameworks in place to support their NDC ambitions, many of which set specific targets for AFOLU emissions.

Mitigation targets in OECD countries are more common for agriculture than LULUCF, and where these agricultural targets have been defined, they are typically lower than the percentage reductions in global emissions needed from the sector to stabilise global temperatures at 2˚C, according to findings from multi-sector integrated assessment models. The surveyed non-OECD countries that pledged sector-specific targets, tended to have more ambitious mitigation targets for agriculture and LULUCF than OECD countries, which are conditional on external financial support. The few unconditional targets for agriculture that were pledged by non-OECD countries are, by contrast small in percentage terms. A snapshot of these and targets from the other surveyed countries is provided in Table 1.

Only two of the countries surveyed have introduced national legislation that sets legally binding mitigation targets for AFOLU emissions. Under the Zero Carbon Act, New Zealand targets the reduction of biogenic methane emissions by 10% by 2030 and by at least 24% to 47% by 2050 (below 2017 levels). Ireland has also set binding emission reduction targets for agriculture of 16.5-18.5 $MtCO_2eq$ in cumulative reductions in the 2021-30 period in its Climate Action Plan. The average annual reduction of emissions over this period represents an 8-9% reduction of “business as usual” emissions from agriculture in 2030.

All European Union (EU) Member States face binding mitigation targets for sectors not covered by the EU emissions trading scheme (EU-ETS). These targets are set for non-ETS sector emissions as a whole and they include agricultural emissions. There is some flexibility to offset non-ETS emissions with LULUCF mitigation measures. While most Member States do not have AFOLU-specific targets, there are exceptions, although unlike Ireland these targets are not legally binding. In addition to the EU countries that were surveyed, a small number of countries have also set non-binding, strategic targets for the sector, including Germany, Finland, Portugal, and other EU countries.

[1] This policy review is partially based on a report prepared for the New Zealand Interim Climate Change Committee (ICCC) (Henderson and Frezal, 2019[248]).

Table 1. Snapshot of GHG mitigation targets for the AFOLU sector in the surveyed countries

Country	Mitigation target ($MtCO_2eq$)	Details (percentage reductions shown where reported)	National Policy	Sector
Ireland	16.5 -18.5	8-9% reduction in 2030 compared to 2017 or 10-15% cumulative reduction against 2030 BAU emissions	Ireland Climate Action Plan	Agriculture
	26.8	Reduction between 2021 and 2030, compared to 2005		LULUCF
Netherlands	3.5	Reduction in 2030, compared to 1990	National Climate Agreement	AFOLU[(a)]
France	20	24% reduction by 2030, compared to 1990	National Low-Carbon Strategy	Agriculture[(b)]
California		40% reduction of manure-based methane emissions by 2030 compared to 2013	Senate Bill No. 1383 on Climate Short-Lived Pollutants	Agriculture
New Zealand	3.3	10% reduction of biogenic methane emissions by 2030 compared to 2017	Zero Carbon Amendment Act	Agriculture[(c)]
Indonesia	4	3.3% reduction against BAU, in 2030, conditional	NDC	Agriculture
	650	91% reduction against BAU, in 2030 conditional		Forestry[(d)]
Benin	26.1	31.1% reduction against BAU, cumulative 2021-2030, conditional	NDC	Agriculture
	112.5	Reduction against BAU, cumulative 2021-2030, conditional		LULUCF
Ethiopia	90	48.6% reduction against BAU in 2030, conditional	NDC	Agriculture[(e)]
	130	144.4% reduction against BAU in 2030, conditional		LULUCF
Nigeria	74	Reduction against BAU in 2030, conditional	NDC	AFOLU

Notes: This table includes mitigation targets scheduled for delivery beyond 2020 and until 2030. Only the three African countries with the largest AFOLU mitigation targets are shown.
Conditional targets are subject to the availability of international support for finance, technology transfer and capacity building.
(a) Includes CO2 emissions from energy use.
(b) Annual average for 2029-33 carbon budget period.
(c) Based on agricultural methane reported in UNFCCC inventory for 2017.
(d) Includes peat fire.
(e) Includes carbon sequestration.

GHG Mitigation policies for AFOLU

Market-based instruments

Where they have been developed, national GHG mitigation strategies and frameworks provide some details about these mitigation policies. Among these policies, there are few examples of market-based instruments being used to incentivise mitigation in AFOLU. Although emission trading schemes have been established in the European Union, New Zealand, Canada, California, and China, only the scheme in New Zealand includes AFOLU. This is also the only ETS scheme in the world that includes the forestry sector placing emission liabilities and entitlements with landholders. It also currently requires agriculture to report its emissions without obligations to surrender any emissions units. New Zealand is currently developing a system for pricing agricultural emissions alongside its ETS and could be the first country to implement such a system. Agricultural emissions will be priced at farm level and fertiliser emissions will be priced at processor level from 2025.

One year prior to the pricing of emissions from agriculture, a pilot of a farm-level accounting and reporting system will be completed across a range of farm types. This transition period allows farmers and government agencies to build capacity on the MRV of emissions. This two-step approach offers a pragmatic template for other countries seeking to introduce carbon pricing policies for the sector. At the very least, introducing countrywide farm-level reporting obligations can help pave the way for any national scale carbon pricing policy in AFOLU. The provision of near-free emission allowances for agriculture, should agriculture emissions enter the NZ ETS, is another pragmatic approach for lowering the economic

burden of the policy on the sector, which could be considered by other countries with emission trading schemes, especially in the initial stages of inclusion.

In some cases, carbon offset mechanisms have been used to link AFOLU to emission trading schemes and support mitigation in the sector. This is the case in the provincial offset schemes in Alberta and Quebec, Canada. A federal offset scheme will be developed at national level in Canada as part of its federal carbon pricing system that is being established under its Pan-Canadian Framework. This offset system will provide opportunities for the AFOLU sector to supply emission reduction credits. In California, an offset credit scheme, has been operational for several years, incentivising emission reductions from livestock, grasslands, rice cultivation and forestry. China's national ETS, which is under development, will also include an offset mechanism that could support mitigation in the AFOLU sector, although details of the abatement sources to be covered have yet to be announced.

Australia's ERF is another market-based mechanism that directly targets abatement sources in agriculture and LULUCF. Between April 2015 and March 2020, auctions have been used to contract 158.35 $MtCO_2$ in emission reduction credits in the LULUCF sector. Its impact on lowering non-CO_2 emissions from agriculture has been modest, with only 1.09 $MtCO_2eq$ in abatement contracted so far, representing a small fraction of agriculture's emissions. However, most of the LULUCF measures in the ERF take place on agricultural land and therefore affect the decision making of the farmers that receive abatement funds. This highlights the potential limitations, from a policy perspective, of distinguishing mitigation actions according to the LULUCF and agriculture inventory categories.

Some criticism has been levelled at the ERF, which also applies more generally to mechanisms that involve paying for abatement, including via the use of offset schemes. For example, Freebairn (2016[5]) and Burke (2016[6]) argue that abatement subsidies, such as the ERF, cannot guarantee additionality, and will inevitably pay for some activities that would have occurred anyway. This issue of additionality applies to any market-based instrument that relies on a business as usual baseline (e.g. baseline and credit emission trading schemes), but not to cap and trade ETS. However, not all abatement options under these types of schemes carry the same risks of non-additionality. For example, payments for abating manure CH_4 emissions from piggeries that are based on measured quantities of biogas destroyed in a combustion device, carry low risks of non-additionality. On the other hand, the risk of non-additionality is high for projects involving deforestation on agricultural land, as it may not be possible to guarantee that a landholder would in fact have cleared the land without participation in a payment or offset scheme. There are, however, eligibility conditions that can lower the risks of non-addtionality. For example, one such condition in the ERF requires landholders to provide evidence of applying and receiving permission to clear land for agricultural production purposes (Clean Energy Regulator, 2016[7]).

The impact of the voluntary approaches relying on either governments or offset income to pay for emission reductions is inherently limited by government budgetary resources and demand for offset credits. These constraints do not apply to carbon pricing instruments that are based on the polluter pays principle. Nevertheless, the experiences gained from these market-based instruments in designing and using the MRV tools that are necessary to create fungible abatement credits will build important technical and institutional capacity. Dissemination of this capacity and knowledge, could be useful for other countries planning to implement market-based mitigation policies in AFOLU.

Grant, income support and credit programmes

Grants are provided to support a broader range of measures that have the potential to mitigate emissions, often as co-benefit rather than as direct objective. These include payments to support afforestation, improved fertiliser use efficiency, soil conservation and biogas development

The majority of the surveyed OECD countries have programmes that provide grants to encourage the adoption of technologies and practices with mitigation potential. The most ambitious of these programmes are those that promote afforestation. In Ireland, the Afforestation Scheme provides since 1990 large-scale

grants to landowners to covert agricultural land to forestry. Ireland's forest cover increased from 6% to 11% since 1985, and this expansion in forest cover is planned to continue under the scheme and reach 18% by 2050. New Zealand's ambitious One Billion Trees programme is also expected to contribute to its national mitigation goals. Approximately 150 million trees had been planted since the programme was announced in 2018. It remains to be seen whether the financial incentives provided under these afforestation policies will be sufficient to encourage the afforestation required to meet the ambitious targets that have been set. In Ireland, it remains to be seen whether the incentives for forestry are sufficient to overcome both the opportunity costs of afforestation and the cultural preferences for land use by farmers and local communities. Similarly in New Zealand, although support to forestry exceeds that for agriculture, the extent of plantation forest has remained stable since 2000, again implying that other economic and social factors may make forestry a less competitive option than agriculture (OECD, 2020[8]).

China's Grain for Green programme, which aims to prevent erosion and deforestation, is reported to have contributed significant emission reductions via increased carbon sequestration in forestry, though these reductions have not been quantified. Over the period 2000-12, the programme achieved the conversion of 9 million hectares of cropland to forest land and afforestation on 24 million hectares (Fu et al., 2019[9]).

Agricultural grants and income support programmes that include GHG mitigation in AFOLU as a co-benefit are beginning to play an important role in a number of the countries surveyed. The Canadian Agricultural Partnership and the EU CAP facilitate emission reductions indirectly through their sustainability objectives. A review of the literature by the European Commission (2019[10]) found limited evidence about the link between GHG mitigation and CAP measures with mitigation and sustainability objectives, and identified a lack of information about how the CAP is used to support mitigation actions. In the absence of this reported evidence, the European Commission (2019[10]) used the GHG – Air Quality Interaction and Synergies (GAINS) model to simulate the impact of CAP measures with mitigation and sustainability objectives, using data on their uptake combined with relevant emission factors. Using this approach they calculate that the greening measures implemented under Pillar I reduced agricultural emissions by 2% in 2016, and that RDP measures with cross-cutting mitigation objectives reduced emissions by 1.5% in 2016. The post-2020 CAP, may set higher environmental and climate ambitions, and increase the role of this policy in achieving the European Union's climate targets. Ireland's Climate Action Plan identifies CAP-funded programmes as critical to the delivery of national mitigation goals.

Grants are also provided to support a broad range of measures with some mitigation potential, including to encourage increased fertiliser efficiency in China, to reduce energy emissions from agriculture in Australia, and to support biogas development in China and the United States. Access to subsidised credit has also been used to encourage the adoption of low-carbon practices in the AFOLU sector. One such example is Brazil's Low Carbon Emission Agriculture (ABC) Programme, which contracted BRL 18.82 billion between 2010-11 and 2017-18, in support of mitigation projects in the agriculture sector. Despite some early challenges, the Programme appears to have made an important contribution to meeting the overall ABC Plan goal of reducing emissions by 133.9-162.9 $MtCO_2eq$ by 2020. After an initial lack of demand, due in part to insufficient marketing and technical assistance, the uptake of programme credit increased over time as more intermediaries became involved, the interest rate fell, and dissemination of information about the programme improved. While access to cheap credit is an important component of the package of available mitigation policy measures, it generates lower incentives for adoption than market-based instruments that price carbon emissions.

Improved monitoring of the GHG mitigation impact of these grant and credit schemes is required to assess their effectiveness and generate knowledge that could feedback into improvement policy design and performance.

REDD+ has been identified as a key measure supporting mitigation in the LULUCF sector in developing countries. A number of countries are in the process of developing national REDD+ strategies, while only two of the countries surveyed (Brazil and Indonesia) are set to receive results-based payments for

mitigation actions undertaken. If developing countries are to reap the full benefits of REDD+ and meet their 2030 emissions targets, they will first need to accelerate efforts to develop the frameworks required for participation.

Environmental regulations

Environmental regulations also facilitate GHG mitigation in AFOLU, in particular in Brazil and Indonesia where there is substantial mitigation potential contained in major forest and peatland carbon sinks. The Forest Code and Forest Moratorium are designed to protect forest stocks in Brazil and Indonesia respectively. With both countries facing increasing pressures from deforestation, these regulations have been identified as crucial for reducing emissions from LULUCF. However, enforcement issues have limited their effectiveness Illegal logging and land conversion, including for agriculture, continue to pose a significant enforcement challenge in these countries If fully implemented, the Forest Code could contribute up to 1.03 Gt CO2eq (i.e. 85 $MtCO_2eq$ yr-1) to Brazil's NDC commitment to reduce GHG emissions by 43% by 2030 (Soterroni et al., 2018[11]). There is also scope to strengthen enforcement of Indonesia's Forest Moratorium and expand its coverage. An expansion to include secondary forests and forest areas under concession licences (timber plantations, oil palm and mining concessions) could increase its mitigation potential from 188 $MtCO_2eq$ yr-1 to 437 $MtCO_2eq$ yr-1 (Wijaya et al., 2017[12]). Estimates of the mitigation potential of the Forest Moratorium assume its full and effective implementation (Wijaya et al., 2017[12]). To date, however, progress toward developing the frameworks and mechanisms required for implementation, monitoring and enforcement of the Moratorium has been limited, which has most likely reduced its impact on GHG emissions.

There are other regulations targeting agricultural pollutants that are also likely to contribute to GHG emission reductions. These include regulations on the quantities and methods of nutrient application on agricultural land, to control nitrates and ammonia emissions (e.g. the Nitrates Directive and National Emissions Ceilings Directive in the European Union). These regulations have an indirect, but potentially important impact on lowering GHG emissions from agriculture by driving production efficiency and limiting N_2O precursors. However, several EU Member States have violated their compliance with different provisions of the Nitrates Directive in recent years, weakening its potential to deliver reductions in GHG emissions (Gruère, Ashley and Cadilhon, 2018[13]).

R&D and knowledge transfer programmes

Programmes to support R&D of GHG mitigation technologies and practices for agriculture are among the most widespread mitigation policy measures undertaken at both national and international levels. The Global Research Alliance on Agricultural Greenhouse Gases (GRA) is the most notable international R&D initiative, which currently has 62 member countries from all regions of the world.

A significant number of research projects are focused on improving emissions measurement and building knowledge on the impact of farm management practices on AFOLU emissions. Examples include the Holos software programme developed by Agriculture and Agri-Food Canada to estimate farm-level emissions from agriculture and LULUCF sources and China's efforts to develop methods to measure emission reductions associated with improved livestock practices at the farm level.

Knowledge transfer programmes are an important component of the mitigation policy package, particularly among OECD countries. These programmes help maximise the impact of mitigation research by facilitating the uptake of existing and emerging abatement technologies and practices. In Ireland, Teagasc places strong emphasis on knowledge transfer programmes. Similarly, France's Joint Technology Networks (JTNs) encourage the adoption of nutrient management tools such as AzoFert and Syst'N through training and knowledge sharing.

Research programmes for mitigation in LULUCF are less prevalent, though some countries are undertaking projects in this area. Noteworthy examples include France's Research and Innovation 2025: Plan for the forest-based sector, and New Zealand's Sustainable Land Management and Climate Change" research programme.

Private industry initiatives

Industry actors, primarily in the livestock industry, have signalled their commitment to GHG mitigation directly by setting industry-specific mitigation targets and developing corresponding action plans. Notable examples include the Sustainable Dairy Chain initiative in the Netherlands and France's Life Carbon Dairy programme. The Australian red meat and livestock industry has also committed to achieving carbon neutrality by 2030. However, this goal would be more assured with additional policy support from government.

2. European Union

In this section, the EU-level policies that are most relevant to the mitigation of GHG emissions in AFOLU are first presented, followed by subsections containing a more detailed survey of policies for selected Member States.

2.1. Background on GHG emissions in AFOLU

In 2018, total emissions from agriculture in the European Union[2] amounted to 436 $MtCO_2eq$ or 10% of total GHG emissions. Of this, 45% is in the form of CH_4 from enteric fermentation. The next largest contributor was direct N_2O emissions from managed soils[3] with a 31% share of total emissions. Emissions from agriculture as a whole declined by 20% between 1990 and 2018, although emissions have been stable since 2005. The largest reductions have occurred in the main emission categories, due to decreasing fertiliser use and falling cattle numbers in most Member States (European Environment Agency, 2020[14]).

The LULUCF sector in the EU-28 was a net carbon sink of -288.6 $MtCO_2eq$ in 2018, up 6% compared to the -271.7 $MtCO_2eq$ sink reported in 1990. Emissions in this inventory sector come mainly from cropland. Forest land and harvested wood products are the only net sinks, with trends in LULUCF mainly affected by forest land, the sector's largest net sink (European Environment Agency, 2020[14]).

2.2. Policies for mitigating GHG emissions in AFOLU

The policy framework for mitigating GHG emissions at the EU-wide level from 2005 to 2020, is the 2020 Climate and Energy package (2008). Within this framework, the policy mechanisms and targets for emissions differ depending on whether emissions from the sector are covered by the EU emissions trading scheme (EU-ETS) or not. The EU-ETS is the key tool for cutting emissions from the power, industry and aviation sectors (e.g. CO_2, N_2O and PCFs), within this framework. For sectors not covered by the EU-ETS, such as agriculture, transport, buildings, and waste, annual mitigation targets are set for these non-ETS

[2] The emission figures from the EU GHG inventory report covers the EU27 plus Iceland and the United Kingdom (European Environment Agency, 2020[14]).

[3] Includes direct emissions from application of organic N fertilisers, inorganic N fertilisers, crop residues incorporated in the soil, urine and dung deposited by grazing animals, cultivation of organic soils and mineralisation associated with the loss/gain of soil organic matter.

sectors as a whole, under the Effort Sharing Decision (ESD) mechanism. The targets differ according to national wealth – from a 20% cut for the richest countries to a maximum 20% increase for the least wealthy; although all Member States are expected to make efforts to limit their emissions. The national ESD targets are set to collectively deliver a reduction of around 10% in total EU emissions from non-ETS sectors by 2020 (compared to 2005 levels) (European Parliament and European Council, 2009[15]).[4]

The 2030 Climate and Energy framework (2014) sets EU-wide policy objectives and targets for the 2021 to 2030 period. In line with the European Union's commitment under the Paris Agreement, the framework contains a binding target to cut emissions in EU territory by at least 40% below 1990 levels by 2030. Again, a higher mitigation obligation is set for the ETS sectors, which must cut emissions by 43%, whereas the non-ETS sectors, including agriculture and LULUCF, have to cut emissions by 30% (compared to 2005 levels) (European Commission, 2014[16]).

The Effort Sharing Regulation, adopted in 2018, sets the national emission reduction targets to meet this EU-wide, non-ETS emission target. These national targets range from 0% to 40% reductions in emissions compared to 2005 levels (European Parliament and European Council, 2018[17]). Together, the ESD and Effort Sharing Regulation form the EU Effort Sharing legislation. Within the national targets set by the legislation, Member States have flexibility regarding the contribution from each non-ETS sector, with some banking/borrowing and trading allowances along with the ability to offset some emissions with reductions from LULUCF measures (according to the LULUCF Regulation (2018)).

While most Member States do not have agriculture-specific targets, there are exceptions. For example, Germany targets a 31-34% annual reduction in agricultural emissions of by 2030, compared to 1990 levels, in its Climate Action Plan 2050 (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2016[18]), and the Climate Change Programme for Finnish Agriculture includes a national reduction goal of 13% for agricultural emissions, between 2005 and 2020 (Ministry of Agriculture and Forestry, 2014[19]). Portugal has also established sectoral objectives for the sectors not covered by EU ETS, including GHG emission reduction goals for agriculture in relation of 8% by 2020 and 11% by 2030, compared to 2005 emission levels. These objectives are set out in the Strategic Framework for Climate Policy (QEPiC) under the Portuguese Climate Change Program for 2020/2030 (PNAC 20/30) (Council of Ministers Resolution, 2015[20]). France, Ireland and the Netherlands have also specified GHG mitigation goals for agriculture, which are discussed in more detail in the country-specific sections below.

The LULUCF Regulation (2018) incorporates GHG emissions and removals from LULUCF into the 2030 Climate and Energy framework. The actions of forest owners and farmers to secure carbon stored in forests and soils will thus contribute to achieving the EU's 40% emission reduction commitment under the Paris Agreement. The regulation establishes a "no debit" rule, which sets a binding commitment for each Member State to ensure that accounted emissions from the LULUCF sector are entirely compensated for with an equivalent removal of CO_2 from the atmosphere through actions in the sector (European Parliament and European Council, 2018[21]).

The European Union also prepared a long-term vision for reducing economy-wide emissions with its 2050 long-term strategy (2018), which defines a roadmap for achieving a net zero GHG emission economy by 2050. Following this, the European Green Deal was announced in December 2019, with a central objective of climate neutrality. As part of this, the European Commission proposed the European Climate Law in March 2020 to pass the 2050 climate-neutrality target into law (European Commission, 2020[22]). Integral to the European Green Deal is the Farm to Fork Strategy, which aims to reduce the environmental and climate footprint of the EU food system, strengthen its resilience, and ensure food security in the face of climate change and biodiversity loss. The strategy sets out a new approach to ensure that agriculture, fisheries and aquaculture, and the food value chain contribute to the delivery of EU GHG mitigation targets.

[4] The ESD covers the six GHG controlled by the Kyoto Protocol (i.e. CO2, CH4, N2O, HFCs, PPFCs, SF6) plus NF3 (European Parliament and European Council, 2018[17]).

Reduced pesticide and fertiliser use and the promotion of organic farming and carbon removals are among the main actions identified to support the transition to sustainable food production (European Commission, 2020[23]).

2.3. Other policies supporting GHG mitigation in AFOLU

Alongside the EU mitigation policy frameworks, a number of EU policies support agricultural GHG mitigation in Member States. The Common Agricultural Policy (CAP), through its aim to tackle climate change and foster sustainable natural resource management, has made increasing contributions to the environmental sustainability of the European agri-food sector in recent years. The current CAP programme (2014-20) provides substantial financial support to practices that have the potential to mitigate GHG emissions in the agricultural sector through its two pillars.

Under Pillar I, Green Direct Payments account for 30% of direct payments of the CAP 2014-20, and are conditional on: a) maintaining permanent grassland, b) the diversification of crop rotation, and c) devoting a certain portion of arable land to biodiversity-friendly practices and features (European Commission, 2013[24]). These payments can in principle provide climate mitigation and/or adaptation benefits by protecting soil carbon pools under permanent grassland, and encouraging landscape resilience through crop diversification and establishment of ecological focus areas (DG Agriculture and Rural Development, 2018[25]).

The Rural Development Programme (RDP), under Pillar II of the CAP, also has an important environmental component. At least 30% of the budget of each Member States' RDP must be devoted to voluntary measures that are beneficial for the environment, and 20% must have cross-cutting impacts that address climate change (European Commission, 2013[24]). Priority 5 of the RDP in particular, addresses "resource efficiency and shift to low carbon and climate resilient economy" in the AFOLU and food sectors. Sub-priorities 5D (i.e. reduction of GHG and NH_3 emissions) and 5E (i.e. carbon conservation and sequestration) are particularly relevant for climate change mitigation in AFOLU. Table 2 shows the share of the total RDP budget spent by each Member State on these priorities. Priority 4 on "restoring, preserving and enhancing ecosystems" can also contribute to climate change mitigation in AFOLU.[5]

Priorities 4 and 5 of the RDP are supported by a number of programmes, including agri-environmental and climate measures (AECMs), which provide payments to farmers for the adoption of environmentally-friendly farming practices that go beyond legal obligations. AECMs cover climate change, water, soil, air, biodiversity and landscapes issues as well as genetic diversity and account for 23% of 2014-20 total RDP funding (DG Agriculture and Rural Development, 2016[26]). Other relevant programmes support organic farming, forest investment and investment in physical assets, including the construction of or improvements to manure storage facilities, nutrient storage or low emissions slurry spreading equipment (European Commission, 2017[27]).

Moreover, Statutory Management Requirements (SMRs) and Good Agricultural and Environmental Conditions (GAEC), as part of the CAP cross-compliance mechanism, encourage farmers to comply with EU standards in the field of environment, management of water and soil, and food safety among others. The most relevant cross-compliance standards with regard to climate change are SMR 1 of the Nitrates Directive, GAECs 1-3 on water protection, and GAECs 4-6 on soil protection. Failure to meet the previous standards can result in a reduction of Pillar I direct payments or Pillar II area-based payments.

Furthermore, two EU directives (National Emission Ceilings Directive (2016) and the Industrial Emissions Directive (2010)) regulate NH_3 (ammonia) emissions, 90% of which originate from agriculture (European

[5] The RDP provides support under six priorities. Other measures under priority 5 include increasing efficiency in water use in agriculture, increasing efficiency in energy use in agriculture and food processing, and facilitating the supply and use of renewable energy.

Commission, 2017[28]). Although, NH_3 is not a GHG in itself, indirect N_2O emissions from NH_3 volatilisation are a significant source of GHG emissions. Therefore, regulations controlling NH_3 emissions will also affect N_2O emissions.

Table 2. The climate mitigation component of the EU Rural Development Programme (RDP) 2014-2020

	Priority 5D (EUR million)	Priority 5E (EUR million)	Priority 5 (EUR million)	Priority 5 share in total RDP expenditure
Austria	21.79	4.16	238.93	3%
Belgium	169.44	5.04	245.34	16%
Bulgaria	55.84	31.16	430.65	15%
Croatia	83.31	17.23	194.6	8%
Cyprus*	2.05	4.99	25.3	10%
Czech Republic	-	10.43	14.63	0.4%
Denmark	54.42	-	92.06	8%
Estonia	0.53	0.81	22.4	2%
Finland	62.9	5.5	146.2	2%
France[a]	12.97	294.02	774.49	5%
Germany	168.23	398.47	718.19	4%
Greece	112.58	147.55	941.39	16%
Hungary	15.77	171.44	447.68	11%
Ireland	351.7	77.3	456.5	11%
Italy	141.57	687.19	1636.48	8%
Latvia	16.44	31.72	75.5	5%
Lithuania	22.77	90.39	133.01	6%
Luxembourg	1.88	-	1.88	0.5%
Malta	1.61	2.51	28.69	22%
Poland	-	270.99	270.99	2%
Portugal	0.34	430.43	952.32	20%
Romania	218.43	106.8	790.06	8%
Slovakia	-	1.12	18.51	0.9%
Spain	76.21	678.08	1583.53	12%
Sweden	23.27	-	48.04	1%

Note: Priority 5: Resource-efficient, climate-resilient economy, Priority 5D: Reducing GHG and ammonia emissions from agriculture, Priority 5E: Fostering carbon conservation and sequestration in agriculture and forestry.

The figures in this table are based on the latest indicative expenditure available in the RDP summaries for each country reported on the European Commission website (European Commission, 2020[29]). No expenditures were reported under priority 5 in Slovenia or the Netherlands at the time of preparing this document. Priority 5 is not identified as a primary focus of the Netherlands RDP. The climate mitigation component is an important pillar for projects undertaken under other priorities of the Netherlands RDP.

a) Includes 22 regional RDP programmes in Metropolitan France (mainland France and Corsica).

**Note by Turkey*: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue".

Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Source: (European Commission, 2020[29]).

First, the National Emissions Ceilings Directive (NEC) (2016), sets NH_3 emission reduction commitments for 2020 and 2030 for each Member State. The Industrial Emission Directive (2010) regulates pollutant emissions from industrial installations and aims to minimise pollution from point sources. In the agricultural sector, it covers intensive rearing of poultry or pigs: a) with more than 40 000 places for poultry; b) with more than 2 000 places for production pigs (over 30 kg); or c) with more than 750 places for sows. These installations are required under the directive to apply control techniques for preventing NH_3 emissions according to best available technology (BAT) (European Parliament and European Council, 2011[30]).

The following section describes specific national level policies in Ireland, France and the Netherlands. Together, these countries accounted for 26% of agricultural emissions from the European Union in 2017 (France 17.4%, Ireland 4.5% and the Netherlands 4.3%), and 8% of the LULUCF net sink reported for the European Union (UNFCCC, 2019[31]). Each country has an overarching national climate policy identifying specific mitigation targets for the AFOLU sector which, in the case of Ireland, are legally binding.

2.4. Ireland

Background on GHG emissions in AFOLU

In 2018, the agricultural sector was responsible for 19.95 $MtCO_2eq$ of GHG emissions in Ireland, the majority of which were CH_4 from enteric fermentation (58%), followed by N_2O from agricultural soils (30%), then CH_4 and N_2O from manure management (10%). Emissions from the sector increased in the 1990s until 1998, then decreased to 2011, but have increased again in recent years, with nearly no change in emissions overall from 1990 to 2018 (Environmental Protection Agency, 2020[32]). A similar trend was observed in OECD countries with overall agricultural emissions declining in the early 2000s before increasing in recent years (OECD, 2019[33]).

In 2017, the LULUCF sector was a source of 4.3 $MtCO_2eq$ of emissions. Over the period 1990-2017, the sector was also a net source of emissions, with carbon losses caused primarily by the drainage of organic soils in grasslands and wetlands. In contrast, forest land has become an increasingly important net sink, with LULUCF emissions in forest land averaging -3.7 $MtCO_2eq$ from 1990 to 2018 (Environmental Protection Agency, 2020[32]).

The GHG emission profile of Ireland differs from that of most other European countries, with agriculture accounting for 32.7% of emissions in Ireland compared to its smaller 10% share of emissions in the rest of the Europe (Environmental Protection Agency, 2020[32]). Agriculture's high share in overall GHG emissions reflects the sector's importance to the economy, the biological nature of agricultural emissions and the lack of heavy industry, rather than environmental inefficiency. (Department of Agriculture, Food and the Marine, 2019[34]).

The 2020 Energy and Climate Package and the 2030 Energy and Climate Framework

As with all EU Member States, policies for mitigating agricultural emissions in Ireland can be linked to the goals of broader EU-wide mitigation policies including the 2020 Energy and Climate Package, the 2030 Energy and Climate Framework and the related Effort Sharing legislation, under which Ireland has committed to cutting its GHG emissions from non-ETS sectors by 20% by 2020 and by 30% by 2030 (European Parliament and European Council, 2009[15]; European Parliament and European Council, 2018[17]). Ireland benefits from the following flexibilities in meeting its 2030 ESD target: 4% of the target is achievable through the use of banking/borrowing of EU ETS allowances, and 5.6% is achievable with net emission reductions from the LULUCF sector (European Parliament and European Council, 2018[17]).

The level of flexibilities is higher for Ireland than for most other EU states as: a) the ratio of Ireland's non-ETS/ETS emissions is higher than in most Member States, and b) the share of agricultural emissions in total Irish GHG emissions is higher than in most Member States. Agriculture accounts for 45% of non-ETS

emissions in Ireland. Agriculture's share of non-ETS emissions is expected to increase to 50.8% by 2030, as other non-ETS sectors are expected to decarbonise at a faster rate (Environmental Protection Agency, 2019[35]).[6]

National policies for mitigating GHG emissions in AFOLU

Climate Action Plan

Ireland's Climate Action Plan (2019) sets out a decarbonisation pathway to 2030 that is consistent with the adoption of a net zero emission target by 2050.[7] Specific targets for reducing emissions from AFOLU, and other sectors, are included in the plan. The plan targets cumulative CH_4 and N_2O emission reductions of 16.5 $MtCO_2eq$ to 18.5 $MtCO_2eq$ from the agricultural sector between 2021 and 2030. These reductions account for 17% of total emission reductions set by this plan over this period. The average annual reduction of emissions over this period represents an 8-9% reduction of the projected 21 $MtCO_2eq$ of "business as usual" emissions from agriculture in 2030. The average abatement cost of achieving the reduction is estimated to be about EUR 57 tCO_2eq^{-1}. The Climate Action Plan also targets emissions abatement of 26.8 $MtCO_2eq$ through LULUCF actions, primarily related to forestry, over the period 2021 to 2030. Agricultural landholders are expected to play an important role in delivering these LULUCF emission reductions, primarily through afforestation and by reducing the management intensity of peatland. The Plan also commits to setting a target for the level of energy to be supplied by indigenous biomethane injection in 2030, taking account of the domestic supplies of sustainable feedstock and considering how the supports necessary to reach such a target would be funded.

The Climate Action Plan identifies measures to meet these emissions targets, and underscores the importance of implementing the cost-effective abatement measures identified by Teagasc in its marginal abatement cost curve (MACC) analyses, as well as the continued role of existing policies supported by the CAP (Government of Ireland, 2019[36]). It also sets out new governance arrangements, including a strengthening of the Climate Change Advisory Council, which was established in 2015 under the Climate Action and Low Carbon Development Act, to make recommendations about cost effective options for fulfilling its mitigation commitments. The Plan also aims to raise transparency about how the CAP and other policy measures can mitigate emissions and are reflected in Ireland's national GHG inventory, and outlines actions to improve MRV of abatement options in the national inventory for agriculture and land use. The government commits to working with the European Commission and other Member States to consider the development of a regulatory regime for agricultural emissions. However, this is dependent on the implementation of the Climate Action Plan and the delivery of Ireland's climate obligations (Government of Ireland, 2019[36]).

Ag-Climatise: A Draft National Climate and Air Roadmap for the Agriculture Sector to 2030 and Beyond

The Department of Agriculture, Food and the Marine (DAFM) recently completed consultations (10 January 2020) on ''Ag-climatise'': A Draft National Climate and Air Roadmap for the Agriculture Sector to 2030 and Beyond" (Department of Agriculture, Food and the Marine, 2019[34]). The roadmap aims to translate the targets set for the AFOLU sector in the Climate Action Plan into more detailed actions and targets for

[6] Ireland did not meet its ESD annual targets in 2016 or 2017, and projections suggest that non-ETS emissions will only be 5% below 2005 levels in 2020 (Environmental Protection Agency, 2019[35]). This is driven primarily by increasing emissions from transport and agriculture. Ireland will have to buy allocations from other Member States who have achieved greater emission reductions than those set in their targets, at an estimated cost of EUR 6 – 13 million (Government of Ireland, 2019[250]).

[7] This is in line with the EU 2050 carbon neutrality objective outlined in the European strategic long-term vision for a climate neutral economy (European Commission, 2018[249]).

delivery over the coming years. Actions proposed for the agricultural sector fall under four categories: i) enhancing soil fertility and nutrient efficiency, ii) promoting the use of protected nitrogen products, iii) developing enhanced dairy and breeding programmes and iv) developing a charter with animal feed manufacturers on the crude protein content of livestock. Specific measures include an increase in the use of low-emissions slurry spreading, prohibiting the use of urea on grassland by 2025, requiring slurry/farm yard manure applied to arable land to be incorporated within 12 hours by 2022, requiring all newly constructed external slurry stores to be covered by 2022 and all recently constructed external slurry stores (i.e. within the last five years) to be covered by 2025. The roadmap also prescribes actions to achieve the LULUCF target, specifically a review of the National Forestry programme and improved soil and peatland management. In addition, the roadmap identifies a role for agriculture in helping Ireland meet its renewable energy targets. The sector will contribute to the decarbonisation of the energy system by providing bioenergy feedstocks for the production of biogas/biomethane.

Other policies with relevance to GHG mitigation in AFOLU

Agriculture

In Ireland, the EU CAP is considered as one of the main supporting policies for mitigation in agriculture. Over the period 2014-20, Ireland allocated 11% of its total RDP budget to priority 5 – 8% of which directly targets GHG and NH_3 emission reductions – and 71% to priority 4 on "restoring, preserving and enhancing ecosystems".

There are also a number of RDP-funded measures, which do not target mitigation directly but deliver emissions reductions as a co-benefit. AECMs are the biggest RDP measure for Ireland in budgetary terms (European Commission, 2019[37]). The continuation and extension of a number of existing RDP-funded programmes under the post-2020 CAP will support the delivery of agricultural emission targets.

The Targeted Agricultural Modernisation Schemes (TAMS II) is an RDP-funded measure supporting the emission reduction target for agriculture pledged in the Climate Action Plan. The programme supports capital investment in a number of target areas, including sustainability. Over the period 2014-20 EUR 10 million was allocated for investments in low emissions slurry spreading equipment, with the objective of reducing GHG and NH_3 emissions from the agricultural sector. An additional EUR 70.7 million has been allocated for investments in farm nutrient storage in order to improve water management, e.g. to reduce nutrient loss from farms (Department of Agriculture, Food and the Marine, 2017[38]). According to Teagasc (2018[39]), TAMS II has the potential to reduce GHG emissions by 102 kt CO_2eq yr^{-1} between 2021 and 2030 and should have an even larger impact on reducing NH_3 emissions.

The Green, Low Carbon, Agri-Environment Scheme (GLAS) provides payments to farmers for the implementation of agricultural production methods that address the issues of climate change, water quality and biodiversity loss. Applicants are required to implement a nutrient management plan as prerequisite, and are ranked in three tiers depending on the sensitive nature of the land. Selected candidates are given grants to support practices such as low input pastures, minimum tillage and low emissions manure spreading techniques (Department of Agriculture, Food and the Marine, 2017[38]).

The Beef Data and Genomics Programme (BDGP) is another RDP-funded programme that aims to reduce GHG emissions by improving the genetic merits of the beef herd. The programme provides per hectare payments to participants (Cawley and Cronin, 2019[40]). Overall, the BDGP could reduce GHG emissions by an estimated 110 kt CO_2eq yr^{-1} between 2021 and 2030 (Teagasc, 2018[39])

Both the BDGP and GLAS benefit from the knowledge and information programme of the RDP. This programme further supports and reinforces GLAS and BDGP by enhancing environmental knowledge and best practices among participants through training and introductory courses.

According to Teagasc (2018[39]), knowledge transfer (KT) programmes have significant mitigation potential, with estimated GHG emission reductions of 4.7 $MtCO_2eq\ yr^{-1}$ to 6.1 $MtCO_2eq\ yr^{-1}$ for AFOLU measures for the period 2021-30. Specific elements of the KT programmes with high mitigation potential include the Carbon Navigator, an online tool that estimates the percentage reduction in farm GHG emissions resulting from the implementation of sustainable farm practices, and the online nutrient management planning tool, which helps farmers optimise nutrient inputs on a paddock by paddock basis, hence reducing overuse of fertilisers (Department of Agriculture, Food and the Marine, 2017[38]).

The Organic Farming Scheme, which provides per hectare based payments to promote organic agriculture as an alternative farming system, could also help mitigate GHG emissions, mainly through its potential to increase soil carbon stocks and lower reliance on mineral fertiliser use. However, the scheme has broader objectives than mitigation, and may be more important for promoting soil health and adaptation to climate change.

LULUCF

Of the 26.8 $MtCO_2eq$ of abatement targeted for LULUCF in the Climate Action Plan, 21 $MtCO_2eq$ is expected to be achieved through the planting of new forests and improved management of existing forests (Government of Ireland, 2019[36]). Ongoing investment in forestry and a strengthening of the national forestry strategy are among the policy approaches identified to support the delivery of this target.

The Afforestation Scheme is expected to continue to play a critical role in achieving the forestry target. Established in 1990, it is a 100% state funded scheme that encourages landowners to convert land from agricultural production into forestry. Grants covering the entirety of establishment costs are provided, along with 15 annual premium payments based on foregone income. According to the Department of Agriculture Forestry and Marine (DAFM), over 13 000 farmers received a forestry payment in 2016 (Department of Agriculture, Food and the Marine, 2017[41]). Ireland had less than 6% forest cover in 1985 (Department of Agriculture, Food and the Marine, 2018[42]). It has since increased to 11% as a result of the scheme and the country plans to expand forest cover to 18% by 2050; with the majority of this expansion to be undertaken by farmers (Department of Communications, Climate Action and Environment, 2017[43]). The cost of the afforestation programme to the state for the period 1990-2030 is estimated at EUR 3.2 billion. In addition to carbon sequestration, these forests will provide wood for timber products, sustainable biomass for energy production and biodiversity benefits (Department of Communications, Climate Action and Environment, 2017[43]).

Further contributions to the national LULUCF mitigation goal are expected to come from lowering the management intensity of grasslands on organic soils (4.4 $MtCO_2eq$), and the improved management of tilled land, grasslands and non-agricultural wetlands (1.4 $MtCO_2eq$) (Government of Ireland, 2019[36]). Policies supporting these measures include the National Peatland Strategy, the National Raised Bog Special Areas of Conservation Management Plan 2017-2022, and the new post-2020 CAP.

Research programmes

Ireland's climate change research is co-ordinated by the Climate Research Coordination Group. Research is undertaken under four themes, one of which is particularly relevant to GHG mitigation in AFOLU: GHG Emissions, Sinks and Management Systems. Agriculture and forestry GHG mitigation research is funded primarily by the DAFM and channelled through Teagasc and the Research Stimulus Fund (RSF); a fund supporting sustainable and competitive agricultural practices (Environmental Protection Agency, 2019[44]). Ireland is working to enhance the links between research, knowledge transfer programmes and policy in order to maximise farms' uptake of new abatement measures.

DAFM also funds the Agricultural Greenhouse Gas Research Initiative for Ireland, a research programme that brings together researchers, students and professionals working to develop mitigation solutions for

Irish agriculture. Research efforts are concentrated on: a) N_2O emissions, b) carbon sequestration, c) CH_4 and the rumen microbiome, and d) integrated land management. The programme received initial funding of EUR 1.5 million in 2012 and is co-ordinated by Teagasc (AGRI-I, 2016[45]). In 2018, Teagasc spent EUR 4 million on GHG emissions research and KT programmes coming from a combination of external and internal funding (Teagasc, 2018[39]).

The AFOLU sector also benefits from Ireland's active participation in EU and international research groups, including: the EU Joint Programming Initiative on Agriculture, Food Security and Climate Change (FACCE-JPI); the agricultural European Innovation Partnership (EPI-AGRI); the Global Research Alliance on Agricultural Greenhouse Gases (GRA)[8] and the Global Alliance for Climate Smart Agriculture; and FAO's Livestock Environmental and Assessment Performance (LEAP). Teagasc leads a European Research Area (ERA) research programme (ERA-GAS), which is investing EUR 14.1 million in agricultural and forestry GHG research and is also participating in a Thematic Action Programme on Soil Carbon (Teagasc, 2018[39]). Each of these research groups has a strong focus on collaborative GHG mitigation research.

Industry initiatives

A number of industry initiatives contribute to GHG mitigation in Ireland's agricultural sector. Origin Green, is a voluntary initiative led by the Irish Food Board (i.e. Bord Bia) that brings together the government, the private sector and the food industry in an effort to improve the environmental performance of farms and food manufacturers. Under the programme, independent auditors perform a sustainability assessment at the farm level based on GHG emissions, biodiversity, water conservation measures, energy efficiency and soil management. A feedback report assessing farm performance and comparing it with similar farms is sent to farmers following each audit, with reassessments every 18 months (Bord Bia, 2016[46]). Origin Green benefits from a very high coverage rate. To date, the carbon footprint of over 50 000 beef farms has been assessed under the programme and certified dairy farms represent almost 100% of Ireland's dairy farms (Origin Green, n.d.[47]).

Another industry initiative with mitigation potential in the agricultural sector is the Smart Farming Programme – a voluntary resource efficiency programme led by the Irish Farmers' Association, in collaboration with the Irish environmental protection agency. It supports the measurement, monitoring and improvement of the environmental performance of farms by performing farm assessments and providing farmers with tailored advice from experts. In 2017, participating farms achieved an average reduction of 10% in GHG emissions (Irish Farmers Association, 2017[48]). This reduction in emissions is largely attributable to:

- Increased genetic merit through the Economic Breeding Index (EBI), a profit index helping farmers to source the most profitable bulls and cows for breeding (it is part of the carbon navigator).
- Improved calving rates, particularly in suckler herds.
- Improved nitrogen efficiency on farms.

2.5. The Netherlands

Background on GHG emissions in AFOLU

In 2018, agriculture generated 18.2 $MtCO_2eq$ of GHG emissions, accounting for 9.7% of national emissions. Emissions from agriculture have fallen by 27.3% since 1990. CH_4 from enteric fermentation accounted for the largest share of agricultural emissions (45.3%), followed by N_2O from agricultural soils

[8] The Global Research Alliance on Agricultural Greenhouse Gases is an international research programme initiated by the New Zealand Government in 2009, which aims to find global solutions to mitigate agricultural GHG emissions (Ministry for Primary Industries, 2017[247]).

(29%), and CH_4 and N_2O emissions from manure management (25%). Agricultural emissions declined by 15% between 2000 and 2012, but increased again by 9% over the period 2012-16. Emissions from agriculture remained relatively stable between 2016 and 2018 (National Institute for Public Health and the Environment, 2020[49]).

The LULUCF sector was a net source of 4.9 $MtCO_2eq$ in 2018. Forestland was a net sink of -1.9 $MtCO_2eq$ (-38%), cropland a net source of 1.6 $MtCO_2eq$ (33%) and grassland 3.2 $MtCO_2eq$ (65%), with the rest mainly coming from settlements and other land. LULUCF emissions declined by 24% in 2018 compared to 1990, largely due to a 42% fall in emissions from grasslands (National Institute for Public Health and the Environment, 2020[49]).

2020 Energy and Climate Package and the 2030 Energy and Climate Framework

Policies for mitigating AFOLU emissions in the Netherlands are linked to the targets set under the 2020 Energy and Climate Package, the 2030 Energy and Climate Framework and the Effort Sharing legislation. With respect to the Effort Sharing legislation, the Netherlands has committed to cutting GHG emissions from non-ETS sectors by 16% by 2020 and by 36% by 2030, compared to 2005 levels in both cases (European Parliament and European Council, 2009[15]; European Parliament and European Council, 2018[17]). The Netherlands benefits from some flexibilities, with 2% of its 2030 target achievable through the banking/borrowing of EU ETS allowances, while an additional 1% can be achieved via offsetting non-ETS emissions with net emission reductions from the LULUCF sector.

National policies for mitigating GHG emissions in AFOLU

The Clean and Efficient Agro Sectors Covenant and the recent Climate Agreement translate the targets communicated under the 2020 Energy and Climate Package and the 2030 Energy and Climate Framework into sector-specific targets, covering agriculture and LULUCF, and identify specific policy measures to achieve these objectives. Mitigation efforts for agriculture in the Netherlands focus on the livestock and the greenhouse horticulture sectors in particular, which together account for 90% of agricultural GHG emissions (Ignaciuk and Boonstra, 2017[50]).

Clean and Efficient Agro Sectors Covenant

Part of the Clean and Efficient Programme (2007), the Clean and Efficient Agro Sectors Covenant is the main policy framework for the Dutch agricultural sector. Drawn up by the government in collaboration with the different agricultural sectors, it specifies targets for energy consumption and savings, energy from sustainable sources, and GHG emissions for the period from 2008 to 2020, with corresponding action plans in 2020 (Ministry of Economic Affairs and Climate Policy, 2017[51]). In particular, it set the following GHG emissions reduction targets to be achieved by:

- A reduction in CO_2 emissions of 3.5 Mt to 4.5 Mt compared to 1990.
- A reduction in non-CO_2 GHG emissions (i.e. CH_4 and N_2O emissions) of 4 Mt to 6 Mt CO_2eq compared to 1990 (correspond to an emission reduction of 25-30%).

It specifies the following measures for CH_4 and N_2O emissions reduction:

- Measures for reducing nitrogen inputs on farms such as precision soil cultivation using global positional system (GPS). In 2017, the government, together with businesses, invested EUR 10 million available for a period of four years in a pilot programme for precision agriculture using innovative technologies such as satellite data and drones (Nationale Proeftuin Precisie Lanbouw, 2019[52]).
- Measures for cattle feed to reduce CH_4 emissions.
- Measures for manure storage to reduce CH_4 emissions.

The non-CO_2 emission reduction target was already achieved by 2015, entirely due to the reduction of N_2O emissions, mainly from the reduced application of mineral nitrogen fertiliser. Methane emissions, however, increased at the time, due to an increase in the number of dairy cattle (Ministry of Economic Affairs and Climate Policy, 2017[51]).

For horticulture, one of the biggest agricultural sectors in the Netherlands, the government and industry have a multi-year agreement which sets out the goals and ambitions for 2020. For securing the reduction of greenhouse horticulture CO_2 emissions, a special innovation and action programme *Kas als Energiebron* (Greenhouse as Source of Energy) has been developed. In addition, CO_2 emissions from energy use in the greenhouse horticulture sector are regulated under a CO_2 emission system that puts a cap on emissions. The use of energy and related CO_2 emissions by greenhouse horticulture in the Netherlands is reported annually by the Wageningen Economics Research Institute (WEcR).

Climate Act and the National Climate Agreement

The proposal for the Climate Act and the National Climate Agreement (Climate Act) was submitted to the national parliament in 2018. It specifies a 49% reduction in GHG emissions by 2030, relative to 1990, and a much more aggressive 95% reduction target for 2050. The National Climate Agreement aims to translate these broader goals into clear GHG emission reduction targets for five sectors of the economy, including the agriculture and LULUCF sectors. During the consultation process, each sector platform (involving organisations, experts and companies) was responsible for defining the instruments and measures required to achieve the 49% cut in GHG emissions by 2030, along with additional measures required to reach a 55% reduction in national emissions by 2030 (Klimaatakkoord, 2018[53]).

In June 2019, the Minister of Economic Affairs and Policy sent the national Climate Agreement to parliament. The participants of the Agriculture and Land Use platform adopted a target to reduce GHG emissions by 3.5 $MtCO_2eq$ by 2030 and identified additional opportunities to reduce emissions by up to 6 $MtCO_2eq$. Emissions reductions will come primarily from livestock farming, improved soil management, reduced deforestation and efforts in the greenhouse horticulture sector to intensify the Greenhouse as a Source of Energy programme (Government of the Netherlands, 2019[54]). Table 3 provides details of the proposed measures and the funding that has been allocated for these measures.

EUR 970 million will be made available in the 2020-30 period to support the 6 $MtCO_2eq$ ambition, of which EUR 330 million will come from the Climate Budget. The government will also set aside additional funds to bring the ambition for the AFOLU sector within reach, and has increased the lending capacity of the Green Fund. Instruments such as the CAP and the Stimulation of Sustainable Energy Production scheme are available to co-finance the climate target (Wiebes, 2019[55]).

Table 3. Overview of measures, emissions reduction and funding in the agriculture and LULUCF sectors in the Netherlands

Theme	Measures	Envisaged CO_2 emissions ($MtCO_2eq$)	Financing 2020-2030
Livestock farming	Precision fertilising dairy farming Low-emission dairy cattle housing and pig housing Lifespan extension and selection of dairy cattle Integrated approach to methane and ammonia emissions Study of nitrification inhibitors Pig farming sustainable housing systems Scaling back pig farming Fertiliser replacement Knowledge and development	1.2 - 2.7 *	EUR 252 million
Livestock farming around Natura2000 areas	Measures to strengthen nature value in Natura2000 areas Measures for the livestock sector		EUR 100 million

Theme	Measures	Envisaged CO_2 emissions ($MtCO_2eq$)	Financing 2020-2030
Peat meadow areas	Stimulus approach to peat meadows Pilots and demos Roll-out of measures Measures relating to nature and agriculture Development of earning models	1.0	EUR 276 million
Agricultural soils and outdoor cultivation	Pilots Knowledge dissemination Technological innovation Training of advisers	0.4 – 0.6	EUR 28 million
Trees, forestry and natural environment	Forest strategy Reduction of deforestation in N2000 Climate-smart management Development of government-owned land Landscape elements	0.4 – 0.8	EUR 51 million
Greenhouse horticulture	Intensification of the Greenhouse as a Source of Energy programme EU Greenhouse as a Source of Energy scheme Additional geothermal energy Residual heat Electric heating	1.8 – 2.9	EUR 250 million
Food waste, residual streams and biomass	Advising entrepreneurs on circular agriculture Combating food waste	0.0	EUR 13 million

Note: * of which at least 1 Mt CO_2-eq is from a reduction in methane emissions.
Source: Government of the Netherlands (2019[54]).

Other policies with relevance to GHG mitigation in AFOLU

EU policies and funding also support GHG mitigation efforts in the Netherlands. The Dutch RDP has an important environmental component. Agri-environmental and climate measures (AECMs) accounted for the second largest share of the RDP budget (EUR 518 million of a total EUR 1.69 billion) over the period 2014-20 (European Commission, 2019[56]). The Dutch RDP puts a strong emphasis on enhancing ecosystems (priority 4 of the RDP), with 57% of the total budget allocated to improving landscapes, stimulating biodiversity and improving water and soil management on 6% of the agricultural land. However, the government has chosen not to include specific measures on priority 5, which supports the development of a resource-efficient, climate resilient economy (Table 2). The Dutch RDP emphasises the role of innovation in strengthening the competitiveness and sustainability of the agricultural sector. Innovative, sustainable investments under the RDP are expected to contribute to environmental and climate objectives (European Commission, 2019[56]).

The Dutch Manure and Fertiliser Act, part of the national application of the EU Nitrates Directive, promotes N_2O and CH_4 emission reductions in the livestock and crop farming sectors. Following the removal of the EU milk quota in April 2015, the number of dairy cows increased, causing an increase in direct GHG emissions in the Netherlands. Since then, the Act has helped reduce N_2O and CH_4 emissions by regulating animal numbers, manure production and application, nutrient content in manure, and fertiliser use (Vandaele, 2012[57]; Government of the Netherlands, 2017[58]; Van Grinsven and Bleeker, 2017[59]).

The abolition of the milk quota and the subsequent increase in dairy herds also increased phosphate production in the Netherlands. In January 2018, a trading system for phosphate emissions was introduced in the dairy sector. The number of allowances is set at the situation in July 2015, minus 8.3%, to bring phosphate production levels back to what they were when the milk quota was in place (Government of the Netherlands, 2017[58]). This measure is expected to reduce the size of the dairy herd, which could help lower GHG emissions from cattle.

Research programmes

In the Netherlands, research on GHG mitigation in the AFOLU sector is mainly undertaken by Wageningen University & Research (WUR). WUR has several research programmes on climate change including one on Climate and Soil and one on Climate Smart Agriculture; both programmes cover agriculture GHG mitigation issues. WUR also performed GHG mitigation research in its livestock research institute with programmes on Livestock and the environment—focusing on the environmental effects of livestock farming on soil and atmosphere—and on Climate-smart livestock farming. The latter provides practical and applicable knowledge at the farm level to reduce GHG emissions from livestock and manure. It also addresses low-emission animal feed and energy transition in the agri-food chain.

In addition, in 2018, WUR developed a comprehensive research programme with the aim of cutting GHG emissions from agriculture and land use in the Netherlands. The programme focuses on: a) forest and nature management, b) greenhouse as an energy source, and c) low-emission livestock farming. The Ministry of Agriculture, Nature and Food Quality allocated more than EUR 11 million to this project. This amount is part of the EUR 300 million made available earlier in 2018 by the cabinet to counter the effects of GHG emissions (Wageningen University & Research, 2018[60]).

The Netherlands is also an active member of EU and international research groups with a focus on agricultural GHG mitigation, including the GRA. Moreover, in 2014 the Netherlands launched - together with the United States, Viet Nam and the Republic of South Africa - the Global Alliance for Climate-Smart Agriculture (GACSA), which aims to encourage partnerships and initiatives in the field of climate-smart agriculture.

Industry initiatives

Industry initiatives play an important role in agricultural GHG mitigation in the Netherlands. Kringloopwijzer is an online management tool developed by the dairy industry that tracks the nutrients entering and leaving farms and can help monitor farm level N_2O emissions. It aims to improve farm nutrient-use efficiency by providing indicators such as nitrogen and phosphate levels, nitrogen and phosphate surpluses, mineral use and NH_3 emissions. Farmers can then compare their environmental performance with legal standards and with that of other farms. This monitoring system is already compulsory for farms with a phosphate surplus and it is expected that all farms will be obliged to implement it within a couple of years. Similar systems have been developed for the pork sector (Ignaciuk and Boonstra, 2017[50]).

Sustainable Dairy Chain is an initiative from the dairy industry (Dutch Dairy Association) and dairy farmers (Dutch Federation of Agriculture and Horticulture). Together, they have set GHG emission reduction targets for the sector and formulated a number of goals to make the dairy sector more sustainable. This includes cutting GHG emissions from the dairy chain by 20% by 2020 (from 1990 levels), and achieving climate-neutral growth compared to 2011. They also defined targets relative to phosphorus production and NH_3 emissions. The Sustainable Dairy Chain initiative promotes a number of good agricultural practices to achieve these emissions reductions, including soil conservation measures, grazing preservation, reduced artificial fertiliser use, improved feed efficiency, lower young cattle population, growing and feeding corn, and the use of clover as a nitrogen source (Duurzame Zuivelketen, 2018[61]).

In line with the objectives of the Sustainable Dairy Chain initiative, a number of Dutch dairy companies have expressed their aim to achieve climate neutrality. For instance, this is the case for Royal Friesland Campina and Vreugdenhil Dairy Foods. The latter also rewards its 850 Dutch dairy farmers for making sustainability efforts regarding energy consumption, renewable energy generation, biodiversity and land-related activities. In 2018, 85% of Vreugdenhil dairy farmers received a sustainability incentive premium (Vreugdenhil Dairy Foods, 2019[62]).

The dairy industry also developed a climate module that has been incorporated into the aforementioned Kringloopwijzer tool. The module, developed by Zuivel NL, the Dutch dairy trade organisation, and Friesland Campina enables measurement of GHG emissions at the farm and sector level (PRé, n.d.[63]). Several dairy companies reward farmers for completing the module. Industry initiatives also contribute to GHG emission reductions in the LULUCF sector. In October 2016, forest and timber organisations, in collaboration with NGO's and other sectors, developed an Action Plan on Forests and Timber. The plan targets increased afforestation, improvement forest management and an increase in the use of timber in construction. The first activities have been undertaken in the field of Climate Smart Forestry (Ramaker, 2016[64]).

2.6. France

Background on GHG emissions in AFOLU

In 2018, agriculture generated 74.8 $MtCO_2eq$ of GHG emissions, accounting for 16.8% of national emissions. The majority of agriculture's emissions were CH_4 from enteric fermentation (46%), followed by N_2O from agricultural soils (43%), then mainly CH_4, but also N_2O from manure management (8%). Overall, agricultural emissions have declined since 2000; with a reduction of 9% over the period 2000-2018. Reduced emissions from enteric fermentation and agricultural soils are responsible for this decline (OECD, 2019[33]; Ministère de la Transition écologique et solidaire, 2020[65]).This is in line with the overall decline in agricultural emissions in the European Union over the past three decades (OECD, 2019[33]).

In contrast to agriculture, the LULUCF sector was a net sink of -25.7 $MtCO_2eq$ in 2017. Forest land was a large net sink and captured -49.5 $MtCO_2eq$ in 2017. Grasslands were also a net sink, while croplands and settlements were the largest sources (Ministère de la Transition écologique et solidaire, 2020[65]). This sink has been growing since 1990, mainly due to increasing carbon stocks in the forestry sector, as a consequence of tree growth, a low harvest rate and an increase in the surface of forestland. However, growth has stagnated in recent years due to an increase in the harvest of wood for energy and a decline in the net growth rate of forests (European Environment Agency, 2019[66]).

2020 Energy and Climate Package and the 2030 Energy and Climate Framework

The 2020 Energy and Climate Package and the 2030 Energy and Climate Framework provide the underlying framework for GHG mitigation policies in France. Under the EU Effort Sharing legislation, France committed to cutting its GHG emissions from non-ETS sectors by 14% by 2020 and by 37% by 2030, compared to 2005. It has the flexibility of meeting 1.5% of its 2030 target with net emission reductions from the LULUCF sector (i.e. corresponding to a limit of 5.8 $MtCO_2eq\ yr^{-1}$). As per the 2013-20 period, overachievement in a given year can be carried over to subsequent years up to 2030, and up to 5% of its annual emissions allocation are tradeable between Member States for the 2021-29 period (European Parliament and European Council, 2009[15]; European Parliament and European Council, 2018[17]).

National policies for mitigating GHG emissions in AFOLU

Energy Transition and Green Growth Act and National Low-Carbon Strategy

The Energy Transition and Green Growth Act (ETGGA) (2015) is the cornerstone of France's climate policy. It sets the target of reducing national GHG emissions by 40% between 1990 and 2030 – in line with the objectives of the European Union and the Paris Agreement – and by 75% between 1990 and 2050 (Ministère de la Transition écologique et solidaire, 2016[67]). The second objective was modified under the

2017 Climate Plan, which set a new target of achieving climate neutrality by the middle of the century (Ministère de l'Écologie, du Développement Durable et de l'Énergie, 2017[68]).[9]

The 2015 National Low-Carbon Strategy (NLCS) translates the ETGGA's objectives into emission reduction targets for seven sectors of the economy. The NLCS also provides long-term guidelines and sector-specific recommendations for undergoing this transition. Carbon budgets, i.e. national GHG emissions caps have been set for each sector for the periods 2015-18, 2019-23 and 2024-28. These emissions ceilings are aligned with EU frameworks and the ETGGA's emission reduction objectives (Ministère de l'Écologie, du Développement Durable et de l'Énergie, 2015[69]).

In its NLCS submitted to the UNFCCC in 2017, France set a target to reduce agricultural emissions by 12% by the end of its third carbon budget period in 2028 (compared to 2013) and by 24% by 2050 (compared to 1990) (Ministère de l'Écologie, du Développement Durable et de l'Énergie, 2015[69]). The NLCS was revised in 2018 to take into account the new objective of carbon neutrality by 2050. In addition, it set the fourth carbon budget covering the period 2029-33 and adjusted previous carbon budgets downward to allow France to meet its EU and international mitigation commitments (Ministère de l'Écologie, du Développement Durable et de l'Énergie, 2018[70]).

Carbon budgets for the agricultural sector are described in Table 4. The current allocation corresponds to an 8% reduction of GHG emissions by 2023, 13% by 2028 and 20% by 2033, compared to 2015 levels (i.e. the year of the implementation of the strategy). The technical measures underpinning reductions mainly focus on precision agriculture, agro-ecology, herd and feed management, and organic farming (Ministère de l'Écologie, du Développement Durable et de l'Énergie, 2018[70]).

Table 4. Carbon budgets allocated to the agricultural sector for the period 2015-33 in France

Emissions (annual average) in Mt CO_2eq	Reference years			1st carbon budget	2nd carbon budget	3rd carbon budget	4th carbon budget
	1990	2005	2015	2015-18	2019-23	2024-28	2029-33
Agriculture/Forestry (without LULUCF)	94	90	89	86	82	77	72
of which N_2O	*40*	*38*	*37*	*37*	*35*	*33*	*31*
of which CH_4	*43*	*40*	*40*	*38*	*37*	*34*	*32*
Total (without LULUCF)	546	553	458	442	421	357	299
Total (with LULUCF)	-	-	417	-	383	319	257

Source: Ministère de l'Écologie, du Développement Durable et de l'Énergie (2018[70]).

A continuation of net annual CO_2 removals from the LULUCF sector will play an important role in achieving emission targets, with an average annual net sink value of between 38 $MtCO_2$ and 42 $MtCO_2$ expected in the future carbon budget periods. This represents an increase in the net annual sink of 6-10 $MtCO_2$ for the sector, compared to 2005. The forestry sector is expected to make a significant contribution to LULUCF removals. The NLCS describes a number of measures for the sector, including an increase in the forest area through afforestation and preventing deforestation of high carbon value forests. Increasing rates of harvesting and marketed wood production, particularly through management incentive schemes, is also identified as an important measure for enhancing carbon storage (Ministère de l'Écologie, du Développement Durable et de l'Énergie, 2018[70]).

The first carbon budget – which ended in 2018 – was evaluated before the NLCS review. In 2016, emissions from the agricultural sector were 3% above the target defined by the NLCS at 90 $MtCO_2$eq; 40% of which was N_2O and 46% CH_4 emissions. This gap can be explained by an increase in the sale of mineral nitrogen over the period 2014-16 (+ 13 000 tonnes); and an increase in livestock number (in particular the

[9] The target of achieving carbon neutrality by 2050 has been reaffirmed in the 2018 National Low Carbon Strategy.

suckler cow population was 10% above the reference scenario in 2015) (Ministère de la Transition écologique et solidaire, 2019[71]). According to the French Energy Agency, agricultural GHG emissions in 2033 will only be 14% below 2015 levels if no additional measures are implemented (Ministère de l'Écologie, du Développement Durable et de l'Énergie, 2018[70]).

Policies supporting GHG mitigation in agriculture

The agricultural emissions targets set under the NLCS will be achieved primarily through the implementation of the agro-ecology project (Government of France, 2015[72]). The project aims to develop solutions "combining high economic, environmental, social and sanitary performance based on positive biological interactions and on the use of ecosystem services". It formulates the ambition of having 50% of French farms committed to agro-ecology by 2025 (Ministère de l'Agriculture et de l'Alimentation, 2017[73]). FAO (2016[74]) found that the implementation of the agro-ecology project could reduce agricultural GHG emissions by 13% between 2010 and 2035. Most of the reduction is expected to come from reduced enteric CH_4 emissions (mainly through anaerobic digestion); and reduced N_2O emissions from agricultural soils through the substitution of mineral fertilisers with organic alternatives. Emissions from livestock are also expected to decrease significantly due to a small reduction in cattle population, better use of grass in dairy feed and optimisation of animal feed. In addition to this, carbon storage is expected to contribute to a reduction of 6.3 $MtCO_2eq\ yr^{-1}$ in agricultural GHG emissions by 2035 mainly coming from a decrease in the conversion of agricultural lands to urban and associated uses (roads, parking lots, buildings, etc.), the implementation of carbon storing practices in arable crops and the development of agroforestry and hedgerows (FAO, 2016[74]).

The implementation of the agro-ecology project has been supported by the creation of ten action plans. These include action plans to support the development of agricultural biogas production, organic agriculture, and agroforestry. The majority of these plans are expected to have significant mitigation potential (FAO, 2016[74]).

Policies supporting GHG mitigation in LULUCF

The targets and measures identified for the LULUCF sector in the NLCS are supported by six strategies that cover sustainable forest management, and in particular by the National Forest and Wood Programme 2016-2026, which provides a policy framework for the sector, and targets an increase in marketable wood production by 12 million m^3 per year by 2026. The programme aims to address climate change and recognises the role of woodlands in reducing GHG emissions through carbon sequestration (Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt, 2017[75]). This programme will be supported locally by Regional Forest and Wood Programmes. Further growth in marketable wood production of more than 0.8 million m^3 per year by 2036 is also promoted by the NLCS (Ministère de l'Écologie, du Développement Durable et de l'Énergie, 2018[70]).

Other policies supporting GHG mitigation in AFOLU

The EU Rural Development Programme also supports GHG mitigation in the French agricultural sector. In France, Pillar II of the CAP is managed by regions, meaning that actions can be tailored to local requirements. This decentralisation of the RDP resulted in the establishment of 22 regional RDP programmes for the period 2014-20.[10] Overall, a significant share of the total RDP budget was spent on programmes with an important environmental component, including a 61% share on priority 4 and a 5% on priority 5, in Metropolitan France. Under priorities 4 and 5, seven French regions allocated more than 19% of total RDP funding (the EU-28 average) to AECMs (European Commission, 2020[29]).

[10] Includes Metropolitan France (mainland France and Corsica). France's five overseas territories are not included.

Measure 11, which supports organic agriculture also receives significant funding; ranging from 2.5% to 15.5% of regional RDP budgets. In addition, a new investment scheme – the Farm Competitiveness and Adaptation Plan – has been funded under measure 4 of the RDP (i.e. investment in physical assets). This plan, which mainly targets livestock housing, contributes to CH_4 and N_2O emission reductions through investments to promote slurry pit covers and effluent management, and investment assistance to reduce the use of mineral fertilisers and develop leguminous crops (Ministère de l'Écologie, du Développement Durable et de l'Énergie, 2017[76]). This plan received a total funding of EUR 200 million a year for the period 2014-20, from the European Union, the French government and local authorities (Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt, 2016[77]).

As required by the EU Nitrates Directive, France translated its requirements into a national action plan, revised every four years, and formulated a number of regional action programmes for the 2014-18 period. Actions carried out under these plans have the potential to generate GHG emission reductions as a co-benefit, although past breaches of the Directive indicate it is not always effective.

The Low Carbon Label, which was created in November 2018 through Decree No. 2018-1043, also supports the mitigation objectives of the NLCS. The label is currently being implemented by the French Ecological Transition Ministry and will encourage the development of projects that reduce GHG emissions or sequester carbon. The low carbon label certifies voluntary projects implemented on French territory that lead to GHG emission reductions that are additional to those achieved by existing regulatory compliance and standard practices. The core objective of this labelling scheme is to promote the financing of certified projects by guaranteeing their quality and environmental integrity to potential investors. The label targets emission reductions in all sectors that are sources of non-point source emissions, particularly forestry and agriculture. The Ecological Transition Ministry has already developed guidelines for emission reduction projects in the forestry sector, including for tree planting and restoration of degraded forests, and in the agriculture sector, for projects that reduce emissions from cattle and field crops (Ministère de la Transition Ecologique et Solidaire, 2020[78]).

Research programmes

France invests in a number of research, development and innovation projects through its National Programme for Agricultural and Rural Development (NPARD), which is funded by a tax on farm revenue. The NPARD funds multi-year projects, transversal actions and pilot projects to foster innovation and good practices in the agricultural sector. It is part of the implementation of the French agroecology project (Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt, 2018[79]).

In particular, the NPARD funds the Joint Technology Networks (JTNs), created in 2006 by the Ministry of Agriculture. JTNs are scientific and technical partnerships, which aim to enhance collaboration between research, technical institutes, and agricultural education institutions on socio-economic and environmental topics. The network acts as a collaborative R&D project incubator. As of January 2019, there were 22 JTNs benefiting the agricultural sector; a number of which contribute to agricultural GHG mitigation. For example, the livestock and environment JTN (2014-19) focuses on the development and use of environmental assessment methods and tools, on emissions reduction from manure management, and on ways to improve nitrogen, carbon and phosphorus recycling (Institut du porc, 2014[80]). The JTN fertilisation and environment (2007-19) also has significant mitigation potential. It aims to identify methods and tools for the sustainable management of biogeochemical cycles and soil fertility in the main French cropping systems, and to encourage their adoption through training, knowledge sharing and transfer. This led to the development of two nutrient management tools: Syst'N and AzoFert (Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt, 2018[81]). Other JTNs focus on agroecology, agroforestry, biodiversity and agriculture, and organic farming which can all contribute to GHG emission reductions and increased carbon sequestration.

Research undertaken by the National Institute of Agronomic Research (INRA) also supports GHG mitigation in agriculture. The INRA's work on GHG mitigation in AFOLU includes the development of tools for monitoring GHG emissions, efforts to help livestock farmers reduce emissions, and improving carbon storage in soils and biomass. France also contributes to EU and international GHG mitigation research and is a member of the GRA.

Research initiatives also facilitate GHG mitigation in the LULUCF sector. For the forestry sector, the Forest-Wood 2025 Research-Innovation Plan, outlines the main R&D priorities for the sector with particular emphasis on increasing the use of high values woods, and improving the performance and resilience of the sector to climate change (Ministère de l'Écologie, du Développement Durable et de l'Énergie, 2018[70]).

Industry initiatives

The French livestock industry co-ordinates a number of initiatives with mitigation potential, in particular the Life Carbon Dairy and Life Beef Carbon programmes. The livestock institute launched Life Carbon Dairy in collaboration with the French Dairy Interbranch Organisation, France Conseil Elevage and the Chamber of Agriculture in 2013. The project aims to reduce the carbon footprint of dairy production by 20% over ten years and develop a climate roadmap for the dairy sector. Supported by EU funds and the Ministry of Agriculture, this project led to the creation of CAP'2ER, an environmental assessment and decision support tool. CAP'2ER provides GHG emissions, energy consumption, biodiversity conservation, water and air quality, and carbon storage indicators at the farm level (Centre National Interprofessionnel de l'Économie Laitière, 2020[82]).

As part of the project, carbon footprint assessment of 3 900 dairy farms across six French regions has been performed using CAP'2ER. On average, Carbon Dairy farms reduced their environmental footprint by 6% and their GHG emissions by 4% between 2013 and 2016; mainly via a reduction in input use (Brocas and Danilo, 2018[83]). Due to its success, the programme was extended to the whole territory in 2015 and renamed the Low carbon dairy farm. To date, environmental assessments have been performed in 9 300 dairy farms. If the 60 000 French dairy farms were to take part in this process, it could cut GHG emissions by an estimated 2 Mt of CO_2eq over ten years (Centre National Interprofessionnel de l'Économie Laitière, 2020[82]).

Similar actions are also undertaken in other livestock sectors. In 2016, France, Ireland, Spain and Italy launched Life Beef Carbon, an initiative that aims to reduce the beef carbon footprint by 15% over ten years in these four major European beef-producing countries. Carbon footprint assessment of 2 000 pilot farms will be performed using the CAP'2ER tool. In addition, 170 farms (125 of which are located in France) will be closely monitored for 5 years and used to test and promote innovative mitigation practices in the beef sector (Institut de l'Élevage, 2015[84]).

3. North America

3.1. Canada

Background on GHG emissions in AFOLU

According to Canada's most recent national GHG inventory report, agriculture generated 59 MtCO_2eq of GHG emissions in 2018, accounting for 8.1% of national emissions. The majority of agriculture's emissions were CH_4 from enteric fermentation (41%) and N_2O from agricultural soils (42%), then mainly CH_4 and N_2O from manure management (13%). Emissions from agriculture increased by 27% from 1990 to 2018,

primarily due to an increase in mineral fertiliser use and numbers of beef cattle and pigs (Environment and Climate Change Canada, 2020[85]).

In contrast, the LULUCF sector was a net sink of -13 $MtCO_2eq$ in 2018, compared to -60 $MtCO_2eq$ in 1990. Among the different land use categories, forest land has the largest impact on total LULUCF emissions, with net removals of -140 $MtCO_2eq$ in 2018. Offsetting a large portion of this are 130 $MtCO_2eq$ of emissions from the closely related category of harvested wood products, which are mainly influenced by forest harvest rates. Grassland LULUCF emission fluxes are negligible, with croplands providing a modest sink of -6.2 $MtCO_2eq$ and wetlands a modest source of 2.6 $MtCO_2eq$ in 2018 (Environment and Climate Change Canada, 2020[85]).

Nationally determined contributions

Canada committed to an economy-wide reduction of its GHG emissions of 30% below 2005 levels by 2030 in its NDC submitted in 2015. All UNFCCC national inventory sectors are covered by this commitment, including agriculture and LULUCF, although no sector specific targets have been set. The Canadian Government reviewed its climate change policies in 2016, in light of the 2030 emission reduction target and developed the Pan-Canadian Framework (PCF) on Clean Growth and Climate Change, outlining a strategy for emission reductions across all sectors of the economy, including AFOLU. In a revision of its NDC submitted in 2017, Canada provided details about the PCF, which is described in the following section. Information on the sector-specific measures outlined in the PCF are also communicated in its Long-Term Low Greenhouse Gas Emission Development Strategy submitted to the UNFCCC in 2016.

National policies for mitigating GHG emissions in AFOLU

Pan-Canadian Framework on Clean Growth and Climate Change

The Pan-Canadian Framework (PCF) on Clean Growth and Climate Change is the main policy framework for mitigating GHG emissions in Canada. The PCF targets a reduction of national GHG emissions of at least 30% by 2030 compared to 2005 levels, in line with Canada's NDC under the Paris Agreement.

Federal carbon pricing system

Carbon pricing is considered as the main instrument to achieve these emission reductions. Provinces are given flexibility regarding which carbon pricing system they want to implement, but are required by the federal government to set up a system that either prices carbon at CAD 20 per tonne from 2019, rising to CAD 50 per tonne by 2022, or that meets, under a cap-and-trade system, similar emission reductions. Four provinces – British Columbia, Alberta, Ontario and Quebec – already had a carbon pricing mechanism in place or under development before the implementation of the PCF (Government of Canada, 2018[86]). However, Ontario and Alberta now fall under the federal backstop, having since moved away from climate policies based on carbon pricing systems. The federal backstop is expected to cover about 80% of national emissions. The largest source of uncovered emissions is non-CO_2 emissions from the agricultural sector (Dobson, Winter and Boyd, 2018[87]).[11] The proposed federal system also provides exemptions from carbon pricing for gasoline and diesel fuel used in farming activities. Similar exemptions already apply in British Columbia and Alberta (Agriculture and Agri-Food Canada, 2018[88]).

The federal carbon pricing system will include emission trading and recognition of offset credits. The Government announced funding for the development of a federal GHG offset system in its 2019 budget.

[11] At a minimum, carbon pricing should apply to substantially the same sources as British Columbia carbon tax (Government of Canada, 2018[86]). British Columbia carbon tax applies to GHGs associated with the combustion of fossil fuels purchased or used within the province and to burning of combustibles -peat and tyres- to produce energy or heat.

The details of this system are still being developed. Under the proposed federal backstop, a regulated facility that exceeds its annual emissions limit could buy eligible carbon offset credits from the agriculture and LULUCF sectors. Credits can be generated from voluntary activities that go beyond "business as usual" practices.

Two Canadian provinces (Alberta and Quebec) already use agricultural carbon offset schemes as part of their cap-and-trade systems. Since 2007, Alberta's farmers can receive money from the sale of carbon offset credits in the province cap-and-trade market by voluntarily implementing agricultural practices that reduce GHG emissions or increase carbon storage in soils. The province currently has 15 agriculture-related offset protocols (Government of Alberta, 2019[89]).

Over the 2002-19 period, 14.4 million $MtCO_2eq$ in offset credits were generated under Alberta's agricultural offset protocols (AEOR, 2019[90]). Emission offsets were mainly created from reduced tillage management under the conservation cropping protocol, and by generating biogas energy from the digestion of cattle manure (Government of Alberta, 2019[89]). Quebec also has one agriculture-related offset protocol as part of its cap-and-trade system, which rewards farmers for "methane destruction from covered manure storage facilities". However, as of July 2019, no offset credits had been generated under this protocol (Ministry of Sustainable Development, Environment, and Fight Against Climate Change, 2019[91]).

Complementary mitigation measures

In addition to carbon pricing, the PCF promotes complementary measures to be taken by federal, provincial and territorial governments to address market barriers for mitigation options where the incentives from carbon pricing are not sufficient to reduce emissions.

The framework document broadly defines the complementary mitigation measures, but does not provide specific details about the policies that would be needed to support these measures. In addition, it identifies some technical mitigation measures for the AFOLU sector, which focus on (Government of Canada, 2018[86]):

- The development and adoption of new technologies to reduce emissions from livestock and crop production, including precision farming, "smart" fertilisers that match the release nutrients with plant needs; and feed innovations to reduce CH_4 emissions from cattle.
- Increasing carbon storage through land management practices such as: increasing zero-till farming, perennials and permanent cover crops; tree planting, forest carbon management, restoring degraded forests, protecting restoring wetlands and other natural areas.
- Increasing the use of wood in construction, e.g. by updating building codes.

Estimates of the potential mitigation contributions from these complementary measures and polices in the AFOLU sector are not provided in the PCF document.

Other policies with relevance to GHG mitigation in AFOLU

The Canadian Agricultural Partnership

Agricultural investment programmes with sustainability objectives can also deliver agricultural emissions reductions. The Canadian Agricultural Partnership is an initiative among Agriculture and Agri-Food Canada (AAFC) and provincial and territorial governments that outlines policy and programme priorities for the agriculture industry across Canada. Federal, provincial and territorial governments have allocated CAD 3 billion for investment in the agri-food sector under the programme over the period 2018–23 (Canada, 2019[92]). The Partnership allocated CAD 1 billion to federal activities and programmes; and CAD 2 billion to cost-shared programmes delivered by provinces and territories to ensure that projects are tailored to meet regional needs.

Federal programmes and activities under the Canadian Agricultural Partnership focus on three priorities, including "innovative and sustainable growth" in the sector. The government supports the resilience and sustainability of the sector by helping farmers adapt to climate change, conserve water and soil resources, and grow their businesses sustainably to meet increasing global food demand. This priority is supported by a CAD 690 million investment in two programmes – AgriInnovate and AgriScience – over the period 2018-23. The AgriInnovate programme (CAD 128 million) funds projects that aim to accelerate the commercialisation, adoption and/or demonstration of innovative products, technologies, and processes or services that boost agri-sector competitiveness and sustainability. Priority areas for funding include the adoption of new or world-leading clean technology such as precision agriculture. The programme covers up to 50% of a project cost to a maximum of CAD 10 million (Agriculture and Agri-Food Canada, 2018[93]). The AgriScience programme is described in Section 3.1.5.

Federal-provincial investments are used to fund strategic programmes and initiatives in the agricultural sector, including some related to climate change mitigation. The Environmental Farm Plan programme supports producers in assessing environmental risks on their farm, preparing Environment Farm Plans (EFP), and implementing best management practices (BMP) with the objective of reducing the impact of agriculture on the environment and/or of adapting to and mitigating the impacts of climate change (Government of Yukon, 2019[94]). In particular, these programmes help farmers by providing payments for the implementation of eligible BMPs and supporting investments in manure storage facilities, biodigesters, surface water management systems, low pressure nozzles and fuel efficiency. The Environmental Stewardship and Climate Change programme supports producers in reducing negative impacts on the environment while enhancing sustainable production, managing climate change and increasing profitability in the agricultural sector (Government of Alberta, 2018[95]).

Low Carbon Economy Leadership Fund

Investments made under the Low Carbon Economy Leadership Fund (LCEF) can also lead to a reduction in agricultural GHG emissions. The Fund provides CAD 1.4 billion to Canadian provinces that have adopted the PCF for investment in projects that reduce GHG emissions; including projects in the agricultural sector (Government of Canada, 2020[96]). Under the LCEF, Ontario received almost CAD 420 million to support its Climate Change Action Plan, including helping farmers to reduce GHG emissions from their operations. Quebec received over CAD 260 million to expand actions under the province's 2013-20 Climate Change Action Plan, including new investment to allow farmers to adopt agricultural best practices that reduce GHG emissions. Alberta received nearly CAD 150 million to support its climate objectives. Alberta's funded projects will help Albertans, including farmers and ranchers, adopt energy efficiency measures and save money (Environment and Climate Change Canada, 2017[97]).

Research programmes

The Canadian federal government also funds research and innovation projects with a focus on agricultural GHG mitigation. The AgriScience programme (CAD 338 million) funds industry-led research that benefits the Canadian agri-food sector under the Canadian Agricultural Partnership (see below). A number of research clusters and projects funded under the programme will address environment and climate change issues, including reducing agricultural GHG emissions. Research projects will also deal with water and soil management issues, and the transformation of agricultural products into biofuels, which can all contribute to GHG mitigation (Agriculture and Agri-Food Canada, 2018[93]).

Agriculture and Agri-Food Canada (AAFC) supports research on agricultural GHG mitigation as part of the Canadian Agricultural Adaptation Program (CAAP) (2014-19). The CAAP funds industry-led projects that help the agri-food sector respond to emerging issues and develop new ideas, products and market opportunities, with several projects involving GHG mitigation efforts (Agriculture and Agri-Food Canada,

2019[98]). In addition, AAFC conducts research into reducing greenhouse gas emissions associated with agriculture at its research centres (Office of Audit and Evaluation, 2014[99]).

AFFC research efforts led to the development of the Holos software programme, a free downloadable programme that estimates GHG emissions from enteric fermentation, manure management, cropping systems and energy use based on information entered for individual farms. This tool also allows users to visualise the effect of a change in farm management practices on GHG emissions. Carbon storage and loss from tree plantings and changes in land use and management can also be estimated. Holos is continually updated with new data and improved features (Agriculture and Agri-Food Canada, 2019[100]).

AAFC also manages the Agricultural Greenhouse Gases Program (AGGP), which funds research projects that help develop technologies, BMPs and processes that can be adopted by farmers to mitigate GHG emissions in Canada. It also contributes to increasing farmers' understanding of GHG emissions. The AGGP focuses on projects that fall under the following priority areas: livestock systems, cropping systems, agricultural water use efficiency and agroforestry. The first phase of the programme (2010-15) allocated CAD 27 million to fund 18 agricultural GHG mitigation research projects across Canada. In 2016, an additional CAD 27 million was made available to support 20 new research projects over a five year-period. Individual projects can receive up to CAD 2 million in support (Office of Audit and Evaluation, 2014[99]).

Canada also participates in international research initiatives that can contribute to GHG mitigation in agriculture. The AGGP is Canada's domestic contribution to the GRA. Canada is also a member of the Global Methane Initiative.[12]

Industry initiatives

The 4R Nutrient Stewardship programme was developed by the Canadian fertiliser industry in collaboration with the federal government, provincial governments, and academia and establishes a set of BMPs that support improved nutrient use efficiency and environmental sustainability.[13] Specifically, it provides recommendations for fertiliser application that matches crop requirements and minimises nutrient losses from fields. Other complementary agronomic and conservation practices such as no-till farming and the use of cover crops are also encouraged (Johnston and Bruulsema, 2014[101]).

The 4R Nutrient Stewardship has been promoted and applied across Canada through a number of provincial and regional programs and initiatives. It is currently being practiced in six Canadian provinces (Alberta, Manitoba, Ontario, Saskatchewan, New Brunswick, and Prince Edward Island). Three of those provinces (Saskatchewan, Manitoba, and Ontario) have included 4R Nutrient Stewardship in their provincial climate plans as a measure to meet environmental targets (Fertilizer Canada, 2019[102]). By 2020, it is expected that 25% of Canada crop production (covering 20 million acres) will be covered by the programme. Fertilizer Canada member companies contributed more than CAD 11.8 million towards 4R Nutrient Stewardship research over the past decade and have committed a further CAD 1.2 million of over the next five years for soil fertility research. It is also used outside of Canada and has been recognised by the FAO as a BMP framework for farming communities around the world (Fertilizer Canada, 2019[102]).

Nitrogen-specific BMPs under the 4R Nutrient Stewardship have been proven to reduce GHG emissions by an estimated 25% and increase growers' profits by as much as CAD 87 per acre (Fertilizer Canada, 2018[103]). Furthermore, the generation of carbon offset credits under Alberta's N_2O emission reduction

[12] The Global Methane Initiative is an international public-private partnership focused on reducing barriers to the recovery and use of methane as a clean energy source in key sectors including agriculture.

[13] 4R Nutrient Stewardship refers to the so-called 4R concept: applying the Right Source of nutrients, at the Right Rate, at the Right Time and in the Right Place.

protocol is conditional on the implementation of a 4R nitrogen stewardship plan (Government of Alberta, 2014[104]).

3.2. United States

Background on GHG emissions in AFOLU

In 2018, agriculture generated 618.5 MtCO2eq of GHG emissions, accounting for 9.3% of national emissions. The majority of agriculture's emissions were N_2O from agricultural soils (55%), followed by CH_4 from enteric fermentation (29%), then CH_4 from manure management (10%), but also N_2O from manure management (3%). Agricultural emissions increased by 7% between 2005 and 2018 (U.S. Environmental Protection Agency, 2020[105]). Increases in agricultural emissions over the period were driven primarily by N_2O from agricultural soils and CH_4 from manure management (OECD, 2019[33]; U.S. Environmental Protection Agency, 2020[105]).

In contrast, the LULUCF sector was a net sink of -799.6 $MtCO_2eq$, offsetting approximately 12% of gross GHG emissions in 2018. Most of this came from increases in carbon stocks on forestland (-663 $MtCO_2eq$) and land converted to forestland (-111 $MtCO_2eq$). Since national inventory reporting commenced in 1990, the LULUCF sector has provided a large net sink for GHG emissions in the United States. However, total carbon sequestration in the LULUCF sector decreased by 7% between 1990 and 2018 (U.S. Environmental Protection Agency, 2020[105]).

Nationally determined contributions

In its NDC submitted in 2016, the United States committed to an economy-wide reduction of GHG emissions of 25-28% below 2005 levels by 2025. All UNFCCC national inventory sectors were covered by this commitment, including the agriculture and LULUCF sectors. The United States also identified potential GHG mitigation measures for these sectors in its Long-Term Low Greenhouse Gas Emission Development Strategy submitted to the UNFCCC in 2016. It should be noted, however, that the United States initiated the process of withdrawing from the Paris Agreement in July 2017.

Policies with relevance to GHG mitigation in AFOLU

The federal government funds a number of agri-environmental programmes in the United States. Although these programmes do not typically include GHG mitigation as a core objective, several of the prescribed conservation practices, can help lower net GHG emissions from the AFOLU sector.

Agri-environmental programmes provide funding for the conversion of environmentally fragile cropland to approved conservation uses, including long-term retirement. These programmes also reward crop and livestock farmers for the implementation of conservation practices that reduce environmental pressures such as cover crops and prescribed grazing (e.g. the Conservation Reserve Program) (OECD, 2019[106]). Since the enactment of the 1985 Farm Act, eligibility for most federal commodity programme payments has been subject to the establishment of an individual farm plan to protect highly erodible cropland and wetlands (OECD, 2019[106]).

Funding for all major national conservation programmes in agriculture is being continued under the current farm law, the Agriculture Improvement Act of 2018 (2018 Farm Act), which will remain in force until the end of 2023 (USDA Economic Research Service, 2019[107]). Producers who maintain grass or tree cover on cropland or marginal pasture will continue to receive funding under the Conservation Reserve Program, with the acreage cap for the programme set to increase from 24 million to 27 million acres in 2023 (Congressional Research Service, 2019[108]). Other conservation programmes continued under the 2018 Farm Act include: the Conservation Stewardship Program, which provides financial payments to producers who meet stewardship requirements on agricultural and forest land; the Environmental Quality Incentives

Program, which provides financial assistance to producers for conservation practices on agricultural and forest land; the Agricultural Conservation Easement Program, which funds, among other things, long-term easements for the restoration and protection of wetlands on farms (U.S. Department of Agriculture Economic Research Service, 2019[109]). The US Department of Agriculture (USDA) also helps farmers mitigate GHG emissions and adapt to climate change by providing educational, technical and financial assistance through various conservation practices and programmes.

Policies to support the development of biogas production also deliver agricultural emissions reductions. The US Environmental Protection Agency (EPA) co-ordinates the AgSTAR programme, which promotes the use of biogas recovery systems to reduce CH_4 emissions from livestock waste (U.S. Department of Agriculture, 2014[110]; U.S. Environmental Protection Agency, 2019[111]). AgSTAR offers technical, financial and policy resources to farmers and industry for the deployment of anaerobic digester and biogas recovery systems for manure management. There are currently about 254 anaerobic digesters in operation on commercial livestock farms in the United States, compared with 24 in 2000. Between 2000 and 2018, AgSTAR helped reduce GHG emissions by 40 $MtCO_2eq$ (U.S. Environmental Protection Agency, 2019[112]).[14]

Research programmes

The United States also invests in R&D, education and demonstration programmes that deliver mitigation benefits for the agricultural sector. One such programme is the National Resources Conservation Service (NRCS) Conservation Innovation Grants programme, supported by the USDA. The programme encourages voluntary demonstration projects across the country to stimulate the development and adoption of innovative conservation programmes and technologies – some of which focus on agricultural GHG emissions reduction and soil carbon (USDA, 2019[113]).

The USDA also supports the Sustainable Agriculture Research and Education program, a decentralised competitive grants programme that funds farmers, researchers, educators and students to advance sustainable agricultural practices in the United States. Example of research areas include: on-farm renewable energy, no-till and conservation tillage and cover crops (S.A.R.E, 2012[114]). In 2014, the USDA established ten Regional Climate Hubs to deliver science-based knowledge, practical information and guide stakeholders for the implementation of climate change mitigation and adaptation activities (USDA Climate Hubs Executive Committee, 2015[115]).

The United States is a member of international research programmes, including the GRA and the Global Methane Initiative.

Industry initiatives

Industry initiatives can also lower agricultural emissions in the United States. The FARM Environmental Stewardship (FARM ES) programme was launched in 2017 by the Innovation Center for US Dairy and the National Dairy Farmers Assuring Responsible Management (FARM). FARM ES provides dairy producers, co-operatives and companies with a single source for voluntary assessment and reporting of GHG emissions and energy use on dairy farms. The programme estimates emissions and energy use, and provides tools and resources for farmers to measure and improve their footprint. By 2018, more than 750 FARM ES evaluations had been conducted (Innovation Center for U.S. Dairy, 2018[116]).

The Innovation Center also works in partnership with Field to Market: The Alliance for Sustainable Agriculture, a collaboration by stakeholders across the agricultural supply chain working to advance the sustainability of US commodity crop production. The Innovation Center supported the development of the Fieldprint platform, launched in 2018. The platform allows actors across the supply chain to measure the

[14] 31.7 MtCO2e of direct emissions reductions and 7.5 MtCO2e of emissions avoided.

environmental impacts of commodity crop production and identify opportunities for improvement (Innovation Center for U.S. Dairy, 2018[116]). The Fieldprint analysis estimates field level performance against a number of sustainability indicators, including GHG emissions.

3.3. California

Some of the most ambitious mitigation policies affecting the agriculture sector in the United States are present at state level. California stands out as one of the most important states in terms of the progress it has made on implementing mitigation policy incentives in the AFOLU sectors.

Background on GHG emissions in AFOLU

California accounts for approximately 6% of US national agricultural GHG emissions. It is the state with the highest number of dairy cows in the United States and the highest dairy CH_4 emissions from manure management and enteric fermentation. Due to the widespread use of flush water lagoon systems for collecting and storing manure, California also has higher per milking cow CH_4 emissions than most US states. However, milk production feed efficiency at California dairies is among the best in the world, resulting in relatively low enteric CH_4 emissions per gallon of milk (California Air Resources Board, 2017[117]).

According to California Air Resources Board (CARB), agriculture generated 32.4 $MtCO_2eq$ of GHG emissions in 2017, accounting for 8% of state-wide emissions, primarily from CH_4 and N_2O sources (California Air Resources Board, 2019[118]). Livestock manure management and enteric fermentation accounted for 36% and 35% of agricultural emissions in 2017 respectively, while 21% of emissions were attributable to crops. Agricultural emissions increased by 4.5% between 2000 and 2017. Emissions from enteric fermentation and manure management increased between 2000 and 2007, but have since remained stable. In contrast, emissions from crop production have decreased since 2007. A notable feature of the agricultural emissions profile in California is the dominance of dairy cattle production, which is responsible for 60% of agricultural GHG emissions. GHG emissions from dairy manure management and enteric fermentation increased by 16% over the period 2000-17 (California Air Resources Board, 2019[118]).

While the LULUCF sector consistently provided a large carbon sink over the period 1990-2017 in the United States, LULUCF fluxes in California have been more variable. There was net loss of 155 $MtCO_2eq$ of carbon stocks from 2001 to 2010, largely as a consequence of high intensity fires. There was a net carbon stock loss of 4.8 $MtCO_2eq$ from 2010 to 2012, and a net gain of -15.6 $MtCO_2eq$ from 2012 to 2014 (California Air Resources Board, 2018[119]).

Policies for mitigating GHG emissions in AFOLU

Mitigation policy framework

In 2005, the government of California issued Executive Order (EO) S-3-05, which sets the target of cutting state-wide GHG emissions by 80% by 2050 (from 1990s levels). Since then, some shorter-term emission reduction targets have been established. In particular, California Global Warming Solutions Act (Assembly Bill No. 32, 2006) sets the target of bringing GHG emissions to 1990 levels by 2020 with maintained and continued reductions post-2020. A decade later, EO B-30-15 (2015) and Senate Bill 32 (2016) established a new state-wide goal: to reduce GHG emissions by 40% by 2030 (from 1990 levels). Finally, in September 2018, an EO was issued (EO B-55-18), which aims to achieve carbon neutrality by no later than 2045 (Poloncarz and Levine, 2018[120]).

California Cap-and-Trade and Offset Credit Scheme

The main instrument used to achieve these GHG emission reductions is a cap-and-trade programme managed by CARB. The programme covers electricity generators and large industrial facilities since 2013, and distributors of transportation, natural gas, and other fuels since 2015 (California Air Resources Board, 2015[121]).

As part of this programme, an offset credit scheme, allows companies to cover a share of their emissions by credit offset purchases. Up to 8% of the compliance obligation of capped companies can be met with offset credits until 2020, down to 4% for the period 2021-25, and 6% over 2026-30. Emission-reduction projects should be located in the United States and starting from 2021 half of the offsets purchased should come from projects located within the state of California (International Carbon Action Partnership, 2020[122]).

The project areas relevant to agriculture for which offset protocols have been developed include livestock projects, rice cultivation projects, and grassland management projects (California Air Resources Board, 2020[123]). Since 2014, more than 80 livestock digesters compliance projects have been completed, generating 4.8 million offset credits.[15] A further 1.7 million offset credits have been generated by early action projects (California Air Resources Board, 2020[123]).[16] Since 2015, CARB allows credits issued for the production of vehicle fuel derived from biogas under the Low Carbon Fuel Standard (LCFS), California's cap and trade scheme for transportation fuels, to count toward avoided dairy CH_4 emissions, using the Livestock Offset Protocol. These credits have dramatically increased the financial viability of anaerobic digester investments – with CARB offset credits worth only one tenth of the value of LCFS credits (Hyunok and Sumner, 2018[124]).[17] However, fuels produced using manure types not included in the protocol (poultry and beef cattle manure for instance) do not qualify.

The offset scheme also delivers emissions reductions from LULUCF. The US Forest Protocol quantifies GHG emission reductions achieved by projects that increase and/or conserve forest carbon stocks (California Air Resources Board, 2015[125]). As of January 2020, 135.69 million compliance offset credits had been issued across the United States under the US Forest Protocol (California Air Resources Board, 2020[126]).[18]

Senate Bill No. 1383 on Climate Short-Lived Pollutants (SB 1383)

Senate Bill No. 1383 on Climate Short-Lived Pollutants (SB 1383) directly targets emissions reductions in the agricultural sector. SB 1383 sets state-wide 2030 emission reduction targets for methane, anthropogenic black carbon, and hydrofluorocarbons gases. In particular, SB 1383 sets the target of cutting dairy and other livestock manure-sourced CH_4 emissions by 40% by 2030 (from 2013 levels). The regulation will be phased in at the beginning of 2024, however, monitoring and reporting of manure-based CH_4 emissions could start by 2020.

The first short-lived climate pollutant (SLCP) reduction strategy – published in 2017 – provides specific direction for CH_4 emission reductions from dairy and livestock manure operations. It focuses on the modification of manure management practices, which will be encouraged through financial incentives, collaboration with industry to overcome technical, market and regulatory barriers as well as market support measures. In particular, SB 1383 calls on CARB to establish energy infrastructure development and

[15] An offset credit is equivalent to a GHG reduction or GHG removal enhancement of one metric tonne of CO2eq.

[16] Voluntary offset projects issued offset credits by approved voluntary registries for GHG reductions between 1 January 2005 and 31 December 2014 that are eligible to be issued CARB offset credits

[17] The price differential between ARB and LCFS credits can mainly be explained by their links to different schemes.

[18] This figure includes 24.96 million in California, 14.6 million in Washington, 10.92 million in Arizona, and 11.38 million in West Virginia (California Air Resources Board, 2020[126]).

procurement policies to encourage dairy biomethane projects and calls on the California Public Utilities Commission (CPUC) to direct gas companies to implement five dairy biomethane pipeline injection pilot projects. CARB is also required to develop a pilot financial mechanism to reduce the value uncertainty of LCFS offset credits from dairy-related projects and to expand the mechanism to other biogas sources. The California Department of Food and Agriculture (CDFA) estimates that at least USD 100 million/year will be needed over the period 2019-24 to support the development of necessary manure management infrastructure in the form of grants, loans and other incentives (California Air Resources Board, 2017[117]).

Other policies with relevance to GHG mitigation in AFOLU

Agricultural investment programmes also deliver emission reductions in California. Proceeds from the cap-and-trade auction, have been used to support a wide range of programmes, many of which contribute to GHG mitigation and deliver other economic, environmental and social benefits. The Legislature allocates money from the Greenhouse Gas Reduction Fund (GGRF) to state agencies for the implementation of these GHG-reduction programmes. GGRF revenue currently funds a number of climate smart agriculture programmes, which are managed by the CDFA.

First, the Alternative Manure Management Program (AMMP) provides financial assistance to California dairy and livestock operations for the implementation of non-digester manure management practices that reduce CH_4 emissions and generate other environmental co-benefits. So far, fifty-eight AMMP projects have been funded for a total of USD 31.2 million. These projects are expected to reduce GHG emissions by 716 800 tonnes of CO_2eq over a 5-year period (CDFA, 2020[127]). The CDFA made between USD 19-33 million available for AMMP projects in 2019.

The CDFA also awards grants for the installation of dairy digesters in California that result in long-term CH_4 emission reductions under the Dairy Digester Research and Development Program (DDRDP). Projects must use methane for renewable energy production or transportation fuel. Since 2017, significant GGFR revenues have been allocated to the DDRDP, with funding in the order of USD 61-75 million available for 2019 (CDFA, 2020[127]). Current DDRDP projects are expected to lead to a reduction in GHG emissions of 12.9 Mt of CO_2eq (CDFA, 2020[128]). The AMMP and DDRDP will support the 40% reduction target for manure-sourced CH_4 emissions set by the SB 1383.

The Healthy Soils Program is another climate smart agriculture programme supported by the proceeds of California's cap and trade system. It provides financial incentives to California farmers and ranchers for the implementation of agricultural management practices that sequester carbon, reduce GHG emissions and improve soil health (e.g. crops, compost, mulch, and hedgerow plantings). Since its launch in 2017, USD 17.8 million has been awarded in grants for 317 projects. USD 28 million was allocated for the programme for 2019-20 (CalCAN, 2020[129]).

The cap and trade scheme revenue also supports the Sustainable Agricultural Lands Conservation programme, which focuses on GHG emissions reduction associated with the conservation of agricultural lands by protecting at-risk agricultural lands from sprawl development. Since 2015, USD 124 million has been invested in 60 easement projects, protecting 90 000 acres of farm and rangeland at risk of urban sprawl or rural ranchette development. This programme could cut GHG emissions by 47 Mt over 30 years (California Climate and Agricultural Network, 2019[130]).

Research programmes

In addition to the aforementioned federal research programmes, a number of research projects with implications for GHG mitigation in AFOLU are undertaken at state level. Many of these projects are funded by the CDFA. The Fertilizer Research and Education Program (FREP) provides funding for basic and applied research, education, training and outreach on nutrient and water management practices. Since its creation in 1990, FREP has invested over USD 17 million in more than 220 research and education

projects. The majority of projects target nutrient or irrigation management, and have led to the development of nitrogen fertilisation models for crops, a nitrogen and water management production guide for coastal vegetables, and best management practices for fertiliser and water use in irrigated agriculture. By promoting improved fertiliser use among farmers this programme can contribute to N_2O emission reductions (CDFA, 2020[131]).

The CDFA also supports research projects that address GHG mitigation through its Specialty Crop Block Grant Program (SCBGP). Results of funded research projects provide knowledge and tools to help growers reduce GHG emissions and increase carbon sequestration (CDFA, 2018[132]).

In 2018, CDFA awarded a USD 213 349 research grant to the California Dairy Research Foundation in collaboration with the University of California to study CH_4 emission reduction strategies at California dairies (CDFA, 2018[133]). The research project focuses on understanding the differences in manure management and CH_4 emissions strategies between large and small dairies. Researchers will also examine cost-saving techniques, evaluate emerging technologies, and investigate the economic impacts of methane regulations on California dairy farms. This research project will provide important knowledge to help achieve the 40% CH_4 emission reduction target set by SB 1383 (Dairy and Livestock Subgroup #3, 2018[134]).

4. Oceania

4.1. Australia

Background on GHG emissions in AFOLU

The agricultural sector in Australia generated 75.6 $MtCO_2eq$ of GHG emissions in 2017, accounting for 13.6% of national emissions (including LULUCF).The majority of agriculture's emissions were CH_4 from enteric fermentation (69%), followed by N_2O from agricultural soils (19%), then CH_4 and N_2O from manure management (10%). Agricultural emissions declined by 11% between 1990 and 2018, driven by a 20% reduction in emissions from enteric fermentation over this period, although emissions from this source increased by 0.2% between 2017 and 2018. In contrast, manure emissions increased by 12.3% from 1990 to 2018, as a consequence of strong growth in the cattle feedlot industry. N_2O emissions from agricultural soils grew by 10% over this period, due to an increase in the use of fertiliser and the retention of crop residues (Department of Industry, Science, Energy and Reources, 2020[135])

The LULUCF sector was a net sink of -20.6 $MtCO_2eq$ in 2018. The forestland category is estimated to have contributed net removals of -57 $MtCO_2eq$ in 2018. Croplands were a small net sink (-1.5 $MtCO_2eq$) while grasslands were a relatively large net source (37 $MtCO_2eq$) in 2018. Between 1990 and 2018, net emissions from LULUCF fell from 192.7 $MtCO_2eq$ to -20.6 $MtCO_2eq$, mainly due to a decline in the conversion of forest to cropland and grassland, and forest regrowth (Department of Industry, Science, Energy and Resources, 2020[136]).

Nationally determined contributions

Australia committed to an economy-wide reduction in its annual greenhouse gas emissions of 26-28% below 2005 levels by 2030, in its NDC submitted to the UNFCCC in 2015 (Australian Government, 2015[137]). All UNFCCC national inventory sectors are covered by this commitment, including the agriculture and LULUCF sectors, no sector-specific targets have been set. In 2017 the Australian Government reviewed its climate change policies so that they can be aligned with achieving Australia's 2030 target and Paris Agreement commitments. Australia is preparing its long term emissions reduction

strategy which will explore opportunities for emission reductions across all sectors of the economy, including agriculture.

4.2. National policies for mitigating GHG emissions in AFOLU

The Emission Reduction Fund

The Emission Reduction Fund (ERF) is the centrepiece of Australia's climate change mitigation efforts and directly funds abatement for a range of eligible activities, including livestock management, revegetation, savannah fire management, waste management and energy efficiency, to reduce emissions and sequester carbon (Department of Industry, Science, Energy and Resources, 2020[138]). The fundamental design of the ERF centres on developing a framework for measuring and incentivising genuine and additional abatement. While this is largely achieved through taxpayer funding of abatement undertaken voluntarily, there is evidence of the changing nature of the scheme, with other sources of demand for Australian Carbon Credit Units (ACCUs) emerging. These include State Government (such as Queensland Government's Land Restoration Fund), voluntary offsets, and entities covered under the safeguard mechanism (see below). The ERF was equipped with a budget of AUD 2.55 billion in 2014. Established in 2019, the AUD 2 billion Climate Solutions Fund (CSF) funds the continuation of the ERF, among other initiatives, and aims to deliver step change to the offset market in Australia by boosting the supply of carbon units.

Landowners and farmers who adopt abatement projects using approved ERF methods can generate ACCUs,[19] which can be sold, either to the government through a competitive reverse auction or to third parties, to provide alternative or additional income streams. The methods approved under the ERF must meet strict integrity requirements including the demonstration of additionality. The ERF also includes a safeguard mechanism that aims to ensure that emission reductions purchased through the ERF are not offset by increased emissions elsewhere in the economy. The safeguard mechanism covers large non-agricultural emitters and is enforceable by the Clean Energy Regulator (Australian Government, 2019[139]).

Between April 2015 and March 2020, the ERF contracted a total abatement portfolio of 193 $MtCO_2eq$ across all ERF sectors[20] over ten auctions, with the average price per tonne of abatement across all auctions ranging between AUD 10 and AUD 16 t CO_2eq [1] (Clean Energy Regulator, 2020[140]). Of this total portfolio, 14.9 $MtCO_2eq$ were contracted in the agricultural sector. Some of this is from projects for reducing agricultural non-CO_2 emissions (destruction of methane from manure in piggeries and dairy facilities), however, the overwhelming majority of the contracted abatement is from sequestering carbon in soils in grazing systems, which is part of the LULUCF inventory sector. Most of the contracted abatement is still scheduled to be delivered, which explains most of the discrepancy between total contracted abatement and abatement delivered (Table 5).

The ACCUs issued include delivery from government-contracted projects and registered projects without a contract. Businesses can register a project, start their abatement activity and begin earning ACCUs before entering into a contract with the government through the auction process. Some registered projects may never win a government contract and will instead seek sale of their ACCUs to non-government sources of demand. This includes other firms covered by the safeguard mechanism, along with secondary market purchasers such as entities with ERF contracts that source ACCUs to help deliver on their contracts (Clean Energy Regulator, 2020[141]). Furthermore, the total amount of abatement under registered projects exceeds the contracted amount. For instance, of the total 55.73 $MtCO_2eq$ of ACCUs issued by 31 October

[19] Each ACCU issued represents one tonne of carbon dioxide equivalent (tCO_2-e) stored or avoided by a project.

[20] Agriculture; vegetation management; energy efficiency; mining, oil and gas; industrial facilities; transport; waste and waste water.

2018, 36.75 $MtCO_2eq$ (exactly two-thirds) were from contracted projects, with the rest from registered but uncontracted projects.

Table 5. Australia's Emission Reduction Fund agriculture projects and abatement

Method	Registered projects	Contracted projects	Contracted abatement (ACCUs in thousands, representing $ktCO_2eq$)	Abatement delivered (ACCUs issued, in thousands)
Beef cattle herd management	5	1	184	177
Destruction of methane biodigesters (piggeries)	1	1	35	17
Destruction of methane from manure in covered ponds (dairy)	1	0	0	0
Destruction of methane from manure in piggeries	13	9	874	648
Sequestering carbon in soils in grazing systems	43	9	13 325	1.9
Measurement of soil carbon sequestration in agricultural systems	6	2	500	0
Total	**69**	**22**	**14 918**	**844**

Note: While projects are required to associate an ERF method with an abatement contract at the time of contracting, ACCUs can be delivered from other project types to fulfil contract obligations.
Source: Clean Energy Regulator, Australian Government (2020).

A further 129.89 $MtCO_2eq$ was contracted in land vegetation projects, with a breakdown of project types provided in Table 6. Many of these projects were undertaken on land used for agricultural production, although none of the abatement contributes directly to the reduction of agricultural emissions in Australia's national GHG inventory.

Table 6. Australia's Emission Reduction Fund vegetation projects and abatement

Method	Registered projects	Contracted projects	Contracted abatement (ACCUs in thousands, representing $ktCO_2eq$)	Abatement delivered (ACCUs issued, in thousand)
Avoided Deforestation	60	56	26 182	18 731
Designated Verified Carbon Standard Projects	2	1	772	521
Avoided Clearing of Native Regrowth	3	2	354	283
Reforestation and Afforestation	19	7	931	1 386
Human-Induced Regeneration of a Permanent Even-Aged Native Forest – 1.1	267	189	95 355	18 356
Measurement Based Methods for New Farm Forestry Plantations	2	0	0	95
Native Forest from Managed Regrowth	36	16	3 473	2 559
Quantifying Carbon Sequestration by Permanent Mallee Plantings using the Reforestation Modelling Tool	1	0	0	0
Reforestation by Environmental or Mallee Plantings – FullCAM	32	5	1 819	369
Plantation Forestry	21	9	981	19
Quantifying Carbon Sequestration by Permanent Environmental Plantings of Native Species using the CFI Reforestation Modelling Tool	11	0	21	40
	454	**285**	**129 886**	**42 359**

Note: While projects are required to associate an ERF method with an abatement contract at the time of contracting, ACCUs can be delivered from other project types to fulfil contract obligations.
Source: Clean Energy Regulator, Australian Government (2020).

There has also been 13.58 $MtCO_2eq$ of abatement contracted in savannah burning projects under the ERF. Some of the savannah fire management projects are on agricultural land, but a substantial proportion are on land managed by Indigenous land managers for other purposes (P. Ryan 2018, Department of the Environment and Energy, personal communication, 7 December, 2018).

Table 7. Australia's Emission Reduction Fund savannah fire management projects and abatement

Method	Registered projects	Contracted projects	Contracted abatement (ktCO2eq)	Abatement delivered (ACCUs issued)
Savannah fire management	75	45	13 580	7 154

Note: While projects are required to associate an ERF method with an abatement contract at the time of contracting, ACCUs can be delivered from other project types to fulfil contract obligations.
Source: Clean Energy Regulator, Australian Government (2020).

Of the 14.92 $MtCO_2eq$ of abatement contracted in agriculture projects, only 0.84 $MtCO_2eq$ has been delivered, with the remainder still scheduled for delivery. For vegetation projects, the schedule of delivery has been more rapid with 42.36 $MtCO_2eq$ of the 129.89 $MtCO_2eq$ contracted abatement already delivered, and for savannah burning 7.15 $MtCO_2eq$ of the contracted 13.58 $MtCO_2eq$ have been delivered.

Other policies with relevance to GHG mitigation in AFOLU

A number of other programmes, which do not include GHG mitigation as a core objective, help reduce GHG emissions in the AFOLU sector. Agriculture ministers committed to a co-ordinated national approach to agriculture and climate change in October 2019. A work programme that builds on the work already being undertaken by industry and governments across Australia was proposed to help the sector adapt to climate change and manage emissions. The programme will focus on four priorities: i) delivering information and tools for better decisions and risk management, ii) driving research and innovation to support adaptation and mitigation, iii) strengthening market opportunities and business models to build resilience, and iv) preparing for increasing biosecurity risks as the risk of pest, disease and weed incursions change (Department of Agriculture, Water and the Environment, 2020[142]).

The National Landcare Program is a large-scale voluntary programme designed to improve natural resource management, agricultural sustainability and biodiversity outcomes. Specific issues tackled by the programme include land and soil degradation, vegetation loss, pests, and water and fire management. The Australian Government invested AUD 1 billion in the programme from July 2014 to June 2018 and will invest a further AUD 1 billion in the next phase from July 2018 to June 2023 (Australian Government, 2019[143]). This includes AUD 450 million for the Regional Land Partnerships programme, which aims to deliver six outcomes including reduction of threats to Ramsar sites; threatened species management; invasive species management; soil, biodiversity and vegetation management; and adaptation to climate change (Australian Government, 2017[144]). Although these outcomes do not directly involve the mitigation of GHG emissions, activities that improve soil management could have soil carbon sequestration benefits.

National agencies and programmes also encourage sector-wide investment in energy efficiency and renewable energy, which can lead to a reduction of energy-related emissions from agriculture. For example, the Clean Energy Finance Corporation (CEFC) is an independent Australian Government agency working to increase commercial investment in renewable energy, low-emissions and energy efficiency projects and technologies (Department of Agriculture, Water and the Environment, 2020[145]). The CEFC invests in projects in a number of sectors, including the agriculture sector. Agricultural projects include investments in lower emissions farm equipment, energy efficient machinery upgrades and biomass energy from waste. The Renewable Energy Target (RET) scheme of the Australian Government also provides incentives to invest in large scale and small scale renewable energy systems (Department of Industry,

Science, Energy and Resources, 2020[146]). In addition, the Australian Renewable Energy Agency provides funding to researchers, developers and businesses that have demonstrated the feasibility and potential commercialisation of their project (ARENA, 2019[147]). Even if agricultural producers achieve high adoption rates of renewable energy technologies, the impact on overall agricultural GHGs emissions will be limited, as GHG emissions from energy use in the sector are minor compared to agricultural non-CO_2 emissions from livestock and agricultural soils in Australia.

Research programmes

The Australian Government set up and funded a number of research, development and outreach programmes for GHG mitigation in the AFOLU sector over the past decade. The main programme was the Carbon Farming Futures (CFF) programme, under which the government invested over AUD 139 million in 200 projects over the period 2012 to 2017 (Department of Agriculture, Water and the Environment, 2020[148]).

The CFF programme consisted of four components. The most significant of these, in terms of its scale and focus, was the Filling the Research Gap (FtRG) programme. FtRG supported research into emerging mitigation technologies in agriculture, practices for sequestering carbon or reducing GHG emissions from the land use sector and assisting farmers to adapt to climate change. The programme funded 88 projects worth AUD 74 million, covering: livestock methane research; manure management research; nitrous oxide research, soil carbon research, modelling and farm systems research; and adaptation research (Department of Agriculture, Water and the Environment, 2020[149]). The FtRG programme also included a national survey of land management practices, which helped provide a benchmark for methodology development and additionality testing in the ERF.

The FtRG programme built on the Climate Change Research Program (CCRP), which received AUD 46.2 million and supported more than 50 projects from 2008 to 2012. The CCRP was delivered in collaboration with industry groups, research providers, universities and state governments. Total investment under the programme, including partner contributions, amounted to AUD 130 million (Department of Agriculture, Water and the Environment, 2020[150]). Research outputs from this programme underpinned a number of methodologies applied under the Carbon Farming Initiative, the predecessor to the ERF (Department of Agriculture, Water and the Environment, 2020[150]).

Action on the Ground, the second component of the CFF programme, provided 89 grants to the value of AUD 44 million to help land managers and farmers conduct on-farm trials of on over 530 properties of abatement technologies, practices and management strategies to demonstrate how they can reduce emissions of methane and nitrous oxide or increase the sequestration of carbon in soil while maintaining or improving farm productivity (Department of Agriculture, Water and the Environment, 2020[151]). The CFF programme also included an Extension and Outreach component, which used extension services to transfer knowledge about managing GHG emissions from agriculture and other land uses. It also supported participation of land holders in the ERF. The programme funded 24 projects worth AUD 21.3 million over the period 2013 to 2017 (Department of Agriculture, Water and the Environment, 2020[152]). The final component of the CFF was the Conservation Tillage Refundable Tax Offset, which provided farmers with a 15% refundable tax offset for the purchase of conservation seeding equipment (Department of Agriculture, Water and the Environment, 2020[148]).

Australia is also a member of the GRA and the Global Methane Initiative.

Industry initiatives

Industry initiatives also help lower GHG emissions from agriculture. In 2017, Meat and Livestock Australia (MLA) commissioned the Commonwealth Scientific and Industrial Research Organisation (CSIRO) to investigate whether the Australian red meat industry could become carbon neutral by 2030 (Mayberry

et al., 2018[153]). Based on the findings of the report, in 2017 the Australian red meat and livestock industry set an ambitious target to be carbon neutral by 2030 (Beavan, 2017[154]).

Mayberry et al. (2018[153]) identified a number of pathways in which different rates of assumed effectiveness for options for reducing animal GHG emissions determined the quantity of carbon sequestration required for the industry to reach its carbon neutrality goal. The most promising mitigation options are land management (e.g. reduced deforestation, sequestration of carbon in trees from afforestation/reforestation and improved forest management, and savannah burning management), and the reduction of enteric methane with new feed additives and vaccines. Some of the mitigation options identified could potentially be eligible to generate ACCUs under the ERF. It is worth noting that no proof of concept exists yet for a methane vaccine, and other feed additives (such as the marine algae *Asparagopsis taxiformis*) are not yet commercially available.

To achieve its carbon neutrality goal the red meat industry are investing in the research and development of low emission practices, including new feed additives that reduce emissions and have productivity benefits for producers. There are also reputational benefits for the sector from achieving this goal which could deliver international and domestic marketing rewards. Nevertheless, the carbon neutrality goal would be more financially feasible to the industry if supported with additional carbon price incentives. This could come from a scaling up of the ERF and the introduction of other policy mechanisms.

The Australian dairy industry has committed to a 30% reduction of GHG emissions intensity by 2030, relative to a 2015 baseline. This objective includes a target to reduce the emissions intensity for manufacturers from a baseline level of 140 tCO_2eq per ML in 2015 to 98 7 tCO_2eq per ML by 2030 and to reduce the emissions intensity for farmers from a baseline of 1 kg CO_2eq per kg FPCM to 0.72 kg CO_2eq per kg FPCM. Potential emissions reduction pathways for both farms and dairy manufacturing have been identified and are currently being assessed. The industry is also considering adopting a goal to be carbon neutral by 2030 (Australian Dairy Industry, 2020[155]).

4.3. New Zealand

Background on GHG emissions in AFOLU

In 2018, New Zealand generated 78.86 $MtCO_2eq$ of gross GHG emissions, to which the agriculture sector was the largest sectoral contributor, accounting for 48% of these national emissions. Of the 37.7 $MtCO_2eq$ of emissions from the sector, CH_4 from enteric fermentation accounted for the largest share (74%), followed by N_2O from agricultural soils (19%). Emissions from agriculture increased by 17.1% from 1990 to 2018, largely due to an increase in N_2O emissions from agricultural soils of 2.5 $MtCO_2eq$ (57%), and an increase in CH_4 emissions from enteric fermentation of 1.39 $MtCO_2eq$ (5%). The increase has been offset partially by a 52.9% reduction in the sheep flock and a 19.1% reduction in the non-dairy cattle herd since 1990 (Ministry for the Environment, 2020[156]). However, despite increased production, agricultural emissions have plateaued since 2006 due to improved emissions intensity of New Zealand products.

In contrast to agriculture, the LULUCF sector was a net emissions sink of -23.39 $MtCO_2eq$ in 2018, offsetting 30% of the country's gross emissions. Forest land was a net sink and contributed -16.91 $MtCO_2eq$. Harvested wood products contributed a further -10.75 $MtCO_2eq$. Croplands were a minor net source, while grasslands were a relatively large source, contributing 3.7 $MtCO_2eq$ in 2018 (Ministry for the Environment, 2020[156]).

Nationally determined contributions

New Zealand committed to an economy-wide reduction in its GHG emissions of 30% below 2005 levels by 2030, in its Nationally Determined Contribution submitted to the UNFCCC in 2016. All UNFCCC national

inventory sectors are covered by this commitment, including the agriculture and LULUCF sectors, although sector-specific targets are not specified within this submission.[21]

National policies for mitigating GHG emissions in AFOLU

Zero Carbon Act

In November 2019, the New Zealand Government passed the Climate Change Response (Zero Carbon) Amendment Act as an amendment to the Climate Change Response Act 2002 (Ministry for the Environment, 2019[157]). The Act will set the framework for New Zealand's transition to a low emission and climate resilient economy. It proposes legislating for separate long-term emission reduction targets for long-lived and short-lived GHGs; including a target for biogenic methane. Biogenic methane emissions refer to methane emissions produced by the agriculture and waste sectors. In particular, the Zero Carbon Act sets targets to:

- Reduce all GHG emissions[22] (except biogenic methane) to net zero by 2050.
- Reduce gross biogenic methane emissions by 10% by 2030 and by at least 24% to 47% by 2050 (below 2017 levels).

These targets are consistent with the Paris Agreement's objective of limiting global warming to 1.5°C above pre-industrial temperature levels. Emission budgets covering five-year periods will be set in order to meet the 2050 targets. The first emission budget, however, will cover the period from 2022 to 2025.

The Ministry for the Environment and the Ministry for Primary Industries will provide advice to Ministers on policies for achieving these emissions targets. This is especially important if the agriculture sector is to achieve the targeted gross reduction in methane emissions as the Act requires biogenic methane emissions to fall. They cannot be offset by removals from the LULUCF sector (MacLachlan, 2019[158]).

Policies for mitigating GHG emissions in agriculture

The New Zealand Emissions Trading Scheme (NZ ETS) is the main tool for achieving the GHG emission targets set under the Zero Carbon Act. The NZ ETS covers all sectors of the economy. Importantly, however, the agricultural sector is required to report on its major emission sources (i.e. CH_4 emissions from ruminants, and N_2O emissions from soils and the use of nitrogenous fertilisers), but is not required to surrender units for these emissions (Ministry for the Environment, 2017[159]).[23]

The Interim Climate Change Committee (ICCC), an independent group of experts established in May 2018, was tasked with exploring policies to reduce agricultural GHG emissions. Based on the ICCC's recommendations, the New Zealand Government consulted on policy options for pricing GHG emissions from agriculture.

Following this consultation, the government decided to price agricultural emissions from 2025. Pricing will be at farm level for livestock and at processor level for fertiliser. The government and the agricultural sector are now working in partnership towards developing a system for farm-level pricing by 2025. The independent Climate Change Commission will assess progress in 2022 and if commitments are not being met, the government can bring the sector into the ETS at processor level before 2025. Mandatory farm-

[21] The approach for accounting for the forestry and other land use sector outlined in New Zealand's NDC builds on experience with accounting under the Kyoto Protocol to ensure consistency and focus on additional action.

[22] Include carbon dioxide, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride, and nitrogen trifluoride.

[23] The following sectors have obligation to surrender units for the reported emissions: forestry, industrial processes, synthetic gases, waste, liquid fossil fuels, stationary energy.

level reporting obligations of livestock emissions in the NZ ETS will apply to 2024 emissions onward (Ministry for the Environment, 2019[160]).

These decisions were included in the Climate Change Response (Emissions Trading Reform) Amendment Bill, introduced to Parliament in October 2019 (Ministry for Environment, 2020[161]). It is expected that the Bill will be enacted in 2020. This bill will amend the current Climate Change Response Act 2002.

Policies for mitigating GHG emissions in LULUCF

The NZ ETS is also the main policy instrument to encourage afforestation and reduce deforestation for climate mitigation purposes. Forest offsets play an important role in helping New Zealand meet its emission reduction targets, as they provide a low-cost option for CO_2 removals (Ministry for the Environment, 2019[162]).

Under the NZ ETS, forests are defined as "post-1989 forest land" or "pre-1990 forest land". Post-1989 forests[24] may be voluntarily registered into the ETS and are eligible to earn emissions units that represent the carbon sequestered by the forest since the start of that mandatory emissions return period (MERP) (a five-year period defined in legislation, the current is 2018-22[25]), but are also liable to repay units if there is a reduction in carbon stock (Te Uru Rākau, 2015[163]).[26] As of June 2018, 50% of post-1989 forest land (approximately 325 000 hectares of 690 000 hectares) had been registered in the NZ ETS (Te Uru Rākau, 2019[164]). In addition, the majority of landowners with exotic forest land defined as "pre-1990 forest land"[27] (approximately 1 440 000 ha) face deforestation liabilities under the NZ ETS (Te Uru Rākau, 2020[165]). There are no liabilities or entitlements for BAU forest harvest and replanting. Between 2016 and 2030, forest offsets are expected to lead to the sequestration of an additional 46.3 $MtCO_2eq$ from the atmosphere (Ministry for the Environment, 2017[159]).

The government conducted a review of the NZ ETS between 2015 and 2019, including of changes and improvements to the scheme for forestry participants. It announced decisions to apply a new accounting approach to forests registered from 2021 called "averaging", which reduces the cost and complexity for forest owners from their participation in the NZ ETS and increases the units they are able to trade at low risk on the market (Jones and Shaw, 2019[166]). Averaging improvements are expected to increase incentives for participation in the ETS and will help drive planting under the One Billion Trees programme (Te Uru Rākau, 2018[167]).

Permanent forestry will also be introduced from 2021. Post-1989 forestry will be registered in the NZ ETS for 50 years, and clear-felling will be prohibited during this period. Forest owners in breach of this requirement will need to pay a penalty linked to the value of the cleared land and surrender carbon units for the emissions resulting from clear-felling (Ministry for Primary Industries, 2020[168]). Changes to the ETS will see an extra 45 $MtCO_2$ stored in New Zealand's forests (Jones and Shaw, 2019[166]).

Other policies with relevance to GHG mitigation in AFOLU

Policies with broader sustainability objectives, such as soil, water, or natural resource management, may also deliver emissions reductions in New Zealand's AFOLU sector. The National Policy Statement for Freshwater Management (NPS-FM) was introduced in 2011, and has been revised in 2014 and 2017. It

[24] Post-1989 forests are those established on land which was not forest on 31 December 1989 and has subsequently become forest. It also includes the forests on deforested pre-1990 forest.

[25] The amendments discussed in paragraph 201 include a special 'mini-MERP' (from 2023 to 2025) to align the ETS forestry reporting with New Zealand's targets under the Paris Agreement.

[26] Te Uru Rākau is New Zealand's forestry agency.

[27] Pre-1990 forests are areas of forest which where forest on 31 December 1989 and predominantly exotic forest on 31 December 2007.

provides national policy direction to regional councils on freshwater management to improve freshwater quality in New Zealand. The NPS-FM sets a number of requirements that are likely to result in a decrease in agricultural emissions. These include (Ministry for the Environment, 2017[169]):

- Caps on nutrient (nitrogen and phosphorus) discharge.
- The implementation of good farm management practices such as manure and fertiliser management and the establishment of fencing and riparian buffers near streams.
- The use of nutrient management tools to optimise productivity and reduce environmental impacts.

These measures are expected to reduce agricultural emissions by placing additional pressure on agricultural production, livestock numbers and land use, and incentivising practices that reduce nitrogen losses (such as the reduction in fertiliser application). The implementation of the NPS-FM could lead to a reduction in agricultural emissions of (N_2O and CH_4) of 7.3 $MtCO_2eq$ between 2016 and 2030 (Ministry for the Environment, 2017[159]). The government recently (October 2019) completed a consultation on changes to the management of freshwater naturally and updating the NPS-FM (Ministry for the Environment, 2019[170]). A number of the proposed requirements could have implications for AFOLU emissions, including improving wetlands protection, limiting agricultural intensification and improving farm management practices.

Measures implemented under the Sustainable Land Management Hill Country Erosion Programme (HCEP) and the One Billion Trees Programme can also help lower GHG emissions in the LULUCF sector. The HCEP aims to protect New Zealand's estimated 1.4 million hectares of pastoral hill country classified as erosion prone. It provides funding to regional councils for the development of four-year erosion control projects. A total of NZD 35.8 million has been approved for the period 2019-23 (Te Uru Rākau, 2020[171]). Selected projects include: the development of whole farm plans to manage erosion on farms with highly erodible land, the development of agroforestry plans, poplar and willow planting, land retirement from production to revert to native bush, and soil conservation and sustainable land management programmes. Although the main purpose of the HCEP is to reduce erosion, it also contributes to the sequestration of carbon in small-scale forests and through planting of poplars and willows. Between 2016 and 2030, these measures will result in the sequestration of an estimated additional 2.3 $MtCO_2eq$ from the atmosphere (Ministry for the Environment, 2017[169]).

The One Billion Trees Programme, replacing the Afforestation Grant Scheme (2008-20), aims to increase the current rate of tree planting to achieve a standing stock of at least one billion trees by 2028 (Te Uru Rākau, 2020[172]). Through its objectives of protecting soil, water and natural resources, increasing biodiversity and enhancing natural landscapes, and optimising land use, the One Billion Trees programme encourages activities that can result in increased carbon sequestration and a reduction in LULUCF emissions (Te Uru Rākau, 2020[172]). Specifically, the programme provides direct grants to landowners as well as partnership grants towards the cost of planting and establishing trees within existing land uses and native tree regeneration. The Government has allocated NZD 120 million through the One Billion Trees Fund for direct grants to landowners; two-thirds of which targets native tree planting (Te Uru Rākau, 2020[172]). The programme also provides incentives to integrate trees on farmland, which can deliver further mitigation benefits. (Te Uru Rākau, 2018[173]).

Research programmes

New Zealand invests in a number of R&D programmes, which explore the costs and benefits associated with different mitigation options, and develop innovative mitigation technologies and practices for the agriculture and LULUCF sectors.

The New Zealand Agricultural Greenhouse Gas Research Centre is a partnership of nine New Zealand research organisations that focuses on developing technologies and practices for reducing the full suite of GHGs generated by agriculture. It also co-ordinates New Zealand's research into agricultural GHG emissions mitigation. It receives NZD 4.8 million per year (NZD 45 million over 2009-19) and was established in 2009 (NZAGRC, 2017[174]).

Established in 2002, the Pastoral Greenhouse Gas Research Consortium is a consortium of agricultural industry organisations, in partnership with the NZL government, investing in research to develop mitigation solutions in the agricultural sector. It focuses on technologies to reduce CH_4 emissions from enteric fermentation, but also funds N_2O research, and is leading the commercialisation of the methane vaccine and methane inhibitor. It receives NZD 5.4 million per year in funding (NZD 37.8 million over 2013-19) (NZAGRC, 2017[174]).

The Sustainable Land Management and Climate Change research programme, established in 2007, is a research fund addressing policy relevant questions in both the agricultural and forestry sectors. These include climate change adaptation and mitigation, forest sinks and cross cutting issues relevant to the agriculture and forestry industries. It receives NZD 2.5 million of funding per year (NZAGRC, 2017[174]).

The Biological Emissions Reference Group, established in 2016, brought together representatives from agricultural sector organisations and government agencies for a limited period. The main objective of the group was to build evidence on opportunities for reducing CH_4 and N_2O emissions from New Zealand agriculture, and to explore the costs, benefits and potential barriers associated with these opportunities.

The New Zealand Government also initiated the Global Research Alliance on Agricultural Greenhouse Gases in 2009, and continues to contribute to this international research programme, The New Zealand Government has so far committed NZD 65 million to the alliance (NZAGRC, 2017[174]).

Industry initiatives

The Dairy Action for Climate Change initiative, established in 2017, was led by the dairy industry, with support from the Ministries of Environment and Primary Industries. The initiative aimed to develop a framework to address CH_4 and N_2O emissions in the dairy sector and contribute to meeting New Zealand's first NDC (DairyNZ, 2017[175]). As part of this initiative, partners committed to work together to:

- Raise farmer and wider industry awareness about the challenges posed by climate change and the available mitigation options through GHG training courses, workshops, and farmers discussion groups.
- Demonstrate opportunities for emission reductions through the implementation of good farm management practices, and support farmers with on-farm changes to address their emissions.
- Test an on-farm GHG recording system as an advisory tool for the dairy industry.

Furthermore, in 2019, primary sector leaders from across the agricultural, horticultural and arable sectors came together to develop the Primary Sector Climate Change Commitment, a five-year plan to support and accelerate the actions necessary to reduce agricultural emissions. The statement outlines the sector's commitment to tackle climate change and provides a set of actions to be taken in partnership with the government. The proposed five-year programme of action aims to ensure farmers and growers are equipped with the knowledge and tools they need to deliver emissions reductions while maintaining profitability. The sector is committed to investing its own resources to develop, implement and support the programme of action. More than NZD 25 million per annum has already been mobilised by the sector for investment in actions to mitigate and adapt to climate change (Beef & Lamb NZ et al., 2019[176]).

5. South America

5.1. Brazil

Background on GHG emissions in AFOLU

According to the UNFCCC GHG database, agriculture generated 429 $MtCO_2eq$ of emissions in 2015 (24% of total national emissions if LULUCF is considered in total emissions, 42% if national emissions excluding LULUCF emissions, 24% including), with most of these emissions coming from CH_4 from enteric fermentation (57%), N_2O from agricultural soils (35%), and manure management (4%). Agricultural emissions increased by 49% over the period 1990-2012 (UNFCCC, 2019[31]).

Total agricultural emissions of 451 $MtCO_2eq$ in 2015 are reported in the FAOSTAT database, with comparable contributions from different sources within agriculture. There was a marginal increase in total agricultural emissions in 2016 (FAOSTAT, 2019[1]).

The LULUCF category was a source of 293 $MtCO_2eq$ of emissions in 2015 (22% of national emissions including LULUCF), down by 61% compared to 1990 according to the UNFCCC GHG database (UNFCCC, 2019[31]). FAOSTAT report higher emissions of 325 $MtCO_2eq$ in 2015, mainly due to the inclusion of 31 $MtCO_2eq$ of emissions from the burning of biomass in the FAOSTAT database. From this category, 90.3% of the emissions are from forest land, driven primarily by deforestation. Much of the remaining emissions come from biomass burning, which contributes 9.6% of LULUCF emissions (FAOSTAT, 2019[2]).

Nationally determined contributions

Brazil committed to an economy-wide reduction in its GHG emissions of 37% below 2005 levels by 2025, along with an indicative pledge to reduce emissions by 43% below 2005 levels by 2030 in its NDC submitted to the UNFCCC in 2016. All UNFCCC national inventory sectors are covered by this commitment, including the agriculture and LULUCF sectors.

Although sector-specific mitigation targets have not been set, Brazil's NDC is more detailed than most other NDCs, in that it identifies a list of actions, including the strengthening of some national policy measures, to support mitigation in the agriculture and LULUCF sectors. For agriculture, Brazil expressed its intention to strengthen the Low Carbon Emission Agriculture (ABC) Plan as the main strategy for sustainable agriculture development, by restoring 15 million hectares of degraded pasture lands, in addition to what has already been achieved under the Plan and enhancing 5 million hectares of integrated cropland-livestock-forestry systems by, both 2030.

Brazil considers large scale measures relating to land use change and forests as one of the main channels for achieving the overall reduction in national emissions outlined in its NDC. Specific actions include strengthening and enforcing implementation of the Forest Code, along with other policies to reduce deforestation (including the goal of zero illegal deforestation in the Amazon by 2030) and to promote reforestation (e.g. restoring and reforesting 12 million hectares of forests by 2030). These policies are described in the following section.

National policies for mitigating GHG emissions in AFOLU

Mitigation policy framework

Most of the policies and measures used to achieve the mitigation targets for the agricultural and LULUCF sectors established in Brazil's NDC are carried out under the National Policy on Climate Change (NPCC) and the Forest Code.

At the 15th COP to the UNFCCC in Copenhagen in 2009, Brazil voluntarily agreed to reduce its national GHG emissions by 36.1-38.9% by 2020 in relation to a baseline scenario. Following this, Brazil communicated its Nationally Appropriate Mitigation Actions (NAMAs), which set out specific actions to deliver this overall reduction in emissions (Gebara and Thuault, 2013[177]). Brazil instituted these goals in Law No. 12.187/2009, establishing its NPCC, which sets out sector-based emission reduction targets. These include a reduction in agricultural GHG emissions of 5-6% by 2020, and a reduction of GHG emissions of 24.7% from the LULUCF sector (compared to projected BAU emissions in 2020).

In December 2010, the Brazilian Government approved Decree 7.390, which regulates the NPCC. It states that the 2020 targets will be achieved through sectoral plans and initiatives. For the agricultural and LULUCF sectors, these include: a) the Low Carbon Emission Agriculture Plan (ABC Plan); b) the Action Plan to Prevent and Control Deforestation in the Amazon (PPCDAm); and c) the Action Plan to Prevent and Control Deforestation and Fire in the Brazilian Cerrado (PPCerrado).

National policies for mitigating GHG emissions on agricultural land

Adaptation and Low Carbon Emission Agriculture (ABC) Plan

Launched in 2010, the ABC Plan integrates the sectoral plans and targets set by Brazil in its NAMAs and its NPCC. The main objective of this plan is to promote sustainable development, reduce CO_2, CH_4 and N_2O emissions and increase carbon removals from agriculture, and increase the resilience and adaptive capacity of agricultural systems. The ABC Plan provides resources and incentives for farmers to adopt sustainable agricultural practices and technologies. It also establishes a support component for training technicians and farmers, financing for R&D, and monitoring of activities and results (Marques de Magalhães and Lunas Lima, 2014[178]). The Plan's goals include rehabilitating 15 million hectares of degraded pastures and increasing the area under zero tillage from 25 million hectares to 33 million hectares by 2020. Overall, the Plan aims to cut GHG emissions by 133.9-162.9 $MtCO_2eq$ by 2020.

The central instrument of the ABC Plan is the ABC Programme, which provides low-interest loans to farmers who want to implement sustainable agricultural practices. Eligible practices include no-till agriculture, restoration of degraded pasture, planting of commercial forests, biological nitrogen fixation, treatment of animal wastes, and integrated production of crops, livestock and forest.

A total of BRL 197 billion was allocated to the ABC Plan over the period 2010-20, of which BRL 157 billion was required to be available for rural credit as part of the ABC Programme (Marques de Magalhães and Lunas Lima, 2014[178]). In its initial phase, the Programme offered credit of up to BRL 1 billion per beneficiary with an annual interest rate of 5.5% and a repayment period of 12 years, but credit conditions evolved over time (Observatório ABC, 2019[179]).

Uptake of the ABC programme was slower than anticipated in its early years, when a lack of demand resulted in the value of contracted credits being far lower than available funds. Uptake increased from 2012, and as more financial intermediaries became involved, the interest rate fell, technical capacity strengthened and dissemination of information about the programme improved (OECD, 2015[180]). Between 2010-11 and 2018-19, 61 650 ABC contracts worth a total of BRL 15.64 billion were signed, corresponding to a disbursement rate of 67%. In more recent years, funds available for ABC rural credit

have been reduced (Table 8). ABC only accounts for a small part of the total funds available for agricultural credit and subsidies as part of the federal Agricultural and Livestock Investment Plan (CEA Consulting, 2016[181]).[28] As mentioned, the government of Brazil announced that it would strengthen the ABC Plan to help achieve its 2030 NDC target. However, it is not yet clear how much additional programme credit will be made available for this purpose.

Table 8. Disbursement of ABC programme funds in Brazil, 2010-18

Period	Interest rate	Funds available (in BRL million) (a)	Value of contracted credits (in BRL million) (b)	Disbursement rate (b/a)	Number of signed contracts
2010-11	5.5%	2 000	420	21%	n.a
2011-12	5.5%	3 150	1 620	51%	4 808
2012-13	5%	3 400	3 050	90%	11 369
2013-14	5%	4 500	3 030	67%	12 103
2014-15	4.5-5%	4 500	3 660	81%	15 002
2015-16	7.5-8%	3 000	2 050	68%	6 353
2016-17	8-8.5%	2 900	1 810	62%	4 559
2017-18	7.5%	2 130	1 500		4 333
2018-19		2 000	1 630		3 123
TOTAL		25 580	18 820		61 605

Source: (Observatório ABC, 2019[179]).

A number of factors have been posited to explain the low uptake of the rural credit provided by the ABC Programme, especially in its early stages, including: a) insufficient marketing, b) excessive bureaucracy, c) producers' lack of knowledge about the potential benefits of adopting sustainable agricultural practices, d) the lack of technical assistance to train small and medium producers in sustainable agricultural practices, e) limited understanding of the programme by bank managers and producers, f) difficulty in getting access to credit, and g) too high interest rates compared to alternative programmes (Amazon Environmental Research Institute, 2012[182]).

The majority of resources available under the programme have been concentrated in the Central West and Southeast regions of the country due to the presence of a stronger technical assistance network resulting in greater interest and demand for programme funds. In contrast, the North and Northeast regions of Brazil – where there are vast expanses of degraded pastures and agricultural efficiency is relatively low - received the lowest share of ABC funds. Overall, most of ABC funds have been invested in pasture recovery (48% in 2016-17), followed by no-till farming, integrated production systems and planted forest (Observatório ABC, 2019[179])

Depending on the methodology used, between its creation in 2010 and 2018, the Plan is estimated to have reduced GHG emissions by between 106.25 and 169.93 $MtCO_2eq$ (Manzatto et al., 2020[183]). Therefore, according to this reports, between 72% and 115% of the Plan's 2020 mitigation target (average of 133.9-162.9 $MtCO_2eq$) has been achieved. These revised estimates in a government database show larger than previously reported emission reductions from animal waste management under the Plan (Minitério da Agricultura, Pecuária e Abastecimento, 2019[184]). This revision will be included in an update of the total emission reductions from the Plan that is expected to be published in late 2020.

[28] For the year 2017-18, the Agricultural and Livestock Plan allocated a total of BRL 190 billion to rural credit, of which only 1% was attributed to the ABC credit programme (i.e. BRL 2 billion). The rest supported marketing policies, rural insurance subsidy, adoption of new technologies, investment in storage facilities, etc. (Presidency of the Republic of Brazil, 2017[246]).

National policies with relevance to mitigation by forestry component of LULUCF

The Action Plan to Prevent and Control Deforestation in the Amazon (PPCDAm)

As mentioned, the PPCDAm is one of two main initiatives for achieving the 2020 NPCC goal of reducing LULUCF emissions by 24.7%. The plan was launched in 2004, when deforestation rates in the Amazon forest were growing significantly. In 2004, the deforestation rate in the Amazon reached 27 772 km^2, up from 18 165 km^2 in 2001 (Ministério do Meio Ambiente, 2018[185]).

The primary objective of the PPCDAm is to reduce deforestation and enable the transition to a sustainable development model in the Amazon. The PPCDAm's actions are structured around three pillars: i) land use, tenure and settlement planning; ii) environmental monitoring and control; and iii) promotion of sustainable production activities. The current fourth phase (2016-20) seeks to align the plan's objectives with Brazil's 2016 NDC and the Forest Code and will involve the implementation of economic and regulatory instruments to control illegal deforestation.

The PPCDAm has helped curb deforestation in the Amazon biome (Ministério do Meio Ambiente, 2018[185]). Lower rates of deforestation in the Amazon reduced land use change emissions between 2004 and 2017, and by 2017 610 $MtCO_2$ had been abated. This implies that Brazil met its NAMA target (i.e. 564 Mt reduction in CO_2 emissions through lowered deforestation in the Amazon by 2020) three years ahead of schedule (Presidency of the Republic of Brazil, 2018[186]). Most of the reduction in deforestation rates achieved under the PPCDAm during this period is attributable to command and control actions carried out under Pillar II of the programme. Declining deforestation rates in the Amazon were accompanied by increased cattle production and productivity in priority municipalities as farmers shifted investment from deforestation to capital investments in farming (Koch et al., 2019[187]).

The Action Plan to Prevent and Control Deforestation and Fire in the Brazilian Cerrado (PPCerrado)

The PPCerrado, which supports GHG mitigation in the Cerrado biome, is the second initiative through which the 2020 NPCC goal of lowering LULUCF emissions will be achieved. The Cerrado biome has experienced an extremely high rate of land conversion in recent decades, with deforestation rates surpassing those in the Amazon. By 2009, the biome had already lost 48% of its forest cover (Gebara and Thuault, 2013[177]). The clearing of vegetation is part of larger process including land speculation, illegal logging and the use of cleared land for cattle grazing and production of crops, soybean in particular (Lahsen, Bustamente and Dalla-Nora, 2016[188]). The planting rate of soy on cleared land has declined in the older frontiers in the Cerrado, but it has increased in other parts of the Cerrado (Ermgassen et al., 2020[189]). Typically, deforested areas are used for grazing and then for crop production, with direct conversion for crop production being much less common (Zaiatz et al., 2018[190]).

Launched in 2010, the PPCerrado targets a sustained reduction in the deforestation rate and a reduction in the occurrence of forest fires and burning in the Cerrado. Specifically, the plan targets a 40% reduction in deforestation by 2020 (based on the 2002-08 baseline); as set in Decree 7.390 (Gebara and Thuault, 2013[177]). The third phase was launched in December 2016 and covers the period up to 2020. As is the case under the PPDCAm, actions under the PPCerrado are grouped according to three pillars: i) monitoring and control; ii) protected areas and land use planning; and iii) the promotion of sustainable activities, including a component on environmental education.

The main achievements of the PPCerrado over the period 2010-15 were communicated before the implementation of the 3rd phase of the plan in 2016. The third pillar (i.e. promotion of sustainable activities) has been most thoroughly implemented. Activities under the other pillars have been limited by a lack of financing (Gebara and Thuault, 2013[177]).

The impact of the programme on GHG emissions has not been not monitored. However, data from the National Institute for Space Research (INPE) suggest that deforestation rates in the biome have declined since the programme was introduced. In particular, between 2016 and 2018, the annual deforestation rate in the Cerrado was more than 40% below the 2002-08 average, suggesting that Brazil may have met its NPCC target (Presidency of the Republic of Brazil, 2018[191]). In 2019, deforestation reached 6 483 km² in the biome, which is marginally lower than the 6 634 km² recorded in 2018 and was 35% lower than in 2010 when the plan was implemented (INPE, 2019[192]). This was the smallest annual deforestation area recorded in the Cerrado since the beginning of the time series.

The Forest Code

Created in 1934, and revised in 2012, the Forest Code is considered as the main environmental law in Brazil. It regulates land-use and conservation to native vegetation on private properties. In particular, it establishes two main types of lands under environmental protection: permanent protection areas, which include riparian areas, springs, hilltops, mountain slopes, and mangroves and legal reserves. The natural vegetation on permanent protection areas should be preserved, meaning that it cannot be used for farming, grazing or any other agricultural activity. A legal reserve is defined as a share of rural property, beyond permanent protection areas, which should be set aside for sustainable or conservation activities. The percentage to be held as legal reserves varies from 80% of the farm area in the Amazon to 20-35% in the Cerrado (depending on location), to 20% in the rest of Brazil (The World Bank, 2016[193]). In the Amazon, this requirement can be reduced to 50 if over 65% of the state's territory is protected by conservation units or indigenous reservations, potentially allowing the conversion of up to 15 million hectares of forest. The Forest Code has prioritised the mapping and identification of individual land holdings in forested areas and enrolling them in the national *Cadastro Ambiental Rural* (Rural Environmental Registry) system (OECD, 2020[8]). By October 2018, approximately 5.4 million properties covering 466 million hectares had been enrolled in the CAR (GIZ, n.d.[194]).

Brazil identified the enforcement of the Forest Code at federal, state and municipal levels as a key mitigation measure in its NDC. However, enforcement of the Forest Code has proved difficult. Only 6% of properties registered in the CAR had taken steps to restore illegally cleared land (OECD, 2020[8]). Inadequate enforcement of the regulation has also led to the expansion of agriculture into some areas not eligible for exploitation. If fully implemented, the Forest Code could contribute up to 1.03 $GtCO_2eq$ (i.e. 85 $MtCO_2eq\ yr^{-1}$) to the ambitious GHG emission reduction target for 2030 (Soterroni et al., 2018[11]).

Despite some initial success for the above policies in slowing deforestation of the Amazon, deforestation rates in the Amazon biome increased by almost 9% between 2017 and 2018, and by 30% between 2018 and 2019 (INPE, 2019[192]). Between August 2018 and July 2019, the INPE recorded deforestation in the Amazon of 9 762 km². This is the highest level since 2008 and is double the rate recorded in 2012 (Butler, 2019[195]). This signals the challenge ahead for Brazil in meeting its NDC goal of achieving zero illegal deforestation in the Amazon by 2030.

International policies supporting GHG mitigation in AFOLU

Brazil also participates in international initiatives that help reduce AFOLU emissions. Reducing emissions from deforestation and forest degradation (REDD+) is an international climate change mitigation mechanism developed by the UNFCCC. It creates a financial value for the carbon stored in forests by offering incentives for developing countries to reduce emissions from forest land and invest in low-carbon paths to sustainable development. The programme incentivises developing countries to maintain their forests by offering results-based payments for actions to reduce or remove forest carbon emissions. REDD+ goes beyond deforestation and forest degradation and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks (UN-REDD, 2019[196]).

Countries participating in REDD+ are required to progress through three phases, primarily associated with readiness, implementation and results-based payments. Phase 1 involves the development of a national REDD+ strategy or action plan, a national forest reference emission level and/or forest reference level, a national forest monitoring system and a safeguards information system. In the second phase, these national policies and action plans are implemented. Phase 3 involves results-based actions that must be fully measured, reported and verified (Green Climate Fund, 2018[197]).

Brazil recognises its national REDD+ strategy and the inflow of results-based payments as important instruments for the implementation of its NDC (Ministério do Meio Ambiente, 2019[198]). Brazil was the first country to voluntarily submit and have a forest reference emission level technically assessed and to submit REDD+ results in a technical annex to the Biennial Update Report for technical analysis. Brazil will also be the first country to receive results-based payments from the Green Climate Fund and will receive USD 96 million for emissions reductions of approximately 19 $MtCO_2eq$ achieved over the period 2014-15. The funding will be used to pilot an environmental service incentive programme for conservation and recovery of native vegetation (known as "Floresta+") and for strengthening the implementation of Brazil's REDD+ strategy (UNFCCC, 2019[199]).

Research programmes

Brazil also funds R&D programmes to facilitate mitigation in the AFOLU sector. The Brazilian Agricultural Research Corporation (Embrapa)—operating under the aegis of the Brazilian Ministry of Agriculture, Livestock, and Food Supply—conducts a number of research programmes that contribute to GHG mitigation in the agricultural sector. Embrapa has a climate change research portfolio with over 40 projects involving the elaboration of mitigation and adaptation strategies for agriculture, modelling of agroforestry systems, and the analysis of social, economic, and environmental risks and sustainability with respect to global climate change. In addition, Embrapa contributes to Brazil's ABC Plan carrying out scientific research on climate change and related mitigation technologies and practices. Embrapa also supports the ABC Programme through technology and knowledge transfer in collaboration with other public organisations, academics, NGOs and through public-private initiatives. These research contributions cover broad range of technologies and practices across crop and livestock sectors including their integration; improved efficiency in the use of fertilizers and nutrient use more broadly including N fixation; feed and pasture management strategies to lower CH_4 emissions from livestock; CO_2 removals; animal genetics; and life cycle analysis of bio fuels and bio products. The impacts of these technology developments and others are captured in Brazil's submissions to the UNFCCC Koronivia negotiation process and are available at the UN Submission Portal.[29] Embrapa co-ordinates the ABC Platform established as a multi-actor platform to monitor the implementation of the ABC Programme, an initiative that contributes to the objective evaluation of the national mitigation actions. In addition to the above R&D programmes for promoting low carbon tropical agriculture, Embrapa also develops technological solutions to increase the resilience of the sector and its adaptation to climate change.

Brazil also contributes to international research on GHG mitigation and is a member of the GRA and of the Global Methane Initiative, as well as of the Global Soil Partnership (GSP) and the Livestock Environmental Assessment and Performance Partnership (LEAP) of the Food and Agriculture Organization of the United Nations (FAO). The contribution from Embrapa and partner Universities and Research Institutions to the

[29] https://www4.unfccc.int/sites/SubmissionsStaging/Documents/201804111110---Submissão.Agricultura.Brasil.pdf; https://www4.unfccc.int/sites/SubmissionsStaging/Documents/201811261042---KJWA%20Brazilian%20Submission.pdf; https://www4.unfccc.int/sites/SubmissionsStaging/Documents/201905241220---Brazil-Koronivia.SB50.pdf; https://www4.unfccc.int/sites/SubmissionsStaging/Documents/201910021734---Brazil_Koronivia.pdf; https://www4.unfccc.int/sites/SubmissionsStaging/Documents/202004231918---Koronivia.Brazil.pdf; https://www4.unfccc.int/sites/SubmissionsStaging/Documents/202003311910---Brazil.%20Submission.%20.pdf.

ABC Plan, GSP, LEAP and other international programmes is a major effort to generate and use low-carbon "resource-saving" technologies capable of promoting the "sustainable intensification" of land use and agricultural production in the country. In this context, Embrapa developed the concept of "Carbon Neutral Brazilian Beef" (CNN), in 2015, represented using a science-based label for beef produced in integrated systems with a mandatory presence of a forestry component. This concept aims to support implementation of more sustainable cattle systems through introduction of trees that can offset emissions related to methane emitted by cattle. A number of variations on this label have also been created (CCN-Calf, CCN-Leather, CCN-Native tree). By developing these label protocols and licensed the use of its related commercial brand to Brazilian beef processing industries, Brazil has created a number of public-private partnerships.

Industry initiatives

A number of industry initiatives help reduce emissions in the agriculture and LULUCF sectors. The Grupo de Trabalho da Pecuária Sustentável (GTPS) (Brazilian Roundtable on Sustainable Livestock), was created in 2007 and was formally constituted in June 2009. It is formed by representatives of all actors of the cattle livestock's value chain; including producers, industries, organisations of the industry and associations, retailers, supplies and services providers, financial institutions, civil society organisations, research centres and universities. The goal of the GTPS is to discuss and formulate principles, standards and common practices for adoption by the beef cattle sector in Brazil, thereby contributing to the development of environmentally, socially and economically sustainable livestock production (Grupo de Trabalho da Pecuária Sustentável, 2012[200]).

The GTPS developed the Sustainable Livestock Indicators Guide (GIPS), an online assessment tool that enables users to test their own sustainability performance as well as that of members of their value chain. It includes sustainability indicators related to GHG emissions intensity of beef production (including emissions from land use conversion), soil conservation, water consumption, energy efficiency, waste treatment, air quality, deforestation, and compliance with the Forest Code's requirements (Brazilian Roundtable on Sustainable Livestock, 2019[201]). The GTPS disseminates information on sustainable livestock value chains through training and activities, the organisation of events and meetings, and various publications. The GTPS is part of the Global Roundtable on Sustainable Beef (GRSB), which has similar objectives and a broader global membership.

The GTPS and GRSB formed the Joint Working Group on Forests (JWG), a technical working group that focuses on engagement and collaboration to address forest-related issues in cattle supply chains. The JWG serves in an advisory role on efforts to mobilize resources to achieve zero-net deforestation by 2020. The JWG aims to understand the conditions under which cattle contribute to deforestation and barriers to improving systems ensuring deforestation-free supply chains, to secure supplies of beef and leather without encouraging deforestation, and facilitate cattle product supply chains that can be verified as being deforestation-free (Global Roundtable for Sustainable Beef, 2017[202]).

6. Asia

6.1. China

Background on GHG emissions in AFOLU

China's agricultural sector generated 830 $MtCO_2eq$ of emissions in 2014, accounting for 8% of gross national emissions. The majority of agricultural emissions were CH_4 from enteric fermentation (24%), followed by N_2O from agricultural soils (35%), CH_4 from rice cultivation (22%), and CH_4 and N_2O from

manure management (17%). Net agricultural emissions increased by 37% between 1994 and 2014 (UNFCCC, 2019[31]).

In contrast, the LULUCF sector was a net sink of -1 115 $MtCO_2eq$ in 2014, with -839.7 $MtCO_2eq$ in removals from forest land, -109.2 $MtCO_2eq$ from grassland and a further -110.6 $MtCO_2eq$ in removals from harvested wood products (Ministry of Ecology and Environment, 2018[203]; UNFCCC, 2019[31]).

Nationally determined contributions

China ratified the Paris Agreement on Climate Change on 3 September 2016. Its NDC includes a commitment to peak CO_2 emissions by 2030 at the latest and lower the carbon intensity of GDP by 60–65% below 2005 levels by 2030.

While the NDC identifies agriculture and LULUCF as sectors contributing to its economy-wide emission intensity target, no sector-specific emission reduction targets have been set. However, practice-based targets were set for some sectors and will have an impact on reducing AFOLU emissions. Such targets include an increase in the share of non-fossil fuels in total primary energy consumption to around 20%, and an increase in forest stock volume by 4.5 billion m^3, by 2030 compared to 2005 levels. The NDC also mentions the promotion of low carbon agriculture, including the goal of achieving zero growth in fertiliser and pesticide use by 2020.

Other qualitative actions for the AFOLU sector are described in the NDC, such as increased afforestation, protection of natural forests and restoration of forests and grasslands. For grasslands, this includes the management of animal stocking densities to prevent degradation as well as restoring grassland vegetation and enhance the storage of carbon in agricultural soils. Other broad objectives include the control of CH_4 emissions from rice fields and N_2O emissions from farmland, and the promotion of comprehensive utilisation of straw or reutilisation of agricultural waste (Climate Action Tracker, 2017[204]; UNFCCC, 2019[205]).

National policies for mitigating GHG emissions in AFOLU

13th Five-Year Work Plan to Control GHG Emissions

The State Council released its 13th Five-Year Work Plan in October 2016. The Work Plan for Controlling Greenhouse Gas Emissions is an important part of the 13th Five Year Plan and sets the target of reducing CO_2 emissions per GDP unit by 18% by 2020 (compared to 2015 levels); in line with China's NDC commitment (Grantham Research Institute on Climate Change and the Environment, 2016[206]). The plan looks to strengthen policies controlling for GHG emissions beyond CO_2, such as CH_4 and hydrofluorocarbons (HFCs).

The 13th Five Year Plan includes targets for the agriculture and LULUCF sectors. It aims to reduce CH_4 emissions from the agricultural sector, though a quantitative emissions reduction target has not been specified (National Development and Reform Commission, 2017[207]). It also aims to modernise agricultural production to reduce over-utilisation of land and convert 1 million hectares of marginal cropland into forest or grassland. Targets set for the LULUCF sector include an increase in forest coverage to 23.04% over the next five years, stable arable land at 124.3 million hectares by 2020 and ensuring that the grassland vegetation coverage reaches 56% by 2020 (Grantham Research Institute on Climate Change and the Environment, 2016[206]).

National Emissions Trading Scheme

The main policy mechanism being considered to mitigate national emissions, is a nation-wide emissions trading scheme that will build on existing pilot schemes. China launched its national Emissions Trading Scheme (ETS) in December 2017. Development of the ETS will involve infrastructure development and

simulation phases, before actual implementation commences (World Bank and Ecofys, 2018[208]). China has spent two years on legal and technical infrastructure construction, and will aim to carry out the first trades in 2020 (International Carbon Action Partnership, 2020[209]).

China's ETS will initially cover CO_2 emissions from the power sector, with around 1 700 companies included and covering a total of over 3 billion metric tonnes of CO_2 emissions (accounting for 37% of China's total emissions). Depending on the findings from this initial phase, the scheme could be expanded to include other sectors, including agricultural processors. However, there is no specific timeline for the inclusion of other sectors as of yet. The scheme will also include an offset mechanism. The agricultural sector is expected to be able to generate offset credits for the national ETS. As of yet, however, specific details on which GHG emissions or abatement sources from agriculture would be covered have not been provided (OECD, 2018[210]).

Other policies with relevance to GHG mitigation in AFOLU

Agriculture

Policies for mitigating GHG emissions in agriculture typically target increased fertiliser efficiency, reduced emissions from rice cultivation, and the development of agricultural biogas production.

Increasing fertiliser efficiency

Increasing fertiliser efficiency is an important policy objective in China. The intensity of chemical fertiliser use grew at an average of 2.5% per year, increasing from 265 kg per hectare in 2000 to 357 kg per hectare in 2013. This use intensity far exceeds the internationally recognised standard to limit the use of fertiliser to 225 kg per hectare (Jin and Zhou, 2018[211]). Since 2005, the Ministry of Agriculture (MOA) has promoted actions to increase fertiliser use efficiency and foster the replacement of mineral fertilisers with organic alternatives, including the development of soil test-based fertilisation across the country. By 2007, these actions had been taken in 1 200 counties to guide farmers in fertilisation, and had covered more than 1 billion Mu by the end of 2009.[30] Excessive use of nitrogen fertiliser fell by 700 000 tonnes in wheat, corn and rape growing regions in 2009 (The People's Republic of China, 2014[212]).

More recently in 2015, the MOA introduced its Action to achieve zero growth in chemical fertiliser by 2020, in line with China's NDC commitment. It targets annual growth rates of chemical fertiliser use of less than 1% from 2015 to 2019 and zero growth of chemical fertiliser use for principal crops by 2020 (Jin and Zhou, 2018[211]). The plan also aims to enhance the chemical fertiliser utilisation rate by at least 1% per year, and bring the utilisation rate of chemical fertiliser for main crops above 40% by 2020 (Jin and Zhou, 2018[211]). In 2017, the national chemical fertiliser use rate of the three major cereal crops, paddy, corn and wheat was 37.8%, 2.6 percentage points higher than in 2015, and zero growth in chemical fertiliser use was achieved three years ahead of schedule. The reduction in inputs of chemical fertilisers is equivalent to reducing nitrogen emissions by approximately 600 000 tonnes (Ministry of Agriculture of the People's Republic of China, 2017[213]).

The MOA is also targeting a 20-50% decrease in mineral fertiliser use by 2020 in fruit, vegetable and tea production areas (Bundesministerium für Wirtschaft und Energie, 2017[214]). In 2017, 100 demonstration counties were established to foster the use of digestate fertilisers. Each county provides a CNY 10 million subsidy for the implementation of the pilot project (i.e. to conduct basic investigations, for investments in facilities including treatment, transportation, application, etc.). These efforts to reduce mineral fertiliser use in China's main crops should also reduce N_2O emissions from agricultural soils.

[30] Mu is a Chinese unit of area measurement: 1 Mu = 666.7 m2.

The MOA will also provide guidance to family farms, co-operatives and leading enterprises to take the lead in reducing chemical fertiliser and pesticide use. Furthermore, it will promote scientific and technological innovation, advocate scientific and effective use of chemical fertilisers and pesticides, and advance green agricultural development by promoting financial innovation and subsidies for organic fertilisers (Ministry of Agriculture, 2018[215]).

Development of agricultural biogas production in China

Agricultural biogas production from the treatment of livestock and poultry manure, straw and agricultural processing waste can reduce manure-based CH_4 emissions and help China deliver on the objectives set out in the 13th Five Year Plan. Biogas digestate can also be used as a replacement for mineral fertiliser and reduce N_2O emissions from agricultural soils.

Two action plans support biogas development in China. The Agricultural Biogas Development plan (2017) aims to reduce China's GHG emissions by 46 $MtCO_2eq\ yr^{-1}$ by 2020 by increasing agricultural biogas and digestate fertiliser production. The MOA has set specific targets to achieve these goals (Table 9). The Bioenergy Development (2016) component of the 13th Five Year Plan aims to support bio natural gas production by establishing 160 demonstration counties by 2020. The plan sets the following targets in demonstration counties: increase solid digestate fertiliser consumption to 10 million tonnes and liquid digestate fertiliser consumption to 50 million tonnes by 2020; and bring the straw utilisation rate above 90% and livestock waste utilisation rate above 95% by 2020. The plan also targets a reduction in ammonia nitrogen pollution of 10% (Bundesministerium für Wirtschaft und Energie, 2017[214]).

Table 9. Targets set in the Agricultural Biogas Development plan in China (2017)

	Current value (2015)	Target value (2020)
BNG plants	25	197
Scale biogas plants	6 972	10 122
Small and medium scale biogas plants	103 476	128 976
Household digesters (in million)	41.93	43.04
Biogas production (in billion m^3)	15.8	20.7
Digestate fertiliser production (in million tonnes)	71	97.51
Agricultural waste treatment capacity (in million tonnes/year)	2 000	2 080.47
CO_2 reduction (in million tonnes/year)	28.6	46.22

Source: (Bundesministerium für Wirtschaft und Energie, 2017[214]).

In addition, in 2016, the MOA launched the Circular on Announcing the Plan of Investment within the Central Budget for Large-scale Biogas Projects, which aims to advance rural biogas transformation and upgrading. The plan actively promotes fuel utilisation technologies such as straw pyrolysis and gasification, straw biogasification, straw curing, and straw carbonization (OECD, 2018[210]). As part of this plan, the MOA will provide a minimum of CNY 2 billion/year to support large scale biogas plants and biomethane projects until 2020 (Bundesministerium für Wirtschaft und Energie, 2017[214]).

Support for agricultural biogas production tends to take the form of subsidies for the construction of biogas digesters or plants. Between 2003 and 2015, the MOA's construction subsidies for biogas plants amounted to CNY 38.5 billion. Output subsidies for electricity generated from livestock, poultry, agro and forestry waste are also provided (Bundesministerium für Wirtschaft und Energie, 2017[214]).

Other policies that promote enhanced livestock and poultry waste utilisation can deliver further reductions in agricultural GHG emissions. The Work Plan for the National Project of the County-wide Promotion of Livestock and Poultry Excrement Resource Utilisation (2018-20) launched the implementation of pilot projects for county-wide promotion of resource use of livestock and poultry excrement (Ministry of Ecology

and Environment, 2018[216]). The Opinions on Accelerating the Promotion of the Livestock and Poultry Breeding Waste Resource Utilization (2017) sets a 75% target for animal manure utilisation rate by 2020 and aims to have 95% of small-medium scale animal farms and 100% of large-scale farms equipped with a manure treatment facility by 2020 (Bundesministerium für Wirtschaft und Energie, 2017[214]). In 2017, the comprehensive utilisation rate of livestock and poultry excrement reached 70%, and the comprehensive utilisation rate of straws and stalks exceeded 82% (Ministry of Ecology and Environment, 2018[216]).

Efforts to reduce methane emissions from rice cultivation

The government also promotes measures to reduce emissions from rice cultivation. Rice cultivation is a major source of CH_4 emissions in China. The irrigation methods used and the type of rice varieties planted directly influence the rate of CH_4 emissions from paddy fields. Both the Ministry of Water Resources and the MOA have supported the expansion of intermittent irrigation over the past decade. Compared with flood irrigation, the adoption of intermittent irrigation can reduce CH_4 emissions by 30-46% (Wang, Huang and Rozelle, 2010[217]). Actions have also been taken to promote high-yield rice varieties with lower associated emissions, and rice cultivation in semi-arid areas (The People's Republic of China, 2014[212]).

Policies with relevance to GHG mitigation in LULUCF

A number of forestry programmes, primarily involving increased afforestation and improved forest management, support GHG emission reductions in the LULUCF sector. China's Grain-for-Green Program (GFGP) is described as the world's largest reforestation scheme (Hua et al., 2016[218]; Sun et al., 2019[219]). The programme, which was launched in 2000, uses cash payments to incentivise farmers to re-establish forest and shrub vegetation on sloped cultivated land at risk of erosion. It also aims to afforest large tracts of barren land (Fu et al., 2019[9]). Following completion of its initial phase in 2007, it was renewed for a further eight years from 2008 to 2016, with a commitment from the Chinese government to extend the programme until at least 2020 (Hua et al., 2016[218]). The GFGP had reportedly converted 9 million hectares of cropland to forestland and achieved 29 million hectares of afforestation by 2012, with total investment in the programme amounting to CNY 32 billion (Fu et al., 2019[9]).

Actions under the National Afforestation Plan (2016-2020) and the Forest Management Plan (2016-2050) will also help reduce deforestation-related emissions. The plans include guidelines for forestry maintenance and restoration, the development of forest management plans at provincial and county levels, and the pilot of sustainable forest management programmes. China's Forest Protection and Remediation System implements a quota on logging of natural forests (Ministry of Ecology and Environment, 2018[216]). In 2017, the area of natural forest management and protection increased by 13.33 million hectares and China achieved an annual reduction in the consumption of forest resources of 34 million cubic metres.

China has also taken steps to strengthen forestry carbon storage statistics. The National Forestry Carbon Sinks Measurement Monitoring System and the Second National LULUCF Carbon Sinks Measurement Monitoring Plan were launched in 2017 (Ministry of Ecology and Environment, 2018[216]).

Research programmes

Research initiatives support GHG mitigation in China's agricultural sector. In 2018, China launched two major research projects on GHG emissions mitigation from livestock as part of a research collaboration between Chinese agencies, the Research Program on Climate Change, Agriculture and Food Security (CCAFS), the Sino-Dutch Dairy Development Centre (SDDDC), Wageningen University & Research, GRA and the private sector (White, 2018[220]).

The first research project focuses on improving agricultural emissions accounting methods at the provincial level. In particular, the project aims to develop a guideline based on Tier 2 methodology to improve MRV of enteric fermentation and manure management emissions from dairy cattle and manure management emissions from pigs. It will enable provincial governments to use high quality data and will be used as a tool to measure emission reductions from improved livestock practices at the farm level.

The objective of the second research project is to identify sustainable dairy practices, especially from novel feeds (such as lignin degradation of maize or rice straw), that can reduce GHG emissions from dairy farming; and to provide accurate estimates of emission reductions associated with these changes in dairy practices (White, 2018[220]).

China is also a member of the GRA and the Global Methane Initiative.

6.2. Indonesia

Background on GHG emissions in AFOLU

In the UNFCCC database, 2000 is the latest year for which emissions data are available. Emissions from agriculture amounted to 73.4 $MtCO_2eq$ in 2000, accounting for 13% of national emissions (excluding LULUCF and 5% including), most of which is CH_4 from rice cultivation (47%), N2O from agricultural soils (29%) and CH_4 from enteric fermentation (17%) (UNFCCC, 2019[31]).

FAOSTAT reports higher emissions than the UNFCCC database. Agricultural emissions in the former amounted to 100.5 $MtCO_2eq$ in 2000, excluding N_2O emissions from the cultivation of organic soils. The reason for this discrepancy is unclear. CH_4 from rice cultivation accounts for the majority of emissions (52%), followed by N_2O from agricultural soils (26%). The FAOSTAT database includes an additional quantity of 30.6 $MtCO_2eq$ in N_2O emissions from the cultivation of organic soils. Total annual agricultural emissions, including this source, increased by 30% between 2000 and 2016, from 132.1 $MtCO_2eq$ to 171.7 $MtCO_2eq$ (FAOSTAT, 2019[1])

Based on data reported in the UNFCCC database, LULUCF made a large net contribution of 821 $MtCO_2eq$ in 2000 (60% of national emissions including LULUCF), up substantially from the 197 $MtCO_2eq$ of emissions in 1990. Most of the emissions were from deforestation (729 $MtCO_2eq$), with significant contributions from soil CO_2 emissions. LULUCF emissions reported in FAOSTAT were slightly lower, at 737 $MtCO_2eq$ in 2000, with the bulk coming from forest land (61%) and cropland (33%). In 2016, LULUCF emissions stood at 1 361 $MtCO_2eq$. This increase is primarily attributable to a large rise in emissions from forestland (FAOSTAT, 2019[2]).

Nationally determined contributions

Indonesia's 2016 NDC includes an unconditional GHG emission reduction target of 29% below business-as-usual (BAU) and a conditional reduction target of up to 38% below BAU by 2030.[31] All UNFCCC national inventory sectors are covered by this commitment, with the majority of reductions in GHG emissions expected to come from the LULUCF and energy sectors. Agriculture is expected to account for between just 3% and 8% of total emission reductions (Table 10).

[31] The conditional target is subject to international assistance for finance, technology transfer, and capacity building. BAU scenario: project emissions in 2030 without any mitigation action (estimated at 2 869 GtCO2e)

Table 10. Sectoral percentage contribution to Indonesia's 2020 and 2030 emission reduction targets

Sector	Unconditional mitigation target		Conditional mitigation target	
	$MtCO_2eq$	Percentage	$MtCO_2eq$	Percentage
Forestry and Peatland	497	70%	650	91%
Waste	11	4%	26	9%
Energy	314	19%	398	24%
Agriculture	9	8%	4	3%
Industry	3	4%	3.25	5%
TOTAL	834	29%	1,081	38%

Source: (Government of Indonesia, 2016[221])

National policies for mitigating GHG emissions in AFOLU

National Action Plan to reduce GHG emissions (RAN-GRK)

Following the submission of its NAMA in 2010, which outlined mitigation measures and targets for the LULUCF sector (including sustainable peatland management, reduced deforestation and land degradation, and carbon sequestration projects in forestry and agriculture), the Indonesian government released its National Action Plan to reduce GHG emissions (RAN-GRK), as a starting point for the implementation of its NAMA commitments.

The RAN-GRK outlines 23 mitigation actions for the LULUCF sector and 7 for the agricultural sector and includes a number of quantitative targets to be achieved by 2020 (Ministry of National Development Planning, 2010[222]). These include:

- Management of 300 500 hectares of agricultural land without burning
- Use of organic fertilisers and bio-pesticides on 250 000 hectares
- Increase in productivity of perennial crops on 860 000 hectares of palm oil, 105 200 hectares of rubber, and 687 000 hectares of cocoa
- Use of cattle manure/urine and agricultural waste for biogas in 1 500 communities
- Rehabilitation of 250 000 hectares of abandoned and degraded peatlands
- Eradication illegal logging
- Forest rehabilitation and reclamation on 354 000 hectares.

The MoA has implemented and reported on three main mitigation policy areas that were set by the RAN-GRK, including the management of lowland rice, promotion of organic fertiliser and the utilisation of livestock manure and agricultural waste for biogas production. However, the reported coverage and mitigation impact of these projects has so far been limited (Ministry of Environment and Forestry, 2018[223])

The RAN-GRK also mandates provincial governments to develop action plans for GHG emission reductions at the provincial level (Thamrin, 2011[224]). Almost all provincial governments had developed a local action plan to reduce GHG emissions (RAD-GRK) by the end of 2012. Since 2010, more than 12 000 mitigation actions have been carried out in the provinces under the RAD-GRK, with most mitigation activities undertaken in the LULUCF sector (Ministry of Environment and Forestry, 2018[223]).

Policies for mitigating GHG emissions in LULUCF

The majority of AFOLU mitigation policies target the forestry sector, reflecting Indonesia's significant forest cover and the sector's contribution to overall emissions. Forests cover 63% of Indonesian territory or 120.6 million hectares. Indonesia also possesses the largest area of tropical peatland in the world covering 15 million hectares or 12% of its forest land (Ministry of Environment and Forestry, 2019[225]). These forests

and peatlands store substantial carbon stocks, but have been under threat as they are increasingly converted to oil palm concessions, pulp and paper plantation and other commercial uses (Wijaya et al., 2015[226]). Deforestation, the degradation of forests and land cover changes involving the drainage and degradation of peatlands have resulted in major GHG emissions from the LULUCF sector. According to Miettinen et al. (2017[227]), peat oxidation in Indonesia was estimated to be responsible for 120 Mt or 439 $MtCO_2eq$ in 2015. In addition, degraded forests and drained and dried out peat are more prone to fires, causing more CO_2 emissions (Wijaya et al., 2015[226]).

Deforestation rates have slowed since their peak in the 1996-2000 period, when average clearing rates of 3.51 million hectares per year were observed. This slowdown in deforestation rates and LULUCF emissions is partly in response to government policies to reduce deforestation, restore peatlands and forests, control fire and foster sustainable forest management.[32]

Reducing deforestation and promoting sustainable forest management

The main policy for reducing deforestation in Indonesia is the *Forest Moratorium*, which was established in 2011. This regulation prohibits the conversion of primary forests and peatlands for oil palm and timber plantations and logging concessions. The Moratorium covers more than 66.4 million hectares of primary forests and peatlands, and aims to reduce GHG emissions from deforestation (Ministry of Environment and Forestry, 2019[225]). The Moratorium is a temporary regulation, which has been renewed every two years since its implementation. However, the Government of Indonesia (GOI) recently expressed its intension to make it permanent (Jong, 2019[228]).

According to a World Resources Institute study by Wijaya et al. (2017[12]), which reviews the mitigation potential of different national policies, Indonesia's Forest Moratorium is identified as the policy with the strongest mitigation potential. According to the authors, it could reduce emissions by 188 $MtCO_2eq\ yr^{-1}$ if it is extended to 2030, in its current form. Wijaya et al. (2017[12]) also estimate that an expansion of the Forest Moratorium to include secondary forests and forest areas under concession licences (timber plantations, oil palm and mining concessions) could increase its mitigation potential to 437 $MtCO_2eq\ yr^{-1}$.

However, since the moratorium is on new licences, it cannot prevent the conversion of forest areas for which concessional licences have already been issued, which places strong limits on its mitigation potential. Furthermore, estimates of the mitigation potential of the Forest Moratorium assume its full and effective implementation (Wijaya et al., 2017[12]). Although providing time to enable the implementation of forest governance reforms was a stated objective of the Forest Moratorium, the progress made has been modest. Local government participation has been inhibited by a lack of information about the land areas protected and the activities prohibited by the Moratorium, the lack of a mandate, resources or technical guidance for monitoring, and inadequate enforcement mechanisms. As administrative and regulatory authority is decentralised in Indonesia, the Moratorium will only be effective if implemented at the local level. Implementation has also been complicated by a lack of data transparency due primarily to differing land maps used by national, provincial and local governments (Kemen et al., 2014[229]). The One Map initiative, a publically accessible database of all provincial forest licences launched in 2018, aims to address these inconsistencies. However, the delay between the policy's introduction and the launch of the database may reduce the effectiveness of the Moratorium and delay the delivery of Indonesia's GHG mitigation objectives.

Policies targeting sustainable forest management could also have significant mitigation potential. Measures include the government's comprehensive programme to fight forest area encroachment and illegal logging, and the forest sustainable management certification (e.g. Timber Legality Verification System).

[32] Deforestation rates: 2014-15=0.82 mh.a, 2015-16: 0.63 mh.a, 2016-17: 0.48 mh.a.

Peatlands restoration

Alongside the Forest Moratorium, several policies have recently been enacted to protect and restore peat ecosystems in Indonesia. This includes Government Regulation No. 57 of 2016 on peatland management and protection, which halts the issuance of new licenses on peatlands permanently (Wijaya et al., 2017[12]), and mandates the retroactive restoration of certain deep peat areas converted by industrial timber and oil palm plantations, by requiring these companies to draft Peat Ecosystem Restoration Plans (Ministry of Environment and Forestry, 2019[225]). This policy also mandates governments at all levels to develop integrated peatland protection and management actions and to restore/rehabilitate degraded peatlands (Ministry of Environment and Forestry, 2018[230]).

In 2016, a Peat Restoration Agency was established and tasked with restoring 2.1 million hectares of peatlands in seven priority provinces by 2019 (Ministry of Environment and Forestry, 2018[231]). Under the current programme, the goal is to restore 2.5 million hectares out of an estimated 23.96 million hectares of degraded peatlands by 2020. This includes restoration of 1.4 million hectares in licensed cultivation zones, as well as 685 000 hectares in protected zones and 397 000 hectares in community cultivation zones to be undertaken by the Government (Ministry of Environment and Forestry, 2019[225]). However, with only 679 901 hectares of degraded peatlands restored by 2018 (Peatland Restoration Agency of Indoensia, 2019[232]), it is unlikely to meet its 2020 restoration target.

Peat restoration measures in Indonesia mainly involve rewetting (through the construction of deep wells, ponds and canal blocks) and revegetation (through seedling transplantation and natural regeneration) (Dohong, 2018[233]). These practices are, however, mostly experimental, and further testing in the field is needed to determine their effectiveness.

Forest and land rehabilitation

Forest and land rehabilitation projects, involving planting, reforestation and land reclamation activities, also help reduce emissions. As of 2013, 24.3 million hectares of forests and lands in Indonesia were classified as critical lands, despite the recent decline in deforestation and forest degradation. The government set a target to reduce the total extent of critical land by 5.5 million hectares across 34 Indonesian provinces over the period 2015–19. A total budget of IDR 39 trillion was allocated for this project. However, this budget was insufficient and could only finance the rehabilitation of approximately 200 000 hectares per year between 2015 and 2017 (Ministry of Environment and Forestry, 2019[225]). In 2018, the government scaled back its ambition and reduced the estimate of critical land to 14 million hectares. National emission reductions from forest and land rehabilitation projects in 2015 and 2016 amounted to 1.6 MtCO2eq and 2.4 MtCO2eq, respectively (Ministry of Environment and Forestry, 2019[225]).

Forest and land fire control

Forest and land fire control also contributes to GHG emissions in Indonesia. In 2015, Indonesia experienced the worst fire season for 20 years. GHG emissions from fires reached 1.62 billion Mt of CO_2, and Indonesia went from being the 6th largest emitter in the world to the 4th in just six weeks (Harris et al., 2015[234]). Since 2016, the Indonesian Government has reaffirmed its commitment to the prevention and control of forest and land fires and has established a national programme for forest and land fire control built around a number of action pillars, including early warning detection systems, capacity building, stronger enforcement, and international co-operation (Ministry of Environment and Forestry, 2019[225]).

Moreover, in 2017, the government launched a two-year plan to reduce land and forest fire hotspots by protecting peat forests. This IDR 39 trillion (USD 2.73 billion) programme aims to ensure that 121 000 km^2 of land, a fifth of Indonesia's peat forest, is fire free by 2019. It corresponds to a halving of the number of fire hotspots in the country in two years. The programme includes economic incentives for preventing fires. Fire-prone villages, for instance, will be eligible for IDR 300 million (USD 21 000) in funding if they manage

to prevent land and forest fires for a full year. Concession holders, on the other hand, risk the revocation of their permit if they are found liable for fires on their land (Jong, 2018[235]).

The number of fire hotspots decreased by 94.6% between 2015 and 2016 and by 36.5% between 2016 and 2017, generating emission reductions of 549 $MtCO_2eq$ and 163 $ktCO_2eq$, respectively (Ministry of Environment and Forestry, 2018[231]; Ministry of Environment and Forestry, 2019[225]). This significant decline in forest and land fires is attributable to both climatic factors and intensified control measures.

International policies supporting GHG mitigation in AFOLU

International initiatives also deliver emissions reductions and support the achievement of NDC targets in Indonesia. The REDD+ programme is a key policy tool for emissions reductions in Indonesia's LULUCF sector. Indonesia has actively engaged in REDD+ negotiations and development since 2007. Following the Bali Action Plan, Indonesia received access to multilateral and bilateral funds to support the REDD+ readiness phase. In 2011, Indonesia launched a REDD+ Task Force[33] and in 2012 the National REDD+ Strategy was launched (Ministry of National Development Planning, 2013[236]). Indonesia submitted a forest emission level benchmark for REDD+ in 2015 that covers deforestation, forest degradation and peat decomposition. This will be used as a reference for evaluating REDD+ performance up to 2020 and then adjusted for the post-2020 period (Ministry of Environment and Forestry, 2015[237]).

In 2010, Norway pledged to support Indonesia as part of the REDD+ programme, with up to USD 1 billion depending on results. Between 2016 and 2017, primary forest loss in Indonesia declined by 60%, triggering Indonesia's eligibility for results-based payments under the REDD+. The first payment would be for approximately 4.8 million tonnes of CO_2 (Royal Norwegian Embassy in Jakarta, 2019[238]; Seymour, 2019[239]). While the size of the payment is still being negotiated, Norway is expected to pay at least the USD 5 per tonne price agreed in previous transactions with other countries such as Brazil (Seymour, 2019[239]).

Research programmes and industry initiatives

Research and industry initiatives can help deliver emission reductions in the AFOLU sector. The Sustainable Intensification of Dairy Production Indonesia (SIDPI) project supports GHG mitigation in the AFOLU sector. Led by Wageningen UR Livestock Research, SIDPI is an action oriented research project aiming to increase the productivity of smallholder dairy farms in West Java while improving food security, and reducing GHG emissions. Activities will focus on developing, implementing and improving strategies for manure, feeding, and animal health and management. Wageningen UR Livestock Research will deliver the project in partnership with local dairy co-operative KPSBU Jabar, Frisian Flag Indonesia and Royal FrieslandCampina, Trouw Nutrition International and IPB University of Bogor (Wageningen University and Research, 2016[240]). Indonesia is also a member of the Global Research Alliance and the Global Methane Initiative.

7. Sub-Saharan Africa

In this section, the focus is on the ten countries of Sub-Saharan Africa that include AFOLU-specific targets in their NDC submissions. The information about policies supporting these mitigation commitments is mainly based on information provided in these submissions. A regional overview of these policies is

[33] The REDD+ task force moved to the Indonesian Ministry of Environment and Forestry in 2016 and is no longer an independent entity.

provided in this section, unlike the country-specific sections of this report, which provide a more detailed inventory of each countries' mitigation policies in more detail.

7.1. Background on GHG emissions in AFOLU

Agricultural emissions in Sub-Saharan Africa amounted to 822 $MtCO_2eq$ in 2017, with 38% coming from enteric fermentation, 32% from N_2O (most of which was from manure deposited on pasture), and a 22% contribution from savannah burning (FAOSTAT, 2019[1]).

LULUCF emissions in 2017 were 1 630 $MtCO_2eq$, approximately double those of the agricultural sector. The main contributing sources were forest land (51%) and the burning of biomass (45%) (FAOSTAT, 2019[2]).

7.2. Nationally determined contributions

A notable feature of this region is the number of countries that set specific and, in some cases, ambitious mitigation targets for AFOLU in their NDC submissions. For many least developed countries, NDCs have been seen as providing an opportunity to potentially mobilise international resources. Thus, several countries in Sub-Saharan Africa provide detailed sector-specific mitigation plans, with financial requirements linked to specific actions in some cases (UNFCCC, 2019[205]).

As shown in Table 11, each of these countries includes mitigation targets for AFOLU sectors, in their NDCs, that are conditional on finance, with a few also providing unconditional targets, which are largely reliant on policies already in place. For countries that provide both, the conditional commitments are between two to five times larger than their unconditional commitments in AFOLU.

The conditional mitigation commitments are substantial. For countries that report data on both their business as usual (BAU) projections and emission reductions, the conditional commitments correspond to emission reductions of approximately 20-50% for either agriculture or AFOLU as whole.

The majority of countries in Table 11 identify specific mitigation measures to support these targets in their NDCs. Six of the nine countries quantify the contributions of specific measures within the agriculture and the forestry sectors. N_2O emissions from mineral fertiliser use are targeted by three countries (Gambia, Ethiopia, and Burundi) through either nutrient management or a reduction of their use, including through their replacement with organic fertiliser. Other mitigation measures for crops include conservation agriculture (Ethiopia and Comoros), and irrigation, drainage, and reduced flooding measures for rice production (Benin and Gambia). Measures to address livestock emissions are important in livestock dominant countries, such as Ethiopia, Namibia and Nigeria, and are typically based on improved feeding practices, including more intensive animal fattening, and improved breeding to lower enteric methane. Ethiopia explicitly mentions the demand management strategy of reducing the consumption of red meat, by encouraging a switch to non-ruminant sources of meat. This is understandable given the country's strong reliance on beef cattle. However, it is a rare example of a least developed country committing to a demand-side mitigation strategy, even if it is a conditional goal.

The NDCs also identify measures to reduce emissions and increase carbon stocks in the LULUCF sector, including agroforestry (Namibia, Nigeria and Comoros), grassland management and the restoration of degraded grasslands (Ethiopia and Namibia). In the forestry sector, countries prioritise reducing deforestation, along with reforestation and afforestation, with a smaller number of countries specifying reduced degradation of forests. Moreover, both Ethiopia and Cote d'Ivoire explicitly identify the importance of the intensification of agriculture as a way to decouple agricultural production and deforestation. This objective is also recognised within the framework of REDD+, which is described in more detail in the following section.

Table 11. AFOLU sector-specific mitigation targets in NDCs submitted by Sub-Saharan African countries

Country	Mitigation target ($MtCO_2eq$)	Details	Sector
Benin	26.1	31.1% reduction against BAU, cumulative 2021-2030, conditional	Agriculture
	4.9	5.8% reduction against BAU, cumulative 2021-2030, unconditional	Agriculture
	112.5	Reduction against BAU, cumulative 2021-2030, conditional	LULUCF
	29.5	Reduction against BAU, cumulative 2021-2030, unconditional	LULUCF
Burundi	1.96	3% reduction against BAU in 2030, unconditional	AFOLU
	14.90	20% reduction against BAU in 2030, conditional	AFOLU
Chad	13.03	Reduction against BAU, in 2030, conditional	Agriculture
	5.21	Reduction against BAU, in 2030, unconditional	Agriculture
	6.96	Reduction against BAU, in 2030, conditional	LULUCF
Comoros	0.085	Reduction against BAU in 2030, conditional	Agriculture
	0.194		LULUCF
Cote d'Ivoire	2.33	Reduction against BAU in 2030, conditional	Agriculture
Ethiopia	90	48.6% reduction against BAU in 2030, conditional	Agriculture*
	130	144.4% reduction against BAU in 2030, conditional	Forestry*
Gambia	1.1	Reduction against BAU in 2025, conditional	Agriculture
	0.275	Reduction against BAU in 2025, unconditional	LULUCF
Mali	25.4	Reduction against BAU in 2030, conditional	Agriculture
	18	Reduction against BAU in 2030, conditional	LULUCF
Namibia	0.2	Reduction against BAU in 2030, conditional	Agriculture
	18.49	Reduction against BAU in 2030, conditional	LULUCF
Nigeria	74	Reduction against BAU in 2030, conditional	AFOLU

Notes: Percentage reductions are included for countries that report these reductions in their NDCs. Conditional targets are subject to the availability of international support for finance, technology transfer and capacity building.
*Ethiopia allocates mitigation contributions by agricultural and forestry sector, in line with its Climate Resilient Green Economy Strategy (CRGE), rather than by agriculture and LULUCF inventory categories. Therefore, measures that promote carbon sequestration on agricultural land are assigned to the agriculture rather than LULUCF sector in this case.
Sources: (UNFCCC, 2019[205])

7.3. National policies for mitigating GHG emissions in AFOLU

As mentioned, this section focuses on the national mitigation policies outlined in the NDCs of the ten Sub-Saharan African countries surveyed. Most of the countries listed in Table 11 outline means of implementing the aforementioned mitigation measures in their NDCs, including technology transfer; capacity building and funding requirements, along with policies and programmes to support implementation. These include the strengthening of existing national policies and the proposal of new policies.

Many countries have also integrated their NDC goals into national climate change policy strategies (Benin, Ethiopia, Namibia, Nigeria, and Mali). For example, Ethiopia, the African country with by far the most ambitious conditional target, committed to building a green economy in its Climate Resilient Green Economy Strategy (CRGE). The CRGE initiative is built around four pillars, two of which contribute to emissions reductions in the AFOLU sector. Specifically, the CRGE prioritises initiatives that will increase the productivity of farmland and livestock and increase carbon sequestration in forestry by increasing afforestation, reforestation and forest management (Government of Ethiopia, 2011[241]).

7.4. International policies supporting GHG mitigation in AFOLU

International initiatives also help reduce AFOLU emissions in Sub-Saharan Africa. Three of the nine countries (Ethiopia, Nigeria, Côte d'Ivoire) participate in the REDD+ scheme. In Ethiopia, the REDD+ programme contributes to the objectives set under the CRGE strategy.

The Clean Development Mechanism (CDM) is another international incentive scheme that has been identified as contributing to emission reductions in Burundi, Cote d'Ivoire, Ethiopia and Namibia. The CDM is a standardised emissions offset instrument that allows developing countries to earn emission reduction credits for mitigation projects (UNFCCC, n.d.[242]). The CDM has had limited success in the AFOLU sector, as projects in the sector only comprise a small share of the CDM portfolio (Smith et al., 2014[243]).

The Great Green Wall is another international initiative integrated into the NDC ambitions of six of the nine countries examined (Chad, Ethiopia, Mali, Nigeria, Benin and Gambia). This pan-African initiative, which includes twenty African countries, set the ambitious goal of restoring 100 million hectares of degraded land and sequestering 250 million tonnes of carbon by 2030 (UN Environment Programme, 2019[244]). Since its launch in 2007, 15 million hectares of degraded land have been restored in Ethiopia and a further 5 million hectares have been restored in Nigeria (UN Convention to Combat Desertification, n.d.[245]).

As mentioned, the NDC targets in Table 11 are conditional on funding, with several countries identifying the Green Climate Fund (GCF) and the Global Environment Facility (GEF) as a potentially important international sources of funds.

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