FORMULATION OF SECTORAL STUDIES
(ELECTRICITY, FUEL, INDUSTRY AND AGRICULTURE)
AND PROPOSITION OF DESIGN OPTIONS FOR CARBON PRICING INSTRUMENTS

COMPONENT 1 OF THE PMR IMPLEMENTATION PHASE

International Experience of Carbon Pricing in the Agriculture Sector

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INTERNATIONAL EXPERIENCE WITH GHG MITIGATION AND CARBON PRICING IN THE AGRICULTURE SECTOR

This report was prepared by Ricardo Energy & Environment as an output for the PMR Programme in Brazil. The objective is to present and assess international experience related to policy measures for GHG mitigation in the agriculture sector, focusing on carbon pricing. The report will conclude by presenting implications for Brazil which is considering implementing carbon pricing in this sector. **Note that the closely related topic of emissions and mitigation options in land use, land-use change and forestry (LULUCF) are not within the scope of this report.**

This report is structured as follows.

Section ***1 - Context: Agriculture in Brazil*** sets the context by providing an overview of the significance and structure of the Brazilian agricultural sector, followed by the key policy objectives, highlighting the objectives of economic growth, sustainability and productivity improvements.

Section ***2 - Policy context: Climate Change Mitigation in Agriculture*** explains the uniqueness of GHG emissions in the sector, and the challenge of reconciling climate change objectives with the imperatives of productivity and sustainability improvements in policy making. The section then provides an overview of the key emission sources in Brazil and a high-level assessment of the priority mitigation options for Brazil.

Section ***3 - Policy instruments for GHG mitigation in Agriculture: Carbon Pricing Instruments*** provides an overview of the international experience regarding the implementation of carbon pricing instruments (CPIs) in the Agriculture sector. Subsequently, four in-depth case studies of carbon pricing in New Zealand, British Columbia (B.C.), Australia and an international multilateral fund are presented.

Section ***4 - Lessons learnt from international experience*** summarizes the key points of interest and lessons learned from the case studies for Brazil, before exploring the CPI implementations challenges further.

Section ***5 - Key considerations for carbon pricing in Brazilian agriculture*** presents the key principles for CPIs for the agricultural sector, and considerations regarding carbon pricing in the Brazilian agricultural sector, in light of the previous sections.

Section ***6 - Alternative climate policy instruments for agriculture*** presents alternative policy instruments for climate change mitigation in agriculture, excluding CPIs. The scope of this report was expanded to include this section in light of the limited experience of CPIs in the agriculture sector.

EXECUTIVE SUMMARY: INTERNATIONAL EXPERIENCE WITH GHG MITIGATION AND CARBON PRICING IN THE AGRICULTURE SECTOR

Context: Agriculture in Brazil

Brazil's agricultural sector has enjoyed significant growth and productivity improvements over the last four decades. However, growth has come at the expense of sustainability, causing rapid deforestation due to land expansion.

Today, the agribusiness sector is of critical importance to Brazil's economy, responsible for 19% of the national GDP in 2016. Brazil is internationally renowned for exporting food, fuel and fiber, with agribusiness accounting for a very significant proportion of total exports, equivalent to 46% in 2016. While Brazil has one of the largest cattle populations worldwide, productivity is low and cattle farming is a key driver of deforestation.

The key policy objectives for the Brazilian agricultural sector are:

- **Growth and economic development.** Sustaining agricultural growth is critical to Brazil's development given the weight of agriculture and agro-industries in the national economy.
- **Environmental protection and sustainability**. Ensuring that agricultural growth is done in a sustainable manner. As growth in agriculture has been a key driver of land use change emissions, this requires an increase land productivity**.**
- **Productivity and innovation.** Productivity improvements have been a key driver of the sectors growth over the past two decades. Innovation is key to meet the competing needs of productivity and sustainability.
- **Equity and social protection.** Rural policy aims to protect small farmers and improved productivity has implications for poverty reduction goals.
- **Climate Change mitigation.** The government wants the agricultural sector to contribute significantly to GHG mitigation targets.

Regarding the Brazilian agriculture sector structure, there is significant regional variation in terms of farm size and land tenure. In Brazil, farm size does not always correlate with productivity and capital intensity. While large scale farms can be characterized as capital-intensive, commercial and export oriented, many small-scale family farms are also technologically advanced and capital intensive. Finally, regional variation in climatic conditions and infrastructure affect significantly productivity and sustainability.

Policy context: climate change mitigation in the agriculture sector

The agriculture sector is unique with respect to Climate Change mitigation. Unlike other sectors, the main GHG produced are nitrous oxide and methane (N_2O & CH_4), rather than carbon dioxide (CO_2). These GHG arise from biological processes in livestock and manure, soil cultivation and use of fertilisers. These emissions are intrinsic to the farming process in the sense that they cannot be substituted, and therefore have fewer abatement options than other sectors. In addition, variations in climate and natural conditions which are outside the farmers control have significant impacts on emissions.

Designing climate policy for the agriculture sector faces the challenge of reconciling productivity, sustainability and climate change objectives. Facing significant pressure to grow and minimize costs, a key objective of the sector is an improvement in productivity, which must be achieved in a sustainable manner. Sustainability goes beyond mitigating GHG emissions, including issues such as pollution, biodiversity, animal welfare and land-use change. Due to the growth imperative in the agriculture sector, policy makers aim to provide incentives for improvements in GHG intensity of production, rather than absolute emission reductions. However, there are risks associated with a narrow focus on improving GHG intensity at a farm level, including deforestation, biodiversity, water, soil and air quality and animal welfare risks.

Policy should focus on incentivising "high quality" mitigation options, which meet sustainability criteria over the long term, and have synergies with improved productivity. Table 1 provides summary of the assessment of priority mitigation options for Brazil, including benefits, risks, and barriers to implementation. Finally, while improvements in productivity may support sustainability and climate goals, this must exist within a framework of regulatory safeguards, to restrict the conversion of marginal and forest land.

Table 1 – Summary of the benefits, risks and barriers to key mitigation options

Key mitigation options	Benefits & Risks	Barriers to implementation
1. Nutritional supplementation	May lead to productivity improvements, however, risks diverting food from human supply chain. In addition, some supplements are banned in major export markets.	Capacity and technology barriers exist. Also, administration is easier in confined systems, which are costly and have welfare impacts.
2. Improved pasture and grassland nutrient management	May lead to productivity improvements, however intensification risks increasing land conversion and deforestation	Significant upfront costs and cultural resistance.
3. Genetic improvement of livestock	Productivity improvements, and animal health benefits.	Long timescales and data intensive.
4. Agroforestry	Productivity and soil carbon improvements associated.	Significant upfront costs and cultural resistance.
5. No-till farming	Productivity and soil improvements associated, as well as less machinery use. However, use of herbicide is a risk.	High upfront costs, capacity barriers.

Source: Ricardo Energy & Environment.

Policy instruments for GHG mitigation in agriculture: carbon pricing instruments

Table 2 provides an overview of where carbon pricing instruments have been used to incentivise the priority mitigation options for Brazil. No examples of ETS and CT systems with the objective of mitigating biological emissions from agriculture (through selected mitigation options) have been identified. Both New Zealand and British Columbia (B.C.) have made attempts at including the agriculture sector in the CPI, but ultimately decided to remove these. On the other hand, numerous examples of crediting mechanisms can be identified, such as the Australian Carbon Farming Initiative. Finally, one example of a Results Based Financing (RBF) mechanism linked to emission reductions in agriculture has been identified – the BioCarbon Fund.

Table 2 - Overview of current use of carbon pricing instruments to incentivise the selected mitigation options in the agriculture sector

Priority mitigation option	**Carbon Pricing Instrument**			
	Emission Trading Schemes	**Carbon Tax**	**Crediting Mechanisms**	**Results-based Finance**
Nutritional supplementation			Many examples included in Clean Development Mechanism (CDM) methodology (e.g. feed supplementation for dairy sector for increased productivity (UNFCCC, 2017)) and in positive list[1] of **Australia Carbon Farming Initiative** (Australian Government Department of the Environment and Energy, 2014).	
Genetic improvement of livestock	No existing examples. However, there are ongoing plans in **New Zealand ETS** to develop an MRV			

[1] A list which defines the abatement opportunities in specific sectors and regions in Australia which can earn emission reduction credits in the scheme.

	system for data collection as first step to incentivise this and other agriculture mitigation and options (Kerr & Sweet, 2008).			
Improved pasture and grassland nutrient management		**British Columbia carbon tax (2008-2012)** covered farm fertilizers, intended to incentivise this mitigation option (Skolrud, 2015).	Many examples. Is included in CDM methodology (e.g. inoculant fertilizer application in grassland (UNFCCC, 2017)) and in positive list of **Australia Carbon Farming Initiative** (Australian Government Department of the Environment and Energy, 2014).	
Agroforestry: integrated cropland-livestock-forestry systems			Many examples, is included in CDM methodology (e.g. inoculant fertilizer application in grassland (United Nations Framework Convention on Climate Change, 2014)) and In positive list of **Australia Carbon Farming Initiative** (Australian Government Department of the Environment and Energy, 2014)	**BioCarbon Fund** covers agroforestry projects (Department of Energy & Climate Change, 2015).
No-till farming			In positive list of **Australia Carbon Farming Initiative,** and the existing **British Columbia** crediting mechanism (Australian Government Department of the Environment and Energy, 2014).	

Existing examples identified	Past example identified	No example identified

Source: Ricardo Energy & Environment.

<u>Lessons learnt from international experience of CPIs</u>

Table 3 presents the key points and lessons from the case studies.

Concerns over competitiveness and distributional impacts, along with implementation difficulties (measurability and choice of point of regulation), are the main reasons for limited application of ETS and CT in agriculture. In New Zealand, the decision to exclude the agriculture sector from the ETS in 2013 was due to negative competitiveness and distributional impacts on participants, as well as difficulties in measuring and monitoring emissions, and limited availability of abatement technologies (Kerr & Sweet, 2008).[2] Nonetheless, the MRV system for agriculture is in place. In B.C., although the agriculture sector was never directly included under the carbon tax, fertilizers were included between 2008-2012. Some of the main reasons for excluding the sector after this date include the negative impacts on competitiveness, and risk of carbon leakage. B.C. is currently considering an alternative carbon tax and rebate mechanism.

Numerous examples of crediting and financing mechanisms exist. Although smaller in scope, governments can qualitatively restrict their mitigation options, and provide financial support to farmers. Governments can choose the types of projects which will receive funding. In addition, knowledge and technology transfer modules address technological and capacity barriers. A key disadvantage however is that the scope of emission reductions of project based variant is potentially much lower than sector wide ETS/CT.

Table 3 - Overview points of interest and lessons for Brazil of CPI case studies

Case Study **(CPI, jurisdiction, key dates)**	**Points of interest and lessons for Brazil**
New Zealand ETS 2008: ETS established (New Zealand Government MfE, 2009) 2009: Methane and nitrous oxide emissions from agriculture planned to be included in ETS from 1 Jan 2015 (Kerr, 2016) 2012: Mandatory reporting on agriculture emissions (Ministry for the Environment in New Zealand, 2012) 2013: New government indefinitely excludes agriculture from NZ ETS (Leining & Allan, 2017).	Attempt at implementing an ETS, and its subsequent exclusion of the agriculture sector mainly because of negative competitiveness and distributional impacts, but also difficulties in measuring and monitoring emissions and limited availabilities of abatement technologies (New Zealand Government MfE, 2009). Up and downstream points of regulation chosen to limit administrative costs and distributional impacts. However, does not provide incentive for productivity improvements, and provides only a weak incentive for farmers to mitigate emissions. MRV and data system established in 2012 may be a model for Brazil. This uses detailed livestock population data together with productivity data to estimate feed intake for beef, sheep, deer and dairy industries. It raises awareness and knowledge of the GHG emissions associated with agricultural production. The aim of the reporting requirement is to set the first step to include the agricultural sector in the NZ ETS. Mandatory and voluntary data is reported by processers of agricultural products and importers/ manufacturers of fertilizers. However, data is difficult to collect and often includes many assumptions. Therefore, agricultural emission estimates from this scheme

[2]However, in 2017 it was decided that stationary energy and transport emissions from the agriculture sector were exposed to ETS costs with immediate effect.

2017: stationary energy and transport emissions from agriculture are exposed to ETS costs (Leining & Allan, 2017).	may underrepresent the actual emissions from the sector. Since indefinitely excluding agriculture from the ETS in 2013, alternative approaches have been suggested by different parties. One suggestion by a New Zealand research institute is an ETS for the agriculture sector with a size threshold for participation, excluding small farmers (Kerr & Sweet, 2008). While this approach may be of interest to Brazil, a nuanced approach to determine which farms are included must be elaborated, as significant number of small farms are not subsistence-oriented.
British Columbia Carbon Tax 2008-2012 (Rivers & Schaufele, 2014) Crediting Mechanism implemented 2008	2008-2012: Carbon tax was not directly applied on agriculture. Instead, was expected to impact inputs costs to agricultural activity (fuel, electricity, fertilizers), however, cost impacts were expected to be minimal, and a number of safety nets existed. In addition, a crediting mechanism is being used for avoided land-use change emissions in agriculture. 2012: The tax was removed from farming inputs. Some of the main reasons cited include lack of mitigation options (fuel substitutes), negative impacts on competitiveness and risk of carbon leakage. The government decided to give the agricultural sector more time for technological advances to create more low-carbon options before including these in the carbon tax. Carbon Tax and rebate mechanism for dairy farming which are currently under consideration aim at incentivising improvements in GHG intensity and productivity, while minimising the negative distributional and competitiveness impacts. However, it is unclear how this will impact sustainability. In the existing crediting mechanism, eligible projects are those that promote improvements in farm productivity as well as GHG abatement, such as no-tillage farming, precision application of fertilizers to reduce the inputs needed and manure management. However, most agricultural credits are used for on-farm energy efficiency and biomass generation projects instead.
Australia Carbon Farming Initiative, Crediting Mechanism, implemented 2011 (Australian Government Department of the Environment and Energy, 2012b)	Example of a crediting mechanism covering agriculture which can be integrated into ETS or CT. The ETS or CT would provide a source of demand for the credits. This is a potential model for Brazil, since the NDC implies that selling credits internationally may no longer be an option. Strong criteria for project eligibility ensures only high quality projects promoting sustainability and productivity are allowed. These include reforestation, avoided deforestation, reducing livestock emissions, reducing emissions from waste deposited in landfills To date, there has been a low participation in this voluntary scheme, due in part to these restrictions, as well as costs associated and the low carbon price (Australian Government Climate Change Authority, 2012).
Biocarbon Fund, Multilateral Results Based Financing Fund, implemented 2013 (Biocarbon Fund, n.d.)	Example of a funding mechanism which can provide a source of demand for credits from agriculture. Relevant given Brazils interest in providing agricultural credit, which can be done in a manner that focuses on GHG emission reduction and sustainability results. Promotes 'climate smart' agriculture and other land uses which increase food production and income opportunity while also providing reduced deforestation, climate resilience, emissions reductions, sustainable water use and carbon sequestration.

Source: Ricardo Energy & Environment.

Key considerations for carbon pricing in Brazilian Agriculture

This section draws together the context on policy making in the agriculture sector, and international experience of implementing CPIs in agriculture, to present some of the principles for designing climate policy instruments in Agriculture. Subsequently, the considerations for Brazil of adopting CPIs are presented.

Principles for climate policy instruments in agriculture

- **Policy instruments should incentivise only high quality mitigation options, which meet sustainability criteria over the long term, and have synergies with improved productivity.** They must also exist within a framework of regulatory safeguards to restrict conversion of marginal and forest land to avoid significant adverse effects in the long term.
- **Policy instruments must be particularly sensitive to the additional costs imposed on obligated entities, for reasons of affordability and competitiveness**. Cost of policies will impact the affordability of food and the competitiveness of an extremely trade exposed sector.
- **A balanced mix of policy instruments is required in order to address barriers to the adoption of GHG mitigation.** Barriers include the technological, financial or capacity challenges, and CPIs alone cannot address these.
- **Finally, given the key challenges with controlling and measuring emissions, careful consideration needs to be given to the type of instrument adopted, and the associated penalties.** CPIs rely heavily on robust measuring and reporting of emissions, however the agricultural sector faces significant challenges with this. In addition, there must be a clear understanding of the kinds of abatement measures which are to be incentivised, and the extent to which the farmer can control and mitigate associated emissions.

Key considerations: choice of carbon pricing instruments

ETS and Carbon Tax instruments create incentives for the lowest cost, rather than highest quality, mitigation options. The carbon price signal created by ETS or CT instruments incentivizes the implementation of cost effective GHG mitigation options up to the value of the carbon price, and policy makers should be aware of the risks associated with this.

Crediting and RBF mechanisms allow for policy makers to impose qualitative restrictions on incentivised mitigation options, but have lower potential emission reduction. These instruments support rather than penalise farmers, however, existing project based mechanisms have limited emission reduction potential due to their reduced scope.

Hybrid CPIs may address some of these key challenges. A carbon tax could be combined with a crediting mechanism (or other financing) to provide both the productivity incentive and support for achieving it. Careful design is needed to provide the correct incentives. For example in the meat industry, a carbon tax could be based on a productivity indicator such as the animal growth rate (reporting age and weight for example). As such, the most efficient farmers pay less tax. In addition, this efficiency incentive could be combined with support for achieving these measures (or other mitigation options) for instance by recycling the revenues raised into a crediting mechanism. An important caveat is that such incentives would need to be combined with robust environmental and sustainability safeguards to mitigate associated risks.

Design of carbon pricing instruments

The point of regulation should be chosen considering practical feasibility, and the strength of the GHG emission reduction and productivity incentives. The agricultural sector in Brazil has a very high number of diffuse emission sources, covering vast and varied geographic territories, so that administering a scheme at farm level may be too costly. Restricting coverage to commercial farmers would make this more manageable although the geographic spread would still be significant. While downstream or upstream designs may be more practical, this may weaken GHG mitigation incentive. Regulating downstream may not create an incentive for improvement in productivity.

The affordability and competitiveness impacts should be mitigated by CPI design and supplementary policy. ETS/CT can be designed in a number of ways to restrict the impact on farmers, and reduce the risk of carbon leakage. New Zealand planned to have phased free allocation of allowances, and is now considering excluding small farms. In Brazil, as physical farm size does not always correlate with emission intensity, other criteria for participation may be required. In addition, carbon tax mechanisms can be designed with rebates or recycling, to mitigate impacts and incentivise best performance, as done in B.C. Supplementary policy includes advisory services for capacity building and results based financial support.

CPIs can be designed to support innovation in agriculture. In the case of Brazil, disseminating innovative techniques is key to meeting the sustainability, productivity and climate objectives. However, the carbon price signal imposed through ETS/CT may not provide direct incentives for innovation, if farmers do not have access to or understanding of new technologies. In this case, revenues raised in the CPI can be recycled for dissemination and support schemes.

Implementation requirements

CPIs must be implemented as part of a policy mix which addresses barriers to implementing mitigation measures. If these barriers to mitigation options are not addressed, carbon pricing effectively becomes a tax on production, harming affordability and competitiveness of the produce. For example, CPIs could be designed to cover only commercial farms which tend to have higher capacity, such as access to technologies. Otherwise, supplementary measures such as provision of capacity building and financial support, may be required.

Extra effort is required to establish robust MRV and data systems for the agricultural sector, given measurability and monitoring challenges. The nature of agricultural emissions presents unique challenges for measurability and monitoring. Emissions cannot easily be estimated by proxies such as land size or volume of production, and much effort is needed to design robust alternatives, as New Zealand is trying to do.

Alternative climate policy instruments for agriculture

In light of the limited experience of CPIs in the agriculture sector, the scope of this report was expanded to include alternative policy instruments for climate change mitigation in agriculture. These instruments have been selected based on a review of international best practice regarding policies to incentivise the mitigation options of relevance to Brazil. Table 11 provides an overview of the main policy instruments (dark blue) and necessary supplementary measures (light blue) for each priority mitigation option.

Measures which combine financial incentives and knowledge exchange, advice and support services are most commonly used for the mitigation options relevant to Brazil. Financial incentives function in a way similar to crediting and RBF mechanisms.

Table 4 - Overview of policies to incentivise five mitigation options

Priority mitigation option	Alternative policy instruments			
	Knowledge exchange, advice and support services	**Research & development**	**Financial incentives**	**Regulatory approaches**
Nutritional supplementation	EU CAP gives out information on appropriate use of feed supplements (Martineau et al., 2017)	The EU gives out grants for research on feed supplements that reduce methane emissions (Martineau et al., 2017)	In theory, this is a possible policy option although no examples exist (Green Growth Institute, 2010).	The EU monitors the usage of additives (Martineau et al., 2017)
Genetic improvement of livestock.	Examples from the Irish Farm Carbon Navigator programme where farmers receive payment to undertake a half-day training courses (Martineau et al., 2017)	Both in Scotland and Ireland grants are provided to use beef herd data to analyse how performance can be improved (Department of Agriculture Food and the Marine, 2015; Martineau et al., 2017).	Example from Ireland where payments are made to farmers to collect performance data on their herds and incentivize selection of the highest performing cattle (Martineau et al., 2017)	
Improved pasture and grassland nutrient management.	Example from the Focus on Nutrients programme in Sweden. This programme includes innovative trainings and advisory approaches (Martineau et al., 2017).		In the EU CAP farmers receive payments for maintenance of the soil organic matter and for activities to limit soil erosion and nitrogen application to land (European Commission, 2017a)	The EU encourages efficient use of nitrogen application through its nitrates directive. This directive limits the allowed application of nitrogen per hectare of land (European Commission, 2010)
Agroforestry: integrated cropland-livestock-forestry systems.	The EU CAP has an advisory service available with information on how to implement agroforestry in an appropriate manner (Martineau et al., 2017)		The EU CAP provides both capital and management payments for agroforestry (Martineau et al., 2017)	For example, Forest codes can be used for retention of agroforestry systems.
No-till farming	The EU CAP provides farm advisory systems which provides either free or heavily subsidized advice on productivity or best practice (Martineau et al., 2017)	The EU is undertaking more research in the area of zero-tillage. This is focused on collecting monitoring information and data to demonstrate the effectiveness of these measures (Martineau et al., 2017)	Examples include area payments for zero-tillage management of land and capital grants for machinery required to convert to zero tillage systems in the EU CAP (European Commission, 2017a) Other examples include US grant funding for equipment and seeds (USDA, 2017) and in Australia conservation tillage counts as a refundable tax offset (Australian Government, 2017)	

	Main relevant policy options		Supplementary measures		No example identified

Source: Ricardo Energy & Environment.

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1 CONTEXT: AGRICULTURE IN BRAZIL

This section provides the Brazilian context to the study. An overview of the significance and structure of the Brazilian agricultural sector is provided, followed by the key policy objectives and instruments in the sector. This will highlight in particular the objectives of economic growth, and sustainability[3] and productivity improvements[4].

1.1 KEY FEATURES OF THE BRAZILIAN AGRICULTURAL SECTOR

Brazil's agricultural sector has enjoyed significant growth and productivity improvements over the last four decades. Growth has mostly been driven by gains in productivity to meet global demand for food, feed, fuel and fiber. This growth has provided cheap food and employment opportunities for low income groups (OECD, 2015). Crop yields doubled since 1970s and also the output from animal farming has increased significantly faster than the population. Some of the increases in the productivity have been attributed to rapid mechanization and replacement of old machinery in the 1990s. For example, the number of tractors increased three-fold in the 1990s and value of machinery doubled in constant prices. Brazil thereby ranked number 12 in the world on the basis of total factor productivity growth between 2001 and 2010. The uptake of technologies of nitrogen fixation, new grain varieties, new livestock breeds and a more competitive environment for the agricultural sector have all been cited as reasons for the rapid improvements in productivity (OECD, 2015).

However, agricultural growth has had negative sustainability implications, causing rapid deforestation due to land expansion. In 2016, the Amazon forest had lost 20% of its original cover, and the Cerrado biome approx. 50% (Ministerio do Meio Ambiente, 2016a). The *Plano de Ação para Prevenção e Controle do Desmatamento da Amazônia,(PPCDAm)* was implemented in 2004 to decelerate the rate of forest degradation and land-use change, and is now in its fourth phase. During the initial phases (2004-2016), the key pillars of the plan were (1) tenure regularization and territorial management (2) monitoring and control of land use and (3) support for sustainable production (New Climate, n.d.). The types of measures used include satellite monitoring of the forest coverage through the PRODES and the DETER programmes. The latter was introduced in 2004 and allows authorities to be quickly alerted regarding deforestation activities thanks to the daily monitoring of satellite images. The first three phases of *PPCDAm* have succeeded in reducing the deforestation rate by 70% in 10 years, between 2004 and 2016.(Ministério do Meio Ambiente, 2017a). In its fourth phase, the

[3] Sustainability is a broad term, and in this report is taken to mean meeting the needs of the present without compromising those of the future, through preservation of local natural resources.

[4]In this report, productivity improvement is a term used in the context of economic activity, meaning a reduction in inputs for every unit of economic output.

PPCDAm is also including an additional pillar, the introduction of fiscal and economic instruments for both prevention and control of deforestation (Ministerio do Meio Ambiente, 2016b).

Moreover, under the Brazil Forest code extensive monitoring actions will be implemented via the '*Cadastro Ambiental Rural'* (Ministerio do Meio Ambiente, 2017a). This programme aims to verify how farmers are complying with the Forest Code. These efforts caused a significant drop in deforestation rates in Brazil (Ministério do Meio Ambiente, 2013). However, in 2013, rates of deforestation increased again and it is uncertain whether this trend can be attributed to the expansion of the agricultural sector (S. Russell & Parsons, 2014). However, gains in agricultural productivity in the same period were enabled by an increase in chemical and fertilizer use.

Today, the agribusiness sector is of critical importance to Brazil's economy, **responsible for 19% of the national GDP in 2016**. Of this, approximately 70% relate to crop systems and 30% to livestock systems, as presented in CEPEA's report (PMR Brasil, 2018). The most important agricultural products are soy (31,3%), sugar cane (14,3%), corn (10,9%) and coffee (5,5%). Regarding livestock, cattle products comprise the majority of produce (63,4%), followed by poultry (18,7%). The agribusiness sector is also a significant employer in Brazil.

Brazil is internationally renowned for exporting food, fuel and fiber, with agribusiness accounting for a very significant proportion of total exports, equivalent to 46% in 2016. These principally consist of soy, meat and sugar and ethanol products. Demand for agricultural products from Brazil has grown rapidly over the last years, due to, for example, development trends in China. Compared to OECD countries Brazil has a very high exposure to international agriculture trade, especially on the export side (PMR Brasil, 2018)).

Brazil has one of the largest cattle populations worldwide, but productivity is low, and cattle farming is a key driver of deforestation. With over 200 million livestock, Brazil has one of the largest cattle populations in the world with most of the extensive grazing lands for beef located in the centre-west of the country (PMR Brasil, 2018)). CEPEA's report affirms that the indicators of productivity are considered to be quite low, and the average animal density in the country is approximately 1 head per hectare. However, this value varies significantly per region, with some presenting even lower density due to high level of pasture land degradation. Cattle farming is one of the drivers for deforestation, and the Global Green Growth Institute (Green Growth Institute, 2010) estimates it is responsible for 33% of deforestation in the Amazon.

Structure and regional variation in the Brazilian Agriculture Sector

There is significant regional variation in farm size and land tenure. CEPEA's report shows that the Brazilian farming structure has a concentrated nature (PMR Brasil, 2018). However, this structure varies regionally, with the least concentration in the Northern and Southern regions. In addition, land tenure varies regionally, with significant lack of regulation in the centre-west and northern regions of the country.

Farm size does not always correlate with productivity and capital intensity. Large scale farms can be characterized as capital-intensive, commercial and export oriented, whereas small-scale family farms have traditionally been characterized as subsistence and low productivity. As CEPEA's report shows (PMR Brasil, 2018), this is not always the case in Brazil as many small-scale farms are also technologically advanced and capital intensive.

Significant regional climatic and infrastructure variability have important productivity and sustainability implications. The Southern half of Brazil has high rainfall patterns and more fertile soils, which together with a good level of infrastructure and access to technologies provides the opportunity for farmers to scale up their production. In contrast, in the northeast and Amazon regions agriculture has traditionally consisted of subsistence farmers, although this has been changing in the last decade. Parts of Maranhão, Tocantins, Piauí and Bahia (Matopiba) in the Northeast and North now consist of farmers who use advanced technology and have high productivity levels, as for example some fruit exporters (Miranda, Magalhães, & Carvalho, 2014). Sustainability trends also vary significantly by geographic regions in Brazil, depending on the type of land, climate and geography (OECD, 2015).

1.1.1 Brazilian Agricultural policy objectives and instruments

A 2015 study by the OECD on Innovation, Agricultural Productivity and Sustainability in Brazil presents the key agricultural policy objectives in Brazil (OECD, 2015), including the following.

Growth and economic development. Sustaining agricultural growth is critical to Brazil's development given the weight of agriculture and agro-industries in the national economy, and its unexploited potential. The slowing of global demand growth (compared to the 1980s and 1990s) has led to greater competition in global agricultural markets, and is driving a need for improved cost competitiveness. From a social perspective, agricultural growth is critical as a key driver of income and employment.

Environmental protection and sustainability. A key objective is to ensure that agricultural growth is obtained in a sustainable manner. The OECD study highlights the historical tension between agricultural growth and sustainability (OECD, 2015). Some environmental issues have long attracted policy attention, such as deforestation, while air, water, and climate change issues are now becoming more prominent. Indeed, another study estimates that around 65% to 70% of deforestation in Brazil from 2000 - 2005 has been attributed to cattle ranching, and most of the remainder (approximately 25%) has been related to soy production (R. Butler, 2017). Increasing agricultural output without putting extra pressure on land conversion and simultaneously recovering original forest cover, is a major challenge for the agricultural sector in Brazil. Logically, the only way to do that is by increasing (land) **productivity**.

Productivity and innovation. The study highlights that policy making has traditionally differentiated between commercial and small scale agriculture[5]. In **commercial agriculture**, objectives relate to boosting production, while making it more technologically advanced and sustainable. This objective to boost production applies to both commercial and subsistence agriculture, although there is a difference in the type of incentive instruments that are used. These could for example include crediting mechanisms or insurance policies. The study confirms that the growth of the Brazilian agricultural sector over the past two decades has largely been driven by improving **productivity**, and underlines the importance of **innovation** in order to meet the competing needs of productivity and sustainability.

Equity and social protection. The rationale behind **small scale** subsistence family farming policy objectives is equity-driven. It aims to promote the generation of better incomes for family farms, through access to agricultural land, financial resources, knowledge and skills (OECD, 2015). Improvements in productivity are also relevant for **poverty reduction** objectives. Agricultural productivity and efficiency gains are estimated to have reduced by half the real cost of Brazil's average food basket 1975-2010 (OECD, 2015).

Climate Change mitigation. The Brazilian NDC (which has been ratified)indicates a contribution from the Agriculture sector (Federative Republic of Brazil, 2015), while it does not include separate sectoral targets. The Brazilian NDC states the intention to strengthen the Low Carbon Emission Agriculture Program (ABC), as the main strategy for sustainable agriculture development. There are also plans to restore an additional 15 million hectares of degraded pasturelands by 2030, and enhance 5 million hectares of integrated cropland-livestock-forestry systems (ICLFS) by 2030 (Federative Republic of Brazil, 2015).

The main objectives presented in the Plan for the Brazilian agriculture sector (PPA 2016-2019) have been categorized below in Table 5 (PPA, 2015). The **instruments** for meeting these objectives are provided in the Appendix A. , and the main instruments used are credit, insurance and price support, although regulatory measures and trade tariffs are also presented.

Table 5 - The main objectives in the plan for the Brazilian Agriculture Sector

Objectives	Specific objectives cited
Productivity and Innovation (for growth and competitiveness)	• Promote intensive, technological and innovative agriculture; • Develop support and logistical infrastructure;
Equity and social protection	• Promote fairness in the distribution of benefits, income and access of producers to public goods and services,

[5] Indeed, CEPEA's report (the main report of this study) affirms that policy for large scale commercial farming is the responsibility of the Ministry of Agriculture (MAPA), whereas the small-scale farming policy was the responsibility of the late Ministry of Agrarian Development (MDA).

Environmental protection and sustainability	• Establish new standards for a sustainable agricultural sector, seeking to use technology in production systems to expand and incorporate sustainable practices; • Strengthen of agricultural and livestock welfare • Compliance with environmental legislation

Source: (PPA 2016-2019).

1.1.1.1 OECD ASSESSMENT AND RECOMMENDATIONS FOR POLICY REFORM, TO MEET PRODUCTIVITY, SUSTAINABILITY AND INNOVATION GOALS

According to the OECD study, Brazil's biggest challenge today is to sustain the high agricultural growth of the past. This puts an emphasis on the need to maintain cost-competitiveness. Agricultural policy must maintain its emphasis on **productivity** and **sustainability improvements**, which is highly dependent on reducing logistics costs (OECD, 2015).

Increased **innovation** is a key means of achieving this objective. However, there are still significant constraints on conditions for innovation. While new programmes have been introduced to support innovation and investment, this could be better targeted. Current programmes have been distortive, with varying support levels per commodity, which reduce incentives to use production factors more efficiently.

The OECD study also highlights the following policy reforms necessary to meet the governments objectives in this sector, highlighting in particular the role of innovation.

Innovation

- Refocusing rural credit support from distortive, short term lending for working capital for commercial producers, to projects that explicitly incorporate technological innovation, advanced farm management and environmental practices.
- Strengthening direct incentives to innovation in food and agriculture through a number of measures, including by supporting EMBRAPA's capacity and flexibility to collaborate with other research and development (R&D) providers and supporting network actions for awareness raising and providing training opportunities.
- Improving capacity to adopt innovative technologies, highlighting the key role that institutions like EMBRAPA have played in R&D of practical and innovative farming solutions. Also underlining the need to engage the private sector further in R&D.
- Improving the uptake and adoption of innovation among poor farmers, which aim to overcome barriers by providing training and technical assistance.

Poor business conditions.

- Significant improvements in the cost, including the high tax and administrative burden, for doing business are needed.
- Tariffs for intermediate goods (such as technological items for farms) are high.

Addressing structural issues.

- Structural issues include poor infrastructure, capital market scarcity (there is lack of private sector **financing**, since domestic credit is costly and long term credit is scarce), and low overall skills. However, it should be noted that there is significant access to agricultural credit from the public sector, supporting operational costs.

2 POLICY CONTEXT: CLIMATE CHANGE MITIGATION IN AGRICULTURE

The agriculture sector contributes significantly to global emissions, but presents unique challenges regarding climate change mitigation, and consequently the design of climate policies. In Brazil, primary agricultural production contributes approximately 25% of all GHG emissions, and the government intends significant mitigation to come from this sector.

Note that this does not include the closely related land use, land-use change and forestry (LULUCF) emissions, which are not within the scope of the report.

This section begins by explaining the uniqueness of GHG emissions in the agricultural sector, and the challenges of reconciling climate change objectives with the imperatives of productivity and sustainability improvements. Finally, the section provides an overview of the key GHG emission sources in Brazilian agriculture and a high level assessment of the mitigation options of greatest relevance for Brazil, including benefits, risks, and barriers to implementation.

2.1 CLIMATE CHANGE MITIGATION IN THE AGRICULTURAL SECTOR

The agriculture sector is unique with respect to Climate Change mitigation. Unlike other sectors, carbon dioxide (CO_2) is not a key GHG produced. The majority of GHGs from agriculture come from the following sources:

- Enteric Fermentation (methane - CH_4) from livestock
- Manure Management (nitrous oxide N_2O & CH_4) from storage and application of manures and slurries
- Soils (N_2O & CH_4) from cultivation and inorganic fertilizer applications

As such, these emissions can be characterized as arising from **biological processes**, which are **intrinsic** to the farming process.

Note that the agricultural sector also produces energy based emissions, primarily from fossil fuel combustion. However, since these emissions are less significant than the above, and as these emissions are covered in the fuel and energy sector reports, they are not further discussed here. In addition, while agricultural activity is clearly a driver for land conversion, **mitigating LULUCF emissions resulting from agricultural activity is considered outside the scope of this report.**

GHG emissions in agriculture arising from soils and animals occur via biological processes, which are largely outside the control of the farmer. The Australia Institute highlights this example**:** **"***As an example, higher rainfall years may result in higher productivity, carbon sequestration in vegetation and soils and therefore lower emissions. Better quality pastures also provide more nutritious and digestible fodder, improving feed conversion efficiency and thereby reducing methane emissions from enteric fermentation. Conversely, dry years result in low productivity and higher* *emissions. Yet these naturally occurring emissions are* ***largely outside the management control of farmers****. Climate and weather also affect farm management decisions, for example on cropping, fertilizer use and stocking density, all of which have direct implications for emissions*" (Saddler, 2008).

Regional variation is out of farmer's control. An additional implication of this for Brazil is that, the regional variability in climate and natural conditions will affect the responses to management practices, resulting in different emission outcomes in different regions.

The biological GHG emissions in agriculture are "intrinsic" to the process, for which there are no substitutes and therefore fewer abatement options than other sectors. As mentioned, the emissions result from biological processes which are intrinsic to the production cycle (such as methane produced by enteric fermentation in the gut of the cattle) for which there are relatively few substitutes when compared to other sectors, such as the energy or industrial sectors. In electricity production there are many competitive low or zero carbon forms of generation (hydro for example). However, while there may be more or less carbon efficient means of producing soy, the agricultural soil emissions will always be associated with this production. In this sense, there are fewer abatement options in the agricultural sector compared to other sectors.

2.2 Reconciling Productivity, Sustainability, and Climate Change Objectives in Agriculture

This section presents the key drivers and objectives in the agricultural sector internationally, which must be reconciled with sustainability objectives, not limited to climate change objectives. In light of this, key principles for the development climate policy for agriculture can be presented.

The agriculture sector faces significant pressures to grow and minimize costs. Domestically, growth is crucial to meet economic development and employment objectives, and food security objectives require an emphasis on affordability. Internationally, there is demand for agricultural output to rise to feed an increasing population. In addition, the highly competitive agricultural commodity markets place an emphasis on keeping prices down to maintain or improve competitiveness.

These pressures lead to a drive for improved productivity of agricultural activity (also known as intensification of activity) so that resources (land, water, feed) are converted more efficiently into agricultural output.

However, this improvement in productivity must be achieved in a sustainable manner. Sustainability means meeting the needs of the present without compromising needs of future generations, through preservation of (local) natural resources. Within this context **sustainable intensification** is a concept which should guide policy making for the agricultural sector. Sustainable intensification is defined as a process through which *"yields are increased without adverse environmental impact and without the cultivation of more land"* (The Royal Society, 2009).

The emphasis on limiting land-use change is particularly important for Brazil, since agricultural growth is a key driver of land conversion, which represents a very significant proportion of overall emissions.

Climate change mitigation is one aspect of sustainability, and the growth imperative in the agriculture sector means that emphasis should be on improving GHG intensity of production. The sustainability of agricultural activities goes beyond mitigating GHG emissions, including issues such as pollution, biodiversity, animal welfare and land-use change. With regards to GHG mitigation, policy makers should provide incentives to improve the GHG intensity of production, e.g. the GHG produced per tonne of crop, litre of milk or kg of meat, rather than impose absolute limits on emissions. Since emissions are intrinsic to the production process, and output must grow, growth in emissions is expected. The complexity of meeting multiple sustainability criteria is significant, as there are many competing requirements. Furthermore, actions to address one sustainability goal may have a negative impact on another. For example – intensification of livestock production systems to reduce GHG emissions increases the risks associated with water and air quality through increased concentrations of ammonia, nitrates and phosphates.

However, a narrow focus on improving GHG intensity at a farm level may have detrimental impacts on sustainability and overall climate change mitigation. The agricultural sector has complex interdependencies, and incentives for efficiency improvements to drive down GHG emissions might encourage less beneficial supply chains from a GHG and a societal perspective, as shown in Box 1 below. Further risks associated with improved productivity include harming deforestation, biodiversity, water, soil and air quality and animal welfare in the sector.

Box 1: Risks of poor quality mitigation measures: Example of Nutritional Supplementation

A possible measure to improve the productivity of cattle farming is through nutritional supplementation. Concentrate supplementation and protein supplementation are both options being considered in Brazil. Depending on the source of protein however, this may actually lead to an increase in GHGs in the long term.

For example, if soy content in cattle diet will be increased to increase productivity, either soy will be diverted into feed for livestock rather than for human consumption or there will be an increased demand for land for soy production leading to deforestation. While soy (which contains protein) can be consumed directly by humans, when it is diverted from the human supply chain and put through an intermediary to produce protein in another form, this is a major inefficiency in the supply chain. In basic feed conversion terms (feed conversion is the rate at which an animal can convert its feed in to commercial product) cattle are the least efficient, at a conversion rate of approximately 6kg of food in 1kg of meat, whereas fish are the most efficient (approximately 1.2:1) followed by chickens (approximately 1.8:1).

This inefficiency in the supply chain means that diverting soy to cattle diets will increase demand for soy, which may result in increased pressures for land conversion and deforestation. As such, it does not meet the requirements of sustainable intensification, as short term and farm-level gains in GHG intensity may actually increase GHG economy wide, in the long term.

As such, "high quality" mitigation options, which meet sustainability criteria over the long term, and have synergies with improved productivity, should be prioritized. The assessment of mitigation options for agriculture requires a wider assessment considering these multiple criteria (also known as an externality assessment), including the following:

- Environmental: Adaptation, pollution, biodiversity
- Animal welfare
- Land-use change – short medium and long term
- Productivity
- Competitiveness and trade
- Barriers to the uptake of these options (technology, finance, capacity and culture)
- Social equity

In some cases, the choice of some mitigation options could be strictly excluded, because they do not allow adaptation or have harmful impacts on e.g. the environment, poverty reduction, employment, trade-balance. Sustainable intensification options which have positive climate impacts (such as more efficient use of fertilizers, or maintaining good soil structure) should be prioritized. These examples can also have important adaptation co-benefits, for instance soil protection by reducing erosion, improved water quality by limited leaching of nitrates and improved air quality by reducing ammonia emissions. In addition, long term and economy wide impacts of the mitigation measures should also be taken into account, rather than a narrow focus on short term and farm level impacts.

While improvements in productivity may support sustainability and climate goals, this must exist within a framework of regulatory safeguards. Safeguards can restrict conversion of marginal and forest land to avoid significant adverse effects in the long term. In Brazil, growth of the agricultural sector is one of the main drivers of deforestation.

Increasing the productivity of beef production could free up land for arable expansion. GGGI's 2010 study affirms that a shift from extensive to intensive cattle farming could free 68 million hectares of land (Green Growth Institute, 2010). However, it is uncertain what impacts this would have on net emissions[6] and on the drivers of deforestation. Regarding deforestation, in theory intensification could increase the amount of land available for agricultural expansion without driving deforestation. However, as the value of marginal land increases as a consequence of the increased productivity of arable land, so do the incentives for conversion. As such, a robust environmental framework with a clear and enforceable regulatory approach to preventing land conversion is required. For example, the enforcement of Brazil's Forest Code is fundamental to protecting existing forests from pressures of land conversion driven by agriculture, preventing further land-use change.

[6]Grassland is also a sink and the emissions from soil from the cultivation of 68m ha of grassland would be significant, so the suitability of this land for cultivation would need to be assessed.

2.3 GHG emissions in Brazilian Agriculture

Agriculture is a major contributor to Brazilian GHG emissions, with animal farming as the main source. Appendix B. provides an overview of GHG emissions in the Brazilian agriculture sectors. The key points are that 25% of 2014 GHG emissions in Brazil came from agriculture, and of these emissions, 60% of emissions were from enteric fermentation (methane) from animal farming, followed by 35% from agricultural soils (nitrous oxide) (Food and Agriculture Organization of the United Nations, 2017).

While agricultural productivity has improved, emission intensity has mixed results. Between 2005 and 2012, the emissions per kg of produce from cattle have decreased, indicating that the productivity per head of cattle has increased in this period, resulting in a lower emission intensity (OECD, 2015). For agricultural soils, although productivity improvements have been achieved through technological improvements, emission intensity has not improved due to high fertilizer use (OECD, 2015).

Cattle rearing and agricultural soils are expected to continue being main contributors to future agricultural emissions. GHG emissions from agriculture in Brazil are expected grow in absolute terms by approximately 30%. The main sources of emissions are expected to remain cattle farming, synthetic fertilizer application and manure left on pasture. Growth is principally driven by global population growth and development, and changing eating habits.

2.4 High level Assessment of Relevant Mitigation options

Table 6 provides a high level assessment of relevant mitigation options for Brazil, including benefits, risks, and barriers to implementation. A short list of the priority mitigation options was defined using the options presented in a 2010 study by the Global Green Growth Institute (Green Growth Institute, 2010), and confirmed by CEPEA's team. Appendix B. provides full details on these options, including abatement potential and costs and key considerations for Brazil.

An understanding of the barriers to implement mitigation options is fundamental to select the appropriate policies and instruments to incentivise the adoption of measures. Typical barriers include the availability of technologies and access to financing for capital intensive projects. In addition, mitigation options can be characterized as "practice based". This implies that cultural changes may be necessary, changing the ways that things have been done for generations. There is also the question of whether farmers have the capacity to understand and implement mitigation options.

Table 6 - Overview of relevant mitigation options, associated opportunities and risks and barriers to implementation

Mitigation option and technologies	Benefits & risks	Barriers to implementation
Nutritional supplementation for direct mitigation of enteric fermentation and intensification of cattle farming. Examples include the use of growth promoters such as Ionophores (a type of antibiotic) and food additives, such as probiotics, propionate precursors, fat supplementation. Growth promoters improve production efficiency by reducing the age at which animals can go to market and thereby the emissions per kg of product produced. Alternatively, probiotics and propionate precursors can reduce the amount of methane produced by the animal by acting on gut processes.	**Benefits** **Productivity.** Use of ionophores and probiotics are complementary to productivity improvements. Fat supplementation is not, however. Propionate precursors can reduce methane production in animals by reducing the amount of available hydrogen in the gut to form methane molecules. Their effect on animal performance and productivity is either neutral or enhancing (O'mara, 2004). **Risks** **Use of ionophore may affect export market**. The EU has banned ionophores due to fears over prophylactic use of antibiotic treatment leading to resistance. This is not an issue for the remaining nutritional supplements. **Sustainability**. Could potentially divert food (e.g. soy production) from the human supply chain to more inefficient animal feed supply chains, leading to long term increases in CO_2 emissions. In ranch based systems this is less likely to be a problem, but in housed livestock systems, soy is likely to be used as a protein source. **Effectiveness.** Resistance may develop in cattle leading to reduced effectiveness of Ionophores, and adding to antimicrobial resistance concerns.	**Costs.** Fat supplementation and propionate precursors are particularly costly; probiotics and ionophores less so (O'mara, 2004). **Capacity.** Capacity building and dissemination of the measures are required in order to support the farmer. **Technology.** Ionophores require further research into their long term effectiveness, their palatability and their effect on antibiotic resistance risks (this was the reason for a ban on usage of ionophores in the EU). Probiotics have limited evidence to date on their effectiveness due to their limited use. **Feasibility**. It is very difficult to control and administer feed additives in pasture based ranch systems, therefore there is limited feasibility in such systems. In particular, the use of supplements may be very costly for small producers. It is much easier to manage rations and feed intake in housed/confined management systems so application would be easier, as experienced in the United States. However, housed systems compared to ranch systems are costly to establish and have environmental impacts on water and air quality and have potential animal welfare implications.
Intensification of cattle farming through improved pasture and grassland nutrient management	**Benefits** **Productivity** - positive impacts. **Risks**	**Costs**. Although additional costs will be incurred, potential cost savings overall. **Capacity.** Capacity building and dissemination of the measures are required in order to support the farmer. There may also be cultural

This includes measures such as land rotation, control of weeds and pests with herbicides. Matching with efficient use of fertilizer to reduce N_2O emissions per output	**Increased emissions.** Increased use of fertilisers may lead to an increase in emissions through increase in N_20. If the aim is to improve grassland to **intensify** production then the likelihood is that increased fertiliser is required to reach optimal production. **Risk of increasing land conversion if not adopted within a framework of environmental safeguards**. While an improvements in efficiency are desirable, the action might not lead to reduced land-use change - in fact it could have the opposite effect as more marginal land looks more attractive and financial margins improve with efficiency. Therefore, it is imperative that incentives for improved efficiency exist within a regulatory framework of environmental safeguards for forests and marginal lands.	resistance to innovative practices.
Genetic Improvement of livestock Selecting the most appropriate traits in livestock is good practice and will lead to long term improvements in productivity. Genomic monitoring help identify traits for selection accurately. We will consider genetic improvements for productivity here and not discuss improvements in lower methane producing animals, due to wider availability and application of the first approach.	**Benefits** **Productivity.** -–Long-term genetic improvement programme can lead to improvements in the productivity and GHG intensity of the beef farming system **Health benefits.** Improvements in general herd health, eradicating disease and improvements in health systems.	**Cost.** Relatively low cost. **Technology/capacity.** Long timescales for improvement. Requires understanding of appropriate breeds, capacity building and dissemination of measures.

Agroforestry Land use management system in which trees or shrubs are grown around or among crops or pastureland, e.g. integrated cropland-livestock-forestry systems. (Note, this will focus on the expansion of agroforestry systems, rather than the retention of them, as retention can be covered through a forest code).	**Benefits** **Productivity.** Benefits include productivity improvements for cattle farming and crops / woodland. **Co-benefits** include additional income from forestry. **Sustainability**. Improvements of carbon in the soil.	**Costs**. Capital costs of tree planting and possible reduction in land available for primary production. **Technological.** Research and understanding of the appropriate agroforestry systems which support productivity. The permanence of the change is a barrier so benefits must be conveyed and backed up by research **Capacity / Cultural**. Significant cultural barriers to increase of woodland in crop or pasture land, since introducing trees into agriculture systems is perceived as reducing productivity. Capacity building and dissemination of measures is also required, there is generally a lack of perceived benefits.
No-till farming Less tillage could potentially reduce erosion and increase moisture and nutrient retention, and improve carbon stocks in the soil.	**Benefits** **Productivity.** Complementary to productivity and beneficial for the farmer – less machinery, improvement of soil quality, maintaining soil moisture. **Risks** Weed control / herbicides risks – no tillage systems rely more heavily on herbicides to control weeds. In Europe this has led to weed species with resistance to herbicides.	**Costs**. High upfront capital costs. **Technology**. Relatively mature, however practices may require dissemination. **Capacity**. Capacity building and dissemination of the measures are required in order to support the farmer

Source: Ricardo Energy & Environment.

3 POLICY INSTRUMENTS FOR GHG MITIGATION IN AGRICULTURE: CARBON PRICING INSTRUMENTS

This section begins with an overview of the international experience regarding the implementation of CPIs in the agriculture sector, before presenting four in-depth case studies of carbon pricing in New Zealand, British Columbia (B.C), Australia and an international multilateral fund.

3.1 OVERVIEW OF INTERNATIONAL EXPERIENCE WITH CARBON PRICING IN AGRICULTURE

A wide range of carbon pricing approaches could in principle be applied to the agricultural sector. This report focuses on emission trading schemes (ETS), carbon taxes (CT), crediting mechanisms and results based financing (RBF) mechanisms[7]. Table 7 identifies examples of international CPIs implemented with the objective of incentivising the mitigation options of relevance to Brazil (selected in Section 2.2).

Appendix C. provides a conceptual introduction to crediting mechanisms and RBF, and a high-level comparison of the advantages and disadvantages of each instrument according to basic criteria (CPI effectiveness, acceptability and feasibility). The rationale for including crediting mechanisms and RBF is explained below.

Crediting Mechanisms. As Table 7 shows, crediting mechanisms are the most widely used CPIs in the agriculture sector. Credits may be sold into compliance and voluntary markets, nationally or internationally. Brazil has considerable experience with crediting mechanisms such as CDM as demonstrated in Appendix 0, although CDM activity has tapered off significantly since 2012.

RBF. Results Based Financing mechanism are presented as they are a potential source of demand for emission reduction credits, and can be funded through revenues recycled from an ETS or a CT. The provision of financial credit to the agriculture sector is a key policy instrument in Brazil. As such, the institutional capacity may already be in place to develop such a RBF fund.

[7]RBF mechanisms can be understood as mechanisms to create demand and provide funding for carbon crediting projects

Table 7 - Overview of current use of carbon pricing instruments to incentivise the selected mitigation options in the agriculture sector

Priority mitigation option	Carbon Pricing Instrument			
	Emission Trading Schemes	**Carbon Tax**	**Crediting Mechanisms**	**Results-based Finance**
Nutritional supplementation			Many examples. Is included in Clean Development Mechanism (CDM) methodology (e.g. feed supplementation for dairy sector for increased productivity (UNFCCC, 2017)) and In positive list of **Australia Carbon Farming Initiative** (Australian Government Department of the Environment and Energy, 2014)**.**	
Genetic improvement of livestock	No existing examples. However, ongoing plans in **New Zealand ETS** to develop an MRV system for data collection as first step to incentivise this and other agriculture mitigation and options (Kerr & Sweet, 2008).			
Improved pasture and grassland nutrient management		**British Columbia carbon tax (2008-2012)** covered farm fertilizers, intended to incentivise this mitigation option (Skolrud, 2015).	Many examples, is included in CDM methodology (e.g. inoculant fertilizer application in grassland (UNFCCC, 2017)) and In positive list of **Australia Carbon Farming Initiative** (Australian Government Department of the Environment and Energy, 2014).	
Agroforestry: integrated cropland-livestock-forestry systems			Many examples, is included in CDM methodology (e.g. inoculant fertilizer application in grassland (United Nations Framework Convention on Climate Change, 2014)) and	**BioCarbon Fund** covers agroforestry projects specifically (Department of

			In positive list of **Australia Carbon Farming Initiative** (Australian Government Department of the Environment and Energy, 2014)	Energy & Climate Change, 2015).
No-till farming			In positive list of **Australia Carbon Farming Initiative,** and the existing **British Columbia** crediting mechanism (Australian Government Department of the Environment and Energy, 2014).	

	Existing examples identified		Past example identified		No example identified

Source: Ricardo Energy & Environment.

Carbon pricing instruments. Table 7 shows that no examples of ETS and CT systems with the objective of mitigating biological emissions from agriculture (through selected mitigation options) have been identified. Both New Zealand and British Columbia (B.C.) have made attempts at including the agriculture sector in the CPI, but ultimately decided to remove these[8]. On the other hand, numerous examples of crediting mechanisms can be identified, such as the Australian Carbon Farming Initiative. Finally, one example of a RBF mechanism linked to emission reductions in agriculture has been identified – the BioCarbon Fund. These case studies are presented in the following sections.

Alternative instruments. Section 6 presents alternatives to carbon pricing for incentivising these mitigation options. For instance, it is worth noting that there are numerous international examples of policies providing financial incentives and advisory services to farmers. Examples include the direct payments in the European Union's Common Agricultural Policy (see EU CAP in Appendix 0), although these are not linked to verified emission reductions.

3.2 International case studies of Carbon Pricing in Agriculture

The case studies presented in Table 8 were selected to provide a comprehensive overview of international experience in the implementation of CPIs in the agriculture sector. Each case study analyses different interactions when introducing CPIs into the agricultural sector and the effects on the competitiveness of the sector, the GHG emissions, the objectives of existing agricultural policies, their

[8] Since 2017, the New Zealand ETS also covers energy and transport fuels consumed by the agriculture sector.

distributional impacts and whether any of these impacts were taken into account in the design of the policy.

Table 8 – Overview of CPI case studies

Jurisdiction	Carbon pricing instruments & key dates
New Zealand	**2008**: Emission Trading System established (New Zealand Government MfE, 2009) **2009**: Methane and nitrous oxide emissions from agriculture planned to be included in ETS from 1 Jan 2015 (New Zealand Government MfE, 2009) **2012**: Mandatory reporting on agriculture emissions (Ministry for the Environment in New Zealand, 2012) **2013**: New government indefinitely excludes agriculture from NZ ETS (Leining & Allan, 2017). **2017**: stationary energy and transport emissions from agriculture are exposed to ETS costs (Leining, Allan, & Kerr, n.d.).
British Columbia	**2008-2012:** Carbon Tax (Rivers & Schaufele, 2014) **2008:** Crediting Mechanism implemented
Australia	**2011:** Australia Carbon Farming Initiative, Crediting Mechanism, implemented (Australian Government Department of the Environment and Energy, 2012a)
International/ Multilateral	**2013:** Results Based Financing BioCarbon fund implemented (Department of Energy & Climate Change, 2015)

Source: Ricardo Energy & Environment.

3.3 Emissions Trading and Agriculture: the case of New Zealand

New Zealand is one of the few countries to have considered including the agricultural sector in an ETS (Vivid Economics, 2017). The agricultural sector in New Zealand was responsible for approximately 4.2% of GDP in 2013 with dairy as one of the most important products. 47.4% of total emissions in New Zealand come from agriculture, of which 65% comprise enteric fermentation, 33% come from agricultural soils and 2% from manure management in 2013.

As these emission compositions for the agricultural sector are comparable to Brazil's and as extensive studies have been carried out on the possible impact of including agriculture in the ETS, New Zealand was chosen as a case study for this research.

3.3.1 Agricultural policy objectives and instruments in New Zealand

New Zealand's agricultural policies were radically transformed and liberalised in 1984 to promote productivity in the sector and encourage growth in the rest of the economy. The liberalisation included the phase-out of subsidy programmes for agricultural products.

Half of New Zealand's total exports come from the agriculture sector. These exports are sold into highly competitive global commodity markets. New Zealand's liberal trade policy makes such exports vulnerable to global market fluctuations. Domestic prices for agricultural products in New Zealand are in line with world prices. The government only makes payments for animal disease control and relief in the event of large-scale climate and natural disasters via insurance policies (Agriculture and Horticulture Development Board, 2016).

Recently the government has introduced policy frameworks to ensure land and water quality. These include producer levies for quality assurance and animal and plant health. Producer unions can decide how these levies are spent and recycled, although payments for trade have been excluded. The liberalised agricultural sector in New Zealand aims that the market will take the responsibility of managing environmental risks (Aerni, 2006).

3.3.2 Emission Trading Scheme in New Zealand

The design of the ETS in New Zealand was unique at the time it was implemented, as it aimed to cover all sectors and gases. **Although New Zealand extensively considered the inclusion of the agricultural sector, it ultimately decided not to do so**. The reasons behind this final decision are explained in this section.

Overview. The ETS in New Zealand was implemented in 2008 as the government's principal policy response to climate change. The scheme requires participants from sectors covered by the ETS to surrender emission units for their emissions (NZUs or carbon allowances). Just over half of the country's GHG emissions are now covered by the NZ ETS. A transitional phase was implemented in the beginning of the ETS whereby participants could surrender only one emission unit for every two tonnes of CO_2e, i.e. the one-for-two surrender obligation (New Zealand Government Ministry of the Environment, 2010). In 2008 the ETS was designed and implemented without an absolute cap. There was no limit to the amount of international carbon allowances that could be acquired under the scheme. The purpose for this cap design mechanism was to enable the inclusion of carbon sequestration from forestry activities and to strengthen the link with international markets. However, the price level of the allowances was fixed. This mechanism was later changed to a fixed cap whereby allowance supply is limited to domestic units.

Design of the ETS for the agriculture sector. In 2009, the government established a plan to include Methane and nitrous oxide emissions from agriculture planned to be included in ETS from 1 Jan 2015

(New Zealand Government MfE, 2009). The following design choices are highlighted as they were intended to mitigate the negative impacts on the agricultural sector in New Zealand.

Mixed point of regulation. The government's preference was to assign the point of regulation (POR) at a downstream point for emissions from enteric fermentation and manure, by placing the obligation on dairy and meat processors. In addition, emissions from nitrogen fertilizers would be regulated upstream, by placing an obligation on fertilizer producers and importers. The inclusion of importers aimed to avoid giving a competitive advantage to high emission products, in this case fertilizers. This is effectively a form of border carbon adjustment.

This mixed point of regulation was intended to reduce administrative costs and avoid negative impacts on individual farmers by not placing the obligation on them. Regarding the latter, this is due to high costs related to managing liabilities, time spent on understanding the emissions pricing and trading processes, and facing other barriers to implementing mitigation options, such as lack of finance or knowledge that are not solved with a carbon price (Kerr, 2016).

Nevertheless, this choice of POR has several disadvantages. Namely, placing the POR downstream does not provide an incentive for increased productivity (and therefore improvements in GHG intensity of production) and, by regulating entities who have no control over emissions, this provides only a weak and indirect incentive for GHG reduction. This has been fully explained in Section 5.

Distribution of allowances in agriculture. At the introduction of the ETS in 2008, the plan was to freely allocate allowances to the agricultural sector. This allocation level was based on 90% of 2005 emissions in New Zealand. The free allocation would then gradually be phased out and end in 2025.

MRV and data system. In 2012, the government established mandatory reporting on agriculture emissions (Ministry for the Environment in New Zealand, 2012). New Zealand now conducts a national inventory annually that includes data on emissions from the agricultural sector. It uses detailed livestock population data together with productivity data to estimate feed intake for beef, sheep, deer and dairy industries. Productivity data is calculated from slaughter weight and live weight of livestock. This data is difficult to collect and often includes many assumptions as described in Box 2.

3.3.3 Expected impact of ETS on GHG emissions

In order to explain the expected emissions reductions from the introduction of an ETS, an overview of the trends in productivity and competitiveness, as well as the key drivers for this, is first provided.

Emission and productivity trends. New Zealand emitted 80.2 million tonnes of CO_2e in 2015. 47.9% of those emissions (38.4 million tonnes CO_2e) came from agriculture (Ministry for the Environment in New Zeland, 2017). From 1990 to 2014 emissions from agriculture in New Zealand increased by 15% as can be seen in Figure 1. In the same period, the livestock population held for dairy increased by 94.7% and the application of nitrogen-containing fertilizer increased by more than 500%. However, between 2006 and 2008 the total emissions from the sectors decreased. This has mostly been attributed to a drought that generated a significant reduction in sheep and cattle populations. From 2008 onwards, after the introduction of the ETS, emissions from agriculture have increased steadily. This was due to higher global demand for New Zealand's agricultural produce and favourable growing conditions (Ministry for the Environment, 2016).

However, the difference in rates of increase between emissions and cattle and sheep population shows that significant GHG intensity improvements occurred during this period as well.

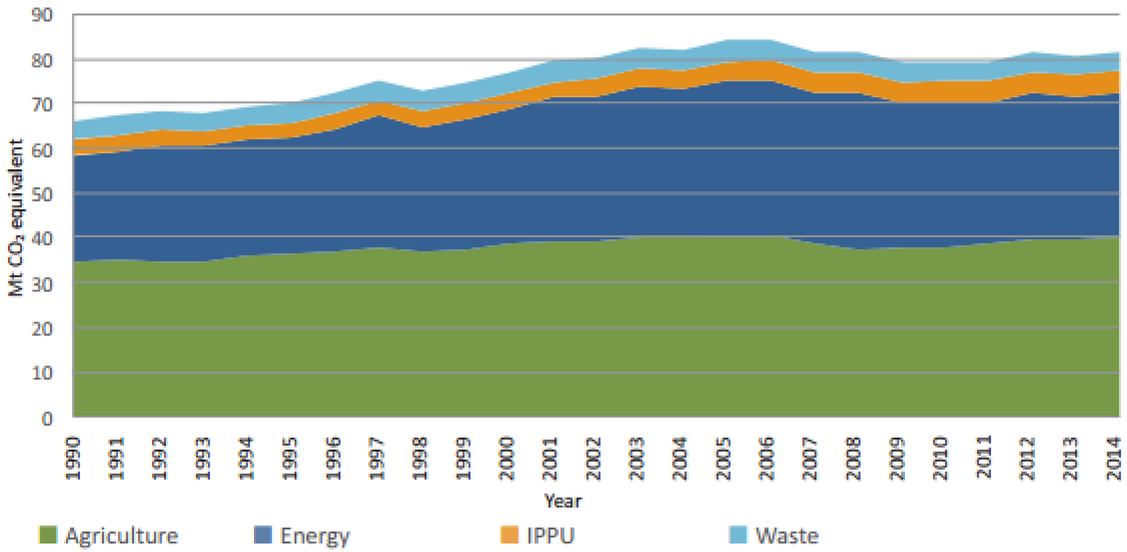

Figure 1 - New Zealand's GHG emissions per sector from 1990 to 2014 (Ministry for the Environment in New Zeland, 2017)

Over the period 1990-2014 productivity of farms in New Zealand increased significantly. This has been attributed to the take up of new technologies and practices, for example vaccines and inhibitors, and through more optimization of land use. The dairy sector has improved efficiency over the last decade by 1% per year. However, this increased productivity has also been associated with negative trade-offs such as decreased water quality. This underlines the importance of taking a holistic approach for emission reduction policies in agriculture.

Limited mitigation options. The available mitigation options to reduce exposure to the ETS are limited in New Zealand. The main abatement options for farmers in New Zealand were either constraining the growth of the sheep population or decreasing the emission intensity. The main method of decreasing emission intensity is through reducing the dry matter intake of animals by fattening the animals over shorter periods of time with higher energy feed, and slaughtering them at an younger age.

Other measures include selective breeding of low-emitting cattle and sheep that could potentially reduce 8-15% of emissions per kg of product and changing ruminant diets towards different grasses or fats (expected 4% reduction), improving management of animal waste could reduce 5% of emissions. Others include the use of vaccines and inhibitors that could reduce 30% of emissions per animal, but these technologies are not available yet. For the agricultural soils there are a few more options for mitigation, including altering the timing and amount of fertilizer that is applied on the land to enhance its uptake and reduce emissions (Kerr & Sweet, 2008).

Nonetheless, **studies have estimated that if mitigation options which have synergies with productivity (as mentioned above) are available and can be implemented, an ETS of 25 USD per tonne of CO_2e could lead to 20% reduction of GHG emissions from agriculture between 2008 and 2020**. These emission reductions are expected to come from animal breeding, switches in animal feed, nitrification inhibitors, conservation tillage and carbon sequestration by afforestation of agricultural land. However, these estimations are based on assumptions on technology improvements and innovation that have not been proven yet (Saunders, Saunders, & Kaye-Blake, 2011).

Barriers to mitigation. The barriers to implement these mitigation options include the lack of finance and knowledge, the highly context-specific outcomes of these measures and therefore a need for close monitoring and the management of all these processes by many diffuse agents. The lack of finance and knowledge shows that a CPI might not be the correct measure to promote the uptake of these mitigation measures. Moreover, many of these mitigation options also require sustained efforts over long-term periods to have full effect, e.g. selective breeding. An early move to develop these technologies could therefore bring competitive advantage for the agricultural sector in New Zealand.

3.3.4 EXPECTED INTERACTION WITH EXISTING AGRICULTURAL POLICY OBJECTIVES AND INSTRUMENTS

Competitiveness and distributional impacts. The primary objective of agricultural policies and instruments in New Zealand is to protect the competitiveness of the sector. It was expected that the ETS would hinder this competitiveness significantly. A study carried out in 2011 (Davison & Keogh, 2011) shows that if no significant technology breakthroughs or changes in food world prices occur in the coming years - especially in the sheep and beef sectors (as compared to arable and dairy sectors) - the agricultural sector would be heavily impacted by a CPI.

With a carbon price of 25 USD per tonne of CO_2e and with the free allocation of 90% of allowances it was expected that costs of the ETS would be about 6% of farm profit before tax for beef and sheep, 2% for dairy producers and 0.5% for arable farms. However, with no free allocation these would be 67%, 22% and 7% respectively (Saunders et al., 2011). With no farm subsidies in place in New Zealand, the selling price of agricultural products is directly linked to international prices. Overall, it has been estimated that a carbon price of 25 USD per tonne of CO_2e would bring a cost of 130 million USD on farmers per year, with the risk of making the sector uncompetitive (Saunders et al., 2011).

Leakage. It has also been estimated that these increases in costs will lead to a high leakage of agricultural production from New Zealand and perhaps also a burden on the high-growth industry of horticulture. However, this needs to be studied in more detail (Kerr & Sweet, 2008).

3.3.5 Excluding Agriculture from ETS and alternative GHG mitigation instruments

Following the assessment of expected impacts of the ETS on the agricultural Sector above, the New Zealand government has ultimately decided to exclude the agriculture sector from the NZ ETS (Leining & Allan, 2017). The following key reasons were given:

- It was expected the ETS would have a significant negative economic impact on the agricultural sector.
- There were concerns around access to international carbon markets for allowances for the agricultural sector
- There were concerns that agricultural production that heavily depended on export markets would move to other countries, i.e. leakage.
- The high administrative burden for many diffuse agents relative to the limited emission reductions expected from the sector when including it in the ETS.

Alternative instruments. While it was decided not to include the agricultural sector in the New Zealand ETS, the government is taking alternative mechanisms for supporting the reduction of GHG in this sector into consideration. The government is also aware that many emission reductions in the agricultural sector could also deliver other co-benefits in line with its agricultural policy objectives. These include the improvement of water quality, stabilizing river banks, improving soils and biodiversity and other environmental benefits by reducing livestock production.

Considering an ETS with a threshold size for participation. Despite the exclusion of agriculture from the ETS, an alternative approach suggested by a New Zealand research institute, is an ETS for the agriculture sector with a size threshold for participation, excluding small farmers (Kerr & Sweet, 2008). This could potentially reduce negative impacts of the ETS on small farms. In an ETS where the POR is at the farm, smaller farms run the risk of being disproportionally affected by a CPI as transaction costs as percentage of total carbon price may be much higher compared to larger farms. The scheme would therefore consist of an ETS for the agricultural sector with the POR at the farm, excluding small farmers and using the existing MRV system for the agricultural sector in New Zealand. Under such an ETS, the exemption to surrender allowances and the free allocation of allowances would be matched to different tranches of farm size. The farm size and associated tranches in this scheme could be determined according to various criteria, including 1) historical emissions of the farm, 2) land size and 3) historical output or production of the farm. The underlying assumption for these categorizations is that the tranches will correspond directly with the amount of emissions from each farm. The CPI will then be designed in such a way that only high emitting farms over a certain threshold are obliged to participate and will need to pay the associated costs of the CPI.

When considering a mechanism with a threshold farm size for participation for Brazil, it needs to be taken into consideration that in Brazil farm size does not always correlate with the level of emissions of that farm. This is because there are a number of farms in Brazil that are small scale, but which use intensive farming operations and thus have higher emission levels. Moreover, these small farms are often the most productive. Therefore, careful consideration needs to be given to the design of thresholds to ensure they correctly correlate with the emission intensities of farms.

In addition, the **MRV and data system is still under implementation**, which is a fundamental step for future development of a CPI for this sector see Box 2.

In 2017 it was decided that stationary energy and transport emissions from the agricultural sector would be exposed to ETS costs with immediate effect (Leining & Allan, 2017).

Box 2: Reporting GHG Emissions from agriculture under the New Zealand ETS

Agriculture reporting under New Zealand ETS. Agriculture has 'reporting without surrender' obligations under the New Zealand ETS. Although biological emissions are not covered by the ETS (no obligation to surrender allowances), a mandatory emission reporting requirement is in place. In addition, a yearly GHG inventory covering agriculture under United Nationals Framework Convention on Climate Change (UNFCCC) reporting requirements is submitted each year by New Zealand.

Objectives. The objective of mandatory reporting and calculating farm level emissions under the ETS is to increase awareness of GHG emissions associated with agricultural production, in order to stimulate the uptake of practices that reduce the emissions intensity (Ministry for the Environment, 2016). In addition, the reporting framework aims to overcome the data barriers associated with possibly including agriculture in the ETS in the future (Ministry for Primary Industries, 2012b).

Key considerations. The stated focus of emission reporting is on "efficiency of production", acknowledging productivity is a key driver for agricultural reporting. The system balances accuracy, timeliness and cost effectiveness. It seeks to avoid overburdening farmers with information requests by cross-linking reporting requirements with existing information.

Point of reporting obligation. The point of obligation for reporting emissions was assigned to the processor level for livestock emissions and at the manufacture or import level for emissions from fertilizers (Leining & Allan, 2017). The reason for this assignment was both to minimise administrative costs by keeping the amount of participants in the system low and to simplify the verification and compliance process. However, this was a contested choice as stakeholders have previously expressed a preference to assign the point of obligation to the farm-level. They have argued that a point of obligation on the processor level would only function as a 'per-kilogram levy' with limited possibility to incentivise farmers to adopt mitigation options. Therefore, the design of the MRV system has incorporated flexibility to change the point of obligation at a later stage by order in council. As of the end of 2016, there are 80 points of obligations in New Zealand for biological emissions from agriculture.

Scope of reporting. Of the 80 entities reporting on emissions, 43 conduct animal slaughter, 12 export livestock, 11 import or manufacture synthetic fertilisers containing nitrogen and the remainder 14 process dairy milk or colostrum. There are several exemptions under the reporting requirement including animal slaughter not for human consumption, egg production (although chicken slaughter is included). Only dairy processing over 500 tonnes of milk solids per year is included, wool-related emissions and deer velvet production are exempt.

Data requirements. Data reported includes animal number and their classification, amounts of fertilizer, breeds of animals, milk protein and weight of fleece or other products. Farmers can also choose to voluntary report on additional information including live and carcass weight of animals, feed type and their digestibility, the use of nitrous oxide inhibitors or manure management and the soil type.

Accuracy. The government has expressed concerns that reporting for the ETS underrepresents emissions by about 3.7% per year when compared to estimates for the agricultural sector from the national inventory. They have attributed these differences to the above outlined exemptions for reporting under the ETS, exclusion of on-farm deaths, retail butchers and home kill and the inherent variability of biological emissions (Ministry for the Environment, 2016).

3.4 Effects of carbon pricing on inputs to the agricultural Sector – the Case of British Columbia

Globally, where a CPI has been introduced, emissions directly and uniquely associated with agricultural processes (enteric fermentation, loss of soil carbon) have been outside the boundary of the instrument (for reasons discussed in section 2.1). **However, a CPI can indirectly increase the price of certain agricultural inputs by influencing energy and other input prices.** The impact of a CPI driven change in energy and input prices on the agricultural sector will be discussed in this section.

The British Columbia example has been chosen as a case study. The CPI introduced in this jurisdiction had two phases which are of high interest. Firstly the 2008-2012 period, when the carbon tax covered inputs for the agricultural sector, such as electricity, fuel and fertilizers. Secondly, from 2012 onwards when these inputs were excluded from the tax (Rivers & Schaufele, 2014). This case study demonstrates the effect of a CPI on farm input prices.

Furthermore, the agricultural sector in British Columbia had several options to earn carbon credits via offsetting mechanisms during and after the time of the introduction of the CPI (Bakker, 2011). This included both a scheme whereby the B.C. public sector aimed to be carbon neutral and used (agricultural) offsets to achieve this (i.e. the Carbon Neutral Government Program from 2010-2014) (Community Research Connections, 2012) and a voluntary market (Technology, Cull, & Forum, 2012).

3.4.1 Agricultural policy objectives and instruments in B.C.

The main objectives of agricultural policies in Canada and British Columbia are enhancing the sector's competitiveness by "achieving sustainable agriculture and agri-food growth and fostering rural opportunities" - and security through "realizing long-term financial security, attaining resource and environmental sustainability and maintaining a safe, high quality food supply" (Barichello, 2000). These objectives and the historic trends of policies in Canada illustrate that since the 1970s B.C. has been promoting stabilization of markets, prices and incomes rather than prioritizing the increase of farmer incomes or decrease of food prices. This emphasis on stabilization is due to Canada's weather risks, its dependence on fluctuating world markets, and the few insurance options available in B.C. Moreover, over time B.C.'s agricultural policies have increasingly been focused on competitiveness and on environmental objectives including biodiversity and animal welfare. However, environmental sustainability goals are mostly perceived to fall under the responsibility of the market place to reduce risks rather than under government responsibility.

Instruments to promote the goals of competitiveness and security in B.C. include:

- Safety net programs to stabilize farmer incomes
- Revenue insurance plans, e.g. crop insurance
- Input subsidies especially for the dairy sector
- Supply management through import quotas, domestic quota system and set domestic prices that reflect changes in farm costs
- Sustainable agriculture payments for soil and water quality and biodiversity

Agriculture consists of about 6% of exports from B.C. for a value around 2 billion dollars and is responsible for 0.6% of the provinces total GDP in 2015 (British Columbia Government, 2015). The economy of B.C. as a whole is therefore less vulnerable to global price fluctuations of agricultural goods than New Zealand's economy. However, the agricultural sector itself is equally dependent on global price fluctuations as compared to New Zealand's agricultural sector.

3.4.2 The B.C. Carbon tax and Crediting Mechanism

The British Columbian carbon tax rate was introduced in 2008 at 10 USD per tonne of CO_2e. It was then gradually increased by 5 USD every year to a price of 30 USD per tonne of CO_2e in 2012. The tax was applied to all fossil fuels based on their carbon content and it was designed to be revenue neutral through reductions in personal income and corporate taxes. It was expected to cover 70% of B.C.'s GHG emissions. When introduced the point of regulation of the carbon tax was set at the retail consumption level (British Columbia Government, 2016). Thus, the extent to which the carbon tax affects the price of farm inputs, and therefore the farmers' income is dependent on how much of the carbon price costs from the point of regulation is passed on downstream (e.g. fertilizer production).

In addition to the Carbon Tax, a crediting mechanism was introduced in B.C. in 2008. This initiative is called the Carbon Neutral Government Programme and the first projects under this scheme earned credits in 2010. This consisted of both a system whereby the B.C. public sector aimed to be carbon neutral and used (agricultural) offsets to achieve this (i.e. the Carbon Neutral Government Program from 2010-2014) and a voluntary market since the 2000s (Community Research Connections, 2012). The Carbon Neutral Government Program aimed to make all public institutions in B.C., including government buildings, schools, universities and health authorities, carbon neutral by 2010. In order to achieve this, B.C. allowed the Pacific Carbon Trust, a state-owned company, to source and supply domestic carbon offsets to the market place for public institutions (Community Research Connections, 2012).

Prices of the credits from the government scheme ranged from 9 to 19 USD per tonne of CO_2e (IETA, 2015a). In total 10.1 million USD was spent via this scheme on approximately 10 agriculture schemes, taking up around 5% of total offsets of this scheme and it included mostly energy efficiency and biomass activities. A study estimates that this created around 9 jobs per USD million disbursement of the scheme (Community Research Connections, 2012). The voluntary market that also included agricultural offsets in Canada, the Chicago Climate Exchange, at the same time had a price between 2 - 7 USD per tonne of CO_2e (Community Research Connections, 2012). Agricultural projects eligible for this scheme included for example no-tillage activities, grassland management and methane capture.

3.4.3 Expected interaction with existing agricultural policy objectives and instruments

In British Columbia (B.C.) only 3.5% of total emissions come from agriculture. However, more than half of those emissions come from methane from enteric fermentation. The costs of inputs on a typical B.C. farm that can be influenced by a carbon price include electricity, fuels and fertilizers. It has been estimated that the average farmer spends 2.1% of its total budget for inputs on electricity, 6.2% on fuels and 11.4% on fertilizers (Environment Canada, 2015).

The prices of the three inputs described above, electricity, fuel and fertilizer may increase due to a carbon price (see chapter electricity tariff policy). In B.C. the following impacts agriculture were expected:

- Electricity prices may rise due to a CPI. However, as most of the electricity generation in B.C. comes from hydro, it is expected to have only a limited impact on electricity price.
- Farmers often generate electricity in a decentralized renewable energy system and can thereby benefit from an environment that rewards low carbon sources of electricity. But as most electricity in B.C. comes from hydropower, there are already significant sources of low carbon electricity and therefore the benefit is likely to be minimal.
- Farmers will have to pay more for using high carbon content fuels.
- In general, it is assumed that fertilizer manufacturers pass through costs from a CPI. Additional costs for fertilizers producers from a carbon tax will mostly originate from the energy intensive nature of fertilizer production. However, B.C. might also decide to include a carbon tax on the fertilizer for its greenhouse gas effect later on when applied on the farm level. Higher costs for producers are expected to raise fertilizer prices significantly. British Columbian farmers will then be likely to buy fertilizer internationally instead for a lower price. This leakage means that a local carbon price such as in British Columbia is unlikely to affect the price of this farm input, but also not reduce the greenhouse gas emissions from this input overall (Rivers & Schaufele, 2014; UNDP, 2015).

Based on these assumptions it was expected in 2008 that farmers' income would not be impacted significantly by the introduction of the carbon price. This expectation and design of the carbon tax was in line with the policy objective in B.C. to stabilize farmer income over time.

If, however, a carbon tax would impact the farmers' income significantly, the insurance policies and safety nets in place in B.C. would reduce any adverse impacts from a carbon tax.

A possible concern when designing the carbon tax is that it by providing incentives for one environmental output, could lead to farms ignoring water quality, soil quality and biodiversity issues. Maintenance and strengthening agricultural payments supporting sustainable activities were considered important prior to introducing the carbon tax.

3.4.4 Actual impact on GHG emissions, productivity and competitiveness, distributional impacts

In Figure 2 both net emissions and emission intensity of the agricultural sector in B.C. from 1990 to 2012 is shown (Environment Canada, 2015). The net emissions in this graph include emissions from production, fuel use and land-use change. **This shows that the introduction of the carbon tax in 2008 did not significantly affect GHG emissions from the sector**. Net emissions have been trending slightly downward, while emission intensity has seen more of a reduction. This demonstrates that over the period 1990 – 2012 agriculture in B.C. has improved its GHG intensity. This has mostly been explained by changes in management practices on the farm. For example, from 1991 to 2011 the milk industry has significantly improved its GHG intensity by reducing 20% of emissions per kg of milk produced.

As illustrated in Figure 2, in the period of 2008 – 2012 while emission intensity stayed constant, net emissions have fallen and then increased. This last period coincides with the introduction of the carbon tax. This decrease in net emissions has been explained by a drop in commodity prices worldwide rather than by the implementation of the carbon tax. It therefore seems to suggest that the carbon tax on fossil fuel inputs into agriculture has not had a significant impact on emission trends from the sector. This could be due to the fact that agricultural subsidies have nullified the effects of the CPI by causing market adjustments. Alternatively, it could be due to the small coverage of agricultural activities in the carbon tax.

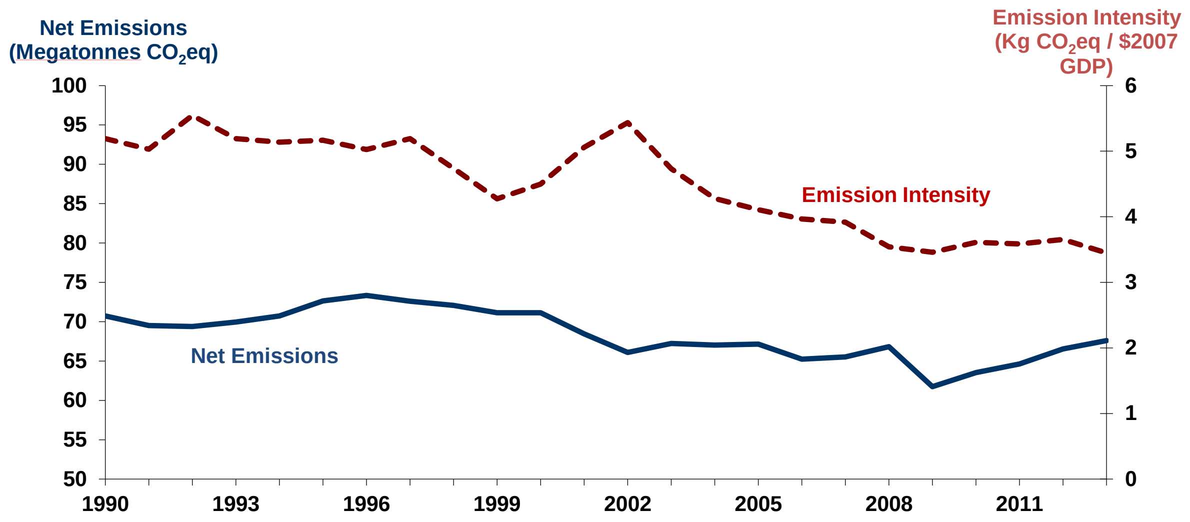

Figure 2 - Emissions and Emission Intensity of the Agriculture Sector 1990 2013

Figure 3 shows the different emission trends for different agricultural categories in B.C.. This shows that direct livestock and crop emissions, which are exempt from the carbon tax have been stable in the 2008 to 2012 period. Similarly, on-farm energy use emissions, which, on the other hand, are included in the carbon tax have also stayed constant.

Lastly, agricultural land use emissions could earn potential credits, since the introduction of a crediting mechanism in 2008, but also these emissions have stayed largely constant. Most offsets from the crediting mechanism were used for energy efficiency and biomass schemes instead (Environment Canada, 2015).

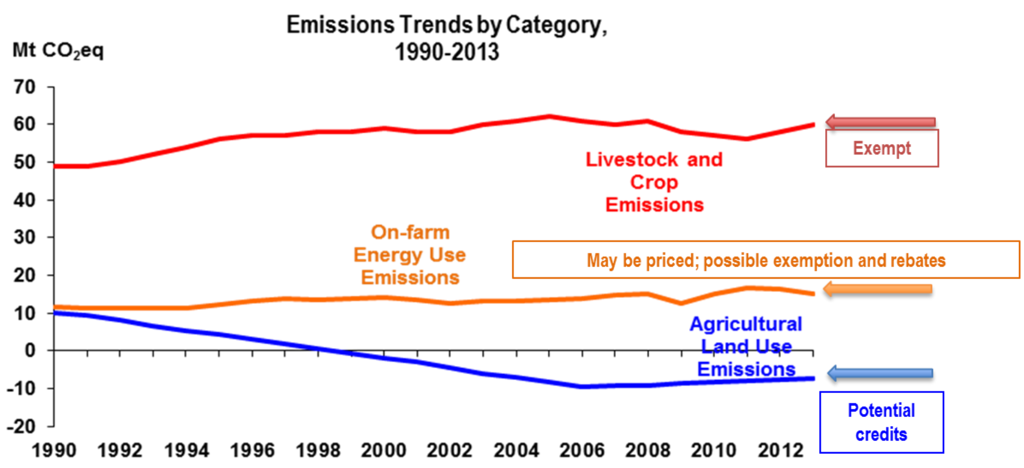

Figure 3 - Emissions Trends by Category in B.C. 1990 - 2013

Whether the competitiveness of the agricultural sector in B.C. has been impacted by the carbon tax on fossil fuels has been contested. Figure 4 shows net exports from agriculture in different Canadian provinces (Rivers & Schaufele, 2014).

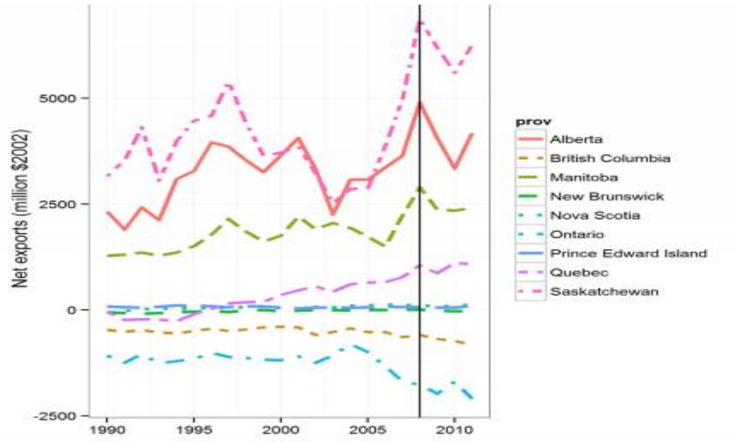

Figure 4 - Net exports for B.C.

While exports from B.C. have decreased since 2008, it has not decreased significantly more than other provinces, which were not included in the carbon tax scheme. Fluctuations in world food prices and extreme weather events that have limited production have been cited as a cause for the reduction in exports, rather than the carbon tax.

While several studies show that the carbon tax has not impacted the competitiveness of the agricultural sector, no studies so far have been carried out to evaluate the impacts on individual farm income for different size farmers in B.C.

Removal of the carbon tax. From 2008 to 2012 energy inputs for agriculture based on fossil fuel consumption were covered by the B.C. carbon tax. However, in 2012 this sector was made exempt. The main reason for this was the "perceived difficulty in decreasing fuel use in the agricultural sector due to a lack of mitigation options in the short-term" (Rivers & Schaufele, 2014). The government therefore decided to give the agricultural sector more time for technological advances to create more low-carbon options before including these in the carbon tax. There were several concerns regarding the carbon tax that convinced the government to exclude the agricultural sector. The main concerns relate to harmful impacts on exports from agriculture in B.C. and the worry that there will be out-migration of agricultural production to outside of B.C.

The government excluded the agricultural sector from the carbon tax by exempting the purchase of fuel for farm use from the carbon tax and giving out a grant scheme that compensates farmers for natural gas and propane. No exemptions have been made for electricity and fertilizers, but as discussed before, the carbon tax had no noticeable effect on their prices (Rivers & Schaufele, 2014).

However, no significant effects on either competitiveness of the agricultural sector or emissions from the sector have been observed during the period of 2008 and 2012 when the carbon tax was in place. Several studies also suggest that the phased and gradual implementation of the carbon tax in B.C. has also contributed to the limited impacts the tax has had on the competitiveness of the sector or its distributional impacts (Rivers & Schaufele, 2014).

3.4.5 How was the CPI designed to be sensitive to competitiveness, productivity and possible adverse impacts?

As explained in the previous chapters, when the carbon tax was introduced in B.C. the expectation was that the cost of agricultural inputs (electricity, fuel and fertilizer) would increase. However, this impact has been neutralized. Due to a low carbon price and several mechanisms, including safety nets, no noticeable impacts have been observed on farmers' income as a consequence of the introduction of the carbon tax. However, despite these observations the government still decided to exclude fuel inputs for the agricultural sector from the carbon tax in 2012. Reasons for this included a lobby from the agricultural sector, that perceived the carbon tax as harming agricultural exports from B.C., and the concern of the government that the carbon tax might shift production from the province elsewhere.

In addition to this there appear to be a number of other ways in which the CPI has been designed or considered to be designed to limit adverse effects.

Revenue neutrality. The carbon tax in B.C. has been designed to be revenue neutral. The main reason for this is to avoid any negative impacts from the carbon tax on the competitiveness of the British Columbian agricultural sector and avoid adverse distributional impacts. The revenue recycling in B.C. is implemented via adjustments to personal and corporate taxes and via lump-sum transfers. For example, there are monetary transfers available for low-income families and rural homeowners, there is a scheme to reduce school property taxes for farmland and a scheme to give property tax credits to industries. In total it was estimated that from 2011 to 2012 the tax raised 960 million USD Canadian dollars which was all recycled via the above described schemes.

It has been estimated that lump-sum rebates as described above should be set at around 15% of carbon tax payments by the agent in the sector. A 100% rebate would over-compensate the sector and influence decision-making at the company level. A lump-sum rebate also distinguishes itself from exemptions as it is not based on a firm's carbon emissions or fossil fuel use but based on sector wide historic emissions estimations.

3.4.6 Alternative GHG mitigation instruments

Despite the removal of the carbon tax from the fuel inputs into the agricultural sector, significant abatement opportunities in agriculture still exist and can be taken advantage of. The main objective in terms of GHG mitigation in B.C. is to improve the GHG intensity of the dairy sector.

Carbon Tax and rebate mechanism dairy farming. An example of a mechanism which seeks to promote GHG intensity improvements on dairy farming revenue recycling linked to the farm's output, i.e. output-based rebates (Rivers & Schaufele, 2014). Within this scheme, farmers are obliged to pay a carbon tax for farm's emissions, but will be compensated via rebates based on the output of the farm. The farmer will thereby have to improve its carbon intensity in order not to be negatively impacted by this scheme. This method has only been proposed and has not been implemented yet. One caveat this intensification incentive might have is that it risks compromising other issues such as water quality, biodiversity and animal welfare. However, basing these output-based rebates on sustainable intensification practices could potentially provide win-win outcomes for different environmental issues.

Crediting mechanism for GHG reductions from farm practices. A crediting mechanism was put in place at the same time as the CT for inputs of the agricultural sector (British Columbia Government, 2016; Rivers & Schaufele, 2014). It provides funding to farmers through the sale of offset credits generated from GHG emission reduction projects. As described above, when applied to the agricultural sector, the public sector crediting scheme mostly included energy efficiency and biomass projects. The eligible projects in the voluntary crediting mechanism however, were selected based on their capability to promote improvements in farm productivity as well as GHG abatement; these included no-tillage farming, precision application of fertilizers to reduce the inputs needed and manure management. As such, improvements GHG intensity could be achieved while providing farmers with new sources of revenue, rather than imposing a carbon cost. In addition, these activities can lead to co-benefits such as improvements in biodiversity, soil conservation, water quality and others that CPI mechanisms fail to consider or protect.

The public sector crediting mechanism was phased out in 2014 after the B.C. public sector achieved carbon neutrality. However, the Climate Action Secretariat of the B.C. government continues to buy 700,000 offsets annually for its long-term offset purchase agreements to maintain carbon neutrality (IETA, 2015a).

There seems to be a trade-off between the cost-effectiveness of measures and their focus on wider environmental issues. Most of these methods have higher costs than traditional farming methods. This means that to stimulate farmers to participate in these voluntary schemes the carbon price needs to be sufficiently high to demonstrate to farmers that it can provide significant revenue. Additional barriers, such as lack of capacity or cultural resistance, may also need to be addressed for these mitigation measures to be implemented.

In general, crediting mechanisms have been proven to be far less effective in reducing GHG emissions compared to CPIs (OECD, 2009). Crediting mechanisms are voluntary and not funded by farmers, and allow governments to impose qualitative restrictions on the kinds of mitigation options supported, so that only high quality ones are eligible (i.e those supporting sustainability, productivity and climate change objectives). It has been suggested however that because of the often strict selection criteria of crediting mechanisms they often have higher costs per tonne of abatement compared to CPIs, where market flexibility allows for the cheapest options, that could potentially also have harmful social or environmental impacts, to be selected (IETA, 2015a; OECD, 2009). However, due to high variability of activities and outcomes no general statement can be made whether carbon pricing instruments are more cost effective than crediting mechanisms.

3.5 CREDITING MECHANISMS – AUSTRALIA CARBON FARMING INITIATIVE

Farmers in Australia are able to earn carbon credits for reductions in GHG emissions on their land through the Carbon Farming Initiative (CFI). The CFI is a voluntary scheme that besides GHG emission reductions also focuses on sustainable farming practices and landscape restoration projects. We will consider this crediting mechanism implemented in 2011 as a case study to demonstrate how it interacts with the existing agricultural policy objectives and instruments in Australia (Australian Government Department of the Environment and Energy, 2012b).

3.5.1 AGRICULTURAL POLICY OBJECTIVES AND INSTRUMENTS IN AUSTRALIA

The agricultural sector in Australia has seen a large movement towards deregulation since the 1970s. Agriculture takes up around 60% of Australian territory (Australian Government Department of the Environment and Energy, 2012b), with large average farm sizes, and is a key sector for the Australian economy. It is often characterized as market-driven and export-oriented.

The main agricultural policy instruments in Australia consist of:

- Risk management programs, for example for drought events
- Agriculture Advancing Australia: a program to promote competitiveness, sustainability and profitability. It includes:
    - Training and education funding
    - Financial management tools and financial training
    - Tax scheme to avoid large fluctuations in income: producers can set aside taxable income in good years to use in more difficult times
    - Farm help program: income support for farmers with financial difficulties

Similar to New Zealand, Australia has very few support schemes or subsidies for farmers. Australia has several transparency institutions, including the Productivity Commission(PC) that ensures policies are efficient and effective in achieving policy objectives (Australian Government Department of the Environment and Energy, 2012a). The PC is independent from the government and is community-driven.

The main objectives of agricultural policy in Australia include (Agriculture and Agri-Food Canada, 2005; Botterill, 2016):

- Market and supply chain responsiveness: focusing on market access and international advocacy for trade liberalization
- Competitiveness: mostly through cooperation between sectors
- Adaptation to change: mostly focused on training and education schemes
- Natural resource governance: focused on water resources, biodiversity and ecosystems

3.5.2 CREDITING MECHANISM: CARBON FARMING INITIATIVE IN AUSTRALIA

Australia established the Carbon Farming Initiative (CFI) in 2011. In July 2015 the CFI transitioned into the Emissions Reduction Fund (ERF), which had an expanded scope to reduce emissions across the economy (Australian Government Department of the Environment and Energy, 2012b; Kragt, Dumbrell, & Blackmore, 2017)·. All projects that existed prior to the transition were automatically included in the ERF, but could if they so wish use either CFI or ERF methodologies.

The programme is a voluntary scheme whereby farmers can earn carbon credits from undertaking a particular set of activities. Farmers earn carbon credits, which can be sold as offsets, through reducing emissions or increasing carbon storage on the land they farm. Prices per tonne of CO_2e are determined by a reverse auction, with the Government paying for lowest cost mitigation projects.

Carbon credits are called Australian Carbon Credit Units (ACCUs). Some activities that generate carbon credits can count towards Australia's mitigation target under the Kyoto Protocol (Kyoto ACCUs). Activities that can earn Kyoto ACCCUs include reforestation, avoided deforestation, reducing livestock emissions, reducing emissions from waste deposited in landfills. The Emissions Reduction Fund came into existence after a period of policy uncertainty in Australia, with an ETS planned but repealed in 2014 by the incoming government (IETA, 2015b)· The Emissions Reduction Fund purchases these Kyoto ACCUs. ACCUs generated from other activities that reduce emissions but are not counted towards Kyoto targets can be sold in the voluntary carbon market.

Carbon credits will be issued for activities which provide 'additional' abatement to baseline. These activities are defined in a list of 'positive activities'. At the same time carbon credits will not be issued for those activities which have negative consequences for land access or agricultural productivity, supply of water, biodiversity conservation and employment. These are known as 'negative activities'.

3.5.3 Expected interaction with existing agricultural policy objectives and instruments

When the CFI was implemented in 2011 it was expected this scheme would be in line with the existing agricultural policies and instruments in Australia. It would be complementary to financial schemes for farmers, as the CFI could potentially provide funding and additional income for farmers. Moreover, most activities that were expected under the CFI include increasing efficiency of fertilizer use and enhancing sustainable intensification, which would be in line with the policy objectives for the agricultural sector to be competitive, profitable and sustainable.

The CFI is also specially designed to avoid impacts on "communities, food security and the environment" (Australian Government Department of the Environment and Energy, 2012a). This is underlined by the permanence condition. This leads on the expectation that if the benefits are to be sustained it must be in the farmers' interest to undertake the project (i.e. improves productivity or is undertaken on unproductive land, having thereby no competition from productive agriculture).

The permanence rule thereby ensures that farmers only undertake activities under the CFI that can increase productivity or have positive environmental effects. This therefore ensures that the CFI is complementary to the agricultural policy objectives and instruments in Australia.

3.5.4 Actual impact on GHG emissions, productivity, competitiveness and distribution

On 3 December 2014, (prior to the transition to the ERF in July 2015) 10.6 million credits had been issued via the CFI which equates to 2.5MtCO_2e per year, representing approximately a 2% reduction in emissions from sectors covered by the CFI (Australian Government Climate Change Authority, 2012). The vast majority of projects (90%) came from projects on landfill and waste management and avoided deforestation with only 1% coming from agricultural projects. The seven agriculture projects came from destruction of methane from pig manure. This experience continued into the transition into the ERF. Out of a total of 348 projects that were contracted by the ERF, only 17 came from the agricultural sector May 2016 (7 sequestration, 10 emission avoidance projects). Participation in the CFI/ERF has thus been limited.

These results were said to be disappointing and significantly below the abatement potential of the crediting scheme. Reasons for disappointing results have been attributed to high costs for participation, policy uncertainty and slow approval of methodologies.

Uncertainty around future carbon pricing policy has been a particularly important determinant of low participation. Price variation means that farmers are less inclined to take up long term projects, where the return is uncertain, and instead favour low-risk projects operating over shorter terms. These issues have been underlined by a low carbon price which has meant that almost all high-cost emission reductions (as can be seen in the abatement curve below in Figure 5) were not implemented under the scheme.

Those participating in the CFI scheme also faced high administration and transaction costs that resulted from application processes and MRV reporting standards (Australian Government Climate Change Authority, 2012).

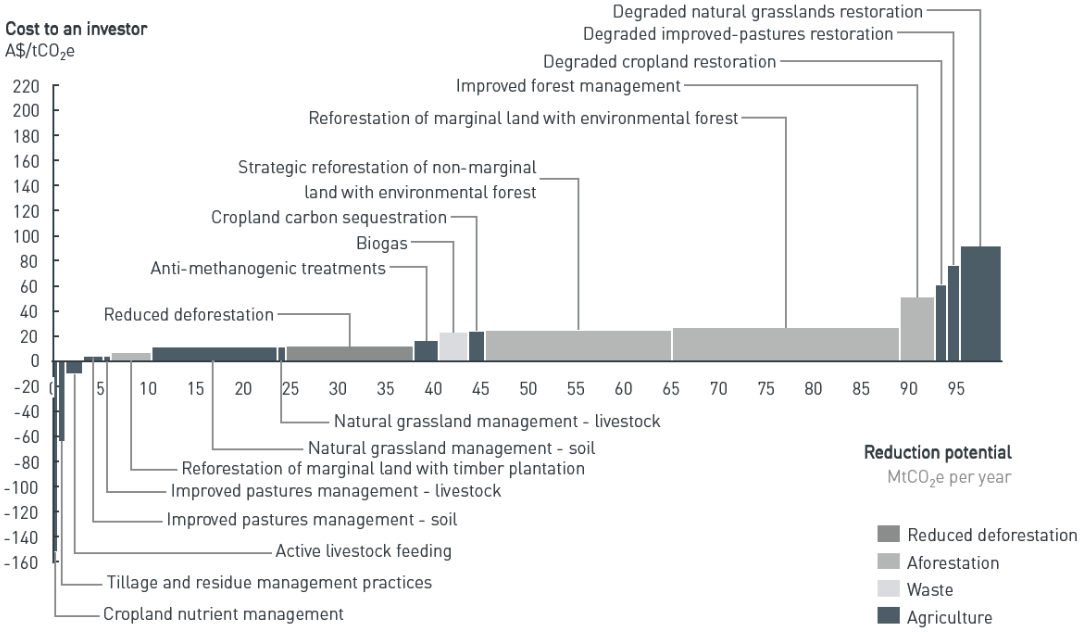

Figure 5 - Abatement curve for Australian agriculture sector

3.5.5 How was the CPI designed to be sensitive to competitiveness, productivity and possible adverse impacts?

The Government of Australia included two important criteria in the CFI to be eligible to earn credits and to avoid any adverse impacts. These are the additionality and permanence requirements.

The additionality criteria outline that there should be no law requiring the activity for which credits are requested and the activity must be on a 'positive list'. This is a list with abatement opportunities for specific sectors and regions. Available evidence suggests that additionality of projects under the CFI has been high. However, in some cases where the CFI projects had a commercial driver the additionality has been questionable.

The CFI is also specially designed to avoid impacts on "communities, food security and the environment" (Australian Government Climate Change Authority, 2012; Australian Government Department of the Environment and Energy, 2012b). This is underlined by the permanence condition. This leads on the expectation that if the benefits are to be sustained it must be in the farmers' interest to undertake the project (i.e. improves productivity or is undertaken on unproductive land, having thereby no competition from productive agriculture). These include for example creating wildlife corridors or improving water quality as co-benefits from GHG emission reduction projects. The rule also avoids that agricultural land is converted into forest if the land has the potential to provide more profitable agricultural uses instead. It thereby ensures the productivity of the agricultural sector (Australian Government Climate Change Authority, 2012).

However, these strict eligibility criteria for projects have said to also limit the participation in the scheme by being too restrictive. Some potentially positive projects have not been included on the list and have therefore not been promoted under the CFI scheme. For example, changing the timing of harvest could reduce GHG emissions through higher carbon sequestration in the soil, but these activities were not included in the positive list.

Other corrective measures of the CFI to maintain the environmental and economic integrity of the scheme include:

- Requirement that sequestered carbon is not released for 100 years, otherwise credits need to be paid back or additional measures have to be taken.
- There is also a 5% loss of credits as a buffer for the adjustment that needs to be made if carbon is released earlier (for example through fire). This is called the risk of reversal buffer and it will be reviewed in the future (if the 5% is the right level).
- In the future a leakage deduction might be included where the amount of earned credits will be reduced based on the expectation of leakage.
- The government aims to address the issue of the low carbon price by fixing the price for the next 7 years, starting at at 23 USD per tonne of CO2e and increasing by 2.5% each year. However, this is only a fixed price for the compliance market and it is hoped that this will encourage the price of voluntary units to go up as well. The government also aims to buy 250 million USD of voluntary units to boost the market.
- Farmers can decide when they sell their allowances, so they can wait for a more suitable price level.

The ERF does recognize that increased productivity of beef cattle herds can count towards emission reductions. Changes in management practices can count towards ACCUs. Targeted supplementation, improved feed quality, improved weaning rates, managing the herd age and installing fencing are approved activities. These activities can support productivity gains additional to the sale of carbon credits (Australian Government Department of the Environment and Energy, 2016). Although the sale of these types of carbon credits has been limited.

3.6 Results-based finance funds - BioCarbon Fund

The Biocarbon Fund Initiative for Sustainable Forest Landscapes (ISFL) seeks to promote sustainable agriculture and land management through providing incentives for reduced GHG emissions and increased sequestration. It became operational in 2013.

The programme understands that agriculture is not only the leading cause of deforestation but also presents huge opportunities for development and poverty reduction. In Ethiopia for example, uncertain tenure and financial barriers have meant short term exploitation of land with low levels of investment, resulting in overgrazing, poor productivity, and deforestation of farming expansion (World Bank, 2014). Agriculture not only is the largest source of methane and nitrous oxide emissions, but also highly exposed to the impacts of climate change. The programme therefore seeks to promote 'climate smart' agriculture and other land uses which increase food production and income opportunity while also providing reduced deforestation, climate resilience, emissions reductions, sustainable water use and carbon sequestration (Biocarbon Fund, n.d.). Examples of support provided by the BioCarbon fund include the technical and financial support for sustainable practices and reforestation provided to coffee farmers in Ethiopia. This makes farmers more resilient to climate change, and boosts productivity through capacity building (Price & Sud, 2016).

The BioCarbon Fund uses the principle of result-based finance. This is a mechanism whereby financing is provided for projects based on pre-defined outcomes of this project. These outcomes could be both quantitative, for example the amount of CO_2e reductions, or qualitative. Most payments are only made after the results are delivered, thereby giving a strong incentive for actual emission reductions to happen. The certainty of delivery of results from results-based finance has also been shown to be attractive to financiers.

The ISFL has four design elements:

- **Working at scale** – ISFL focuses on jurisdictions within a target country. This provides the opportunity to have large scale impacts. A landscape approach is adopted which necessitates an understanding of trade-offs between parties and land use. The initiative seeks to provide environmental, economic and social impact.
- **Leveraging partnerships** – The initiative seeks to develop public private partnerships to provide capital and ensure objectives are aligned. Private sector actors range from subsistence farmers to multinational firms. Partnership and engagement can include collaborating on sustainability approaches, blending finance or convening stakeholders to ensure goals are aligned.
- **Incentivising results –** ISFL provides results based climate finance by purchasing verified emissions reductions.
- **Building on experience –** ISFL aims to build on initial land use pilots and incentivise sustainable land use at scale. ISFL uses institutional infrastructure created by the REDD+ readiness work of Forest Carbon Partnership and UN-REDD.

ISFL looks to develop a landscape carbon accounting approach, which will form the basis for purchasing carbon credits. This landscape approach requires consideration of multiple uses of land and the trade-offs between different stakeholders and therefore seeks to provides development strategies which result in environmental, economic and social impacts.

Germany, Norway, UK and USA contribute to the fund. ISFL has 360 million USD of capital across distributed across the following two types of funding (Biocarbon Fund, n.d.; World Bank, 2016a):

- **BioCF *plus* (90m USD)–**grant funding to support enabling environment for sustainable land use, piloting activities, and develop monitoring, reporting and verification activities.
- **BioCF T3 (270m USD)**– results based finance through purchase of VERs over 10-15 year period.

The initiative has been applied in the following countries:

- **Colombia –** The project seeks to address the drivers of land-use change and deforestation in the Orinoquia region. The project focuses on sustainable agriculture practices and production. The project is supporting the development of enabling environments and providing results based finance based on verified emissions reductions (BioCarbon Fund, n.d.-a).
- **Ethiopia –** The Ethiopia project focuses on the Oromia region. The project seeks to support equitable, sustainable low carbon development. A 18 million USD mobilization grant supports enabling activities over a 5 year period and emission reduction payments are provided. An integrated landscape approach is required, support is provided for the enabling environment (BioCarbon Fund, n.d.-b).
- **Zambia –** Focused in Zambia's Eastern Province, the program seeks to improve environmental and economic outcomes in rural communities and improve the ability to

respond to emergencies. It is expected to achieve emission reductions on average of 3.5 million tCO_2e/year (BioCarbon Fund, n.d.).

3.6.1 Expected interaction with existing agricultural policy objectives and instruments

The first design element of the ISFL relates to its focus on jurisdictions within a country and at the existing policy landscape. This would imply that the ISFL is designed such that it will be aware of any interactions occurring with existing agricultural policy objectives and instruments in the focus countries.

For example, the Zambia Integrated Forest Landscape Program has been designed within the country's 'Vision 2030' development framework. This vision 2030 framework also includes a development plan for the agricultural sector. This shows that the objectives of the RBF project have been designed to be in line with the existing agricultural policy objectives and instruments in Zambia (BioCarbon Fund, n.d.).

3.6.2 Actual impact on GHG emissions, productivity, competitiveness and distribution

As described above, a RBF system is inherently designed to deliver carbon reduction efforts. However, it cannot account for any possible rebound effects, as it is project-based. Overall, it has been estimated that the BioCarbon Fund in 2015 had caused the avoidance of 28,882,024 tonnes of CO2e, affecting around 64000 lives and livelihoods (Department of Energy & Climate Change, 2015).

Most of the projects funded via the ISFL do not only specify a carbon reduction goal, but also include a development goal. According to the draft Emission Reductions (ER) Program requirements, the ISFL program seeks to "catalyse the development of a low-carbon rural economy in each of its program areas that will simultaneously result in livelihood opportunities for communities and an overall reduction in GHG emissions from the land" (Biocarbon Fund, 2017).

The requirements also state that the program "inherently" provides social and environmental benefits beyond emissions reductions or increased sequestration. Benefits arising from emissions reductions will be distributed in the program area and how this will occur should be described in a Benefit Sharing Plan.

3.6.3 How was the CPI designed to be sensitive to competitiveness, productivity and possible adverse impacts?

By providing funding for sustainable agricultural practices, this mechanism is beneficial for farmers as they do not need to bear the costs themselves.

In addition, the fund develops its programmes with national government representatives, which ensures that the results achieved are in line with broader policy objects. For example, in Zambia, these took into consideration productivity and competitiveness issues.

In addition, the ISFL Emission Reduction Program is designed with a number of requirements. These include (not an exhaustive list) (Biocarbon Fund, 2017):

- Non carbon benefits including livelihoods, transparent and effective governance structure, improving land tenure, enhancing biodiversity and ecosystem systems. Should be monitored and reported through M&E mechanisms defined by the World Bank and ISFL.
- A benefit sharing plan should be created to identify how benefits from ER are distributed.

These requirements are similar to those specified for voluntary emission reduction standards. Although the program requirements states that social and environmental benefits are inherent to the program, setting out plans on how to effectively distribute the benefits and monitor livelihoods and non-carbon impacts ensures that these are achieved.

One aspect to be aware of with RBF is that funds are needed. While the BioCarbon Fund is internationally funded, domestic RBF schemes could potentially shift government's budget and tax revenue. A RBF can be designed in such a way that revenue is collected from related measures, such as a carbon tax.

4 LESSONS LEARNT FROM INTERNATIONAL EXPERIENCE OF CPIS

This section summarises the key points of interest and lessons learnt from the case studies for Brazil, before exploring the CPI implementations challenges further.

4.1 KEY LESSONS FOR BRAZIL FROM CASE STUDIES

Table 9 presents the key points and lessons from the case study presented in the previous section, which are also summarised here.

Concerns over competitiveness and distributional impacts, along with implementation difficulties (measurability and choice of point of regulation), are main reasons for limited application of ETS and CT in agriculture. The overview in Section 3.1 identified no existing examples of ETS/CT in the agriculture sector. New Zealand and British Columbia's (B.C.) made attempts but ultimately decided to remove CPIs. In New Zealand, the decision to exclude the agriculture sector from the ETS in 2013 was due to negative competitiveness and distributional impacts on participants, as well as difficulties in measuring and monitoring emissions, and limited availabilities of abatement technologies (Kerr & Sweet, 2008).[9] Nonetheless, the MRV system for

[9]However, in 2017 it was decided that stationary energy and transport emissions from the agriculture sector were exposed to ETS costs with immediate effect,.

agriculture is in place. In B.C., although the agriculture sector was never directly included under the carbon tax, fertilizers were included between 2008-2012. Some of the main reasons cited by the government for excluding the sector after this date include the negative impacts on competitiveness, and risk of carbon leakage. B.C. is currently considering an alternative carbon tax and rebate mechanism.

However, numerous examples of crediting and financing mechanisms can be identified for the agriculture sector, such as the Australia carbon farming initiative, the BioCarbon fund and CDM. In addition, while B.C. chose to exclude agriculture from the carbon tax, a crediting mechanism is still in place. A key advantage of crediting mechanisms compared to ETS/CT is that it supports farmers to fund mitigation options through the sale of carbon credits. In addition, knowledge and technology transfer modules (sometimes part of the mechanism, common in CDM projects) can address technological and capacity barriers. Finally, they allow governments to qualitatively restrict the types of projects which will receive funding. A key disadvantage however is that the scope of emission reductions of project based variant is potentially much lower than sector wide ETS/CT. Regarding RBF mechanisms, other examples exist if the scope of mitigation options is widened. For example California is implementing an RBF mechanism to fund the development of manure management infrastructure. Grants will be distributed based on expected emission reduction potential of projects (Weisberg, 2017).

Table 9 – Overview points of interest and lessons for Brazil of CPI case studies

Case Study (CPI, jurisdiction, key dates)	**Points of interest and lessons for Brazil**
New Zealand ETS **2008**: ETS established (New Zealand Government MfE, 2009) **2009**: Methane and nitrous oxide emissions from agriculture planned to be included in ETS from 1 Jan 2015 (Kerr, 2016) **2012**: Mandatory reporting on agriculture emissions (Ministry for the Environment in New Zealand, 2012) **2013**: New government indefinitely excludes agriculture from NZ ETS (Leining & Allan, 2017). **2017**: stationary energy and transport emissions from agriculture are exposed to ETS	Attempt at implementing an ETS, and its subsequent exclusion of the agriculture sector mainly because of negative competitiveness and distributional impacts, but also difficulties in measuring and monitoring emissions and limited availabilities of abatement technologies (New Zealand Government MfE, 2009). Up and downstream points of regulation chosen to limit administrative costs and distributional impacts. However, does not provide incentive for productivity improvements, and provides only a weak incentive for farmers to mitigate emissions. MRV and data system established in 2012 may be a model for Brazil. This uses detailed livestock population data together with productivity data to estimate feed intake for beef, sheep, deer and dairy industries. It raises awareness and knowledge of the GHG emissions associated with agricultural production. The aim of the reporting requirement is to set the first step to include the agricultural sector in the NZ ETS. Data that is reported by processers of agricultural products and importers and manufacturers of fertilizers include both mandatory data and voluntary additional information. However, data is difficult to collect and often includes many assumptions. Therefore, agricultural emission estimates from this scheme may be underrepresent the actual emissions from the sector. Since indefinitely excluding agriculture from the ETS in 2013, alternative approaches

costs (Leining & Allan, 2017).	have been suggested by different parties. One suggestion by a New Zealand research institute is an ETS for the agriculture sector with a size threshold for participation, excluding small farmers (Kerr & Sweet, 2008). While this approach may be of interest to Brazil, a nuanced approach to determine which farms are included must be elaborated, as significant number of small farms are not subsistence-oriented.
British Columbia Carbon Tax 2008-2012 (Rivers & Schaufele, 2014) **Crediting Mechanism** implemented 2008	2008-2012: Carbon tax was not directly applied on agriculture. Instead, was expected to impact inputs costs to agricultural activity (fuel, electricity, fertilizers), however, cost impacts were expected to be minimal, and a number of safety nets existed. In addition, a crediting mechanism is being used for avoided land-use change emissions in agriculture. 2012: The tax was removed from farming inputs.. Some of the main reasons cited include lack mitigation options (fuel substitutes), negative impacts on competitiveness and risk of carbon leakage. The government decided to give the agricultural sector more time for technological advances to create more low-carbon options before including these in the carbon tax. Carbon Tax and rebate mechanism for dairy farming which are currently under consideration aim at incentivising improvements in GHG intensity and productivity, while minimising the negative distributional and competitiveness impacts. However, it is unclear how this will impact sustainability. In the existing crediting mechanism, eligible projects are those that promote improvements in farm productivity as well as GHG abatement, such as no-tillage farming, precision application of fertilizers to reduce the inputs needed and manure management. However, most agricultural credits are used for on-farm energy efficiency and biomass generation projects instead.
Australia Carbon Farming Initiative, Crediting Mechanism, implemented 2011 (Australian Government Department of the Environment and Energy, 2012b)	Example of a crediting mechanism covering agriculture which can be integrated into ETS or CT. The ETS or CT would provide a source of demand for the credits. This is a potential model for Brazil, since the NDC implies that selling credits internationally may no longer be an option. Strong criteria for project eligibility ensures only high quality projects promoting sustainability and productivity are allowed. These include reforestation, avoided deforestation, reducing livestock emissions, reducing emissions from waste deposited in landfills To date, there has been a low participation in this voluntary scheme, due in part to these restrictions, as well as costs associated and the low carbon price (Australian Government Climate Change Authority, 2012).
Biocarbon Fund, **Multilateral Results Based Financing Fund**, implemented 2013 (Biocarbon Fund, n.d.)	Example of a funding mechanism which can provide a source of demand for credits from agriculture. Relevant given Brazils interest in providing agricultural credit, which can be done in a manner that focuses on GHG emission reduction and sustainability results. Promotes 'climate smart' agriculture and other land uses which increase food production and income opportunity while also providing reduced deforestation, climate resilience, emissions reductions, sustainable water use and carbon sequestration.

Source: Ricardo Energy & Environment.

4.2 Challenges of implementing a CPI in the agriculture sector

As the New Zealand ETS and B.C. Carbon tax case studies demonstrate, there are unique challenges associated with implementing a sector wide CPI in the agricultural sector, namely challenges in measurability of emissions and designing the point of regulation.

Challenges with measurability of emissions. Measuring and estimating farm level emissions is arguably more challenging than any other sector, posing significant problems for the data and MRV systems which must underpin CPIs. This is due to the fact that the emissions are produced over vast areas with significant variability. In addition, emissions are produced through biological processes which are often beyond human control, since they are produced in the digestive systems of livestock and/ or chemical processes and microbial activity in the soil (Saddler, 2008).. Note combustion emissions are not taken into consideration, as they are negligible for the sector.

The challenges can be best illustrated by considering how approaches to monitoring agricultural emissions compare with fuel combustion. To determine the emissions from fuel combustion the quantity of fuel consumed can be monitored, and then multiplied by well-established emission factors. Alternatively, there are robust measurement technologies available.

In agriculture however, the amount of digestive methane produced by ruminant livestock depends on the quantity and quality of food consumed, and the characteristics of the individual animal. Estimating the diet of free range herds is very difficult. Direct measurement techniques involve attaching equipment to animals and are only approximate. In addition, they would not be effective for routine on-farm decision-making because of their cost and complexity relative to their potential emissions reduction benefit (Saddler, 2008). At present, these techniques are only used in research facilities.

Challenges designing the CPI's point of regulation. The diffuse nature of emissions sources in agriculture pose a challenge for choosing the point of regulation for ETS and CT systems. The choice involves trading off practical considerations with strength of GHG emission incentive. Implementing ETS/CT systems requires the identification of entities that are obliged to monitor and report emissions. These could be entities that directly emit the GHGs themselves (mid-stream or farm-level), those that supply fuel to these entities (upstream) or those who use consume the outputs produced by these entities (for example by covering electricity consumers, which is downstream). The possibility of upstream, midstream or downstream approaches is referred to here as the point of regulation (POR).

The level of effort required by administrators to implement and monitor the policy instrument increases with the number of emission sources included, and varies with the chosen POR. The cost of administering a scheme involving farm-level POR is potentially prohibitive, although there may be mitigating design aspects, for instance, restricting the scope to cover only large scale farms.

Alternatively, a different point of regulation (POR - up or downstream) could be selected, with the aim monitoring a smaller number of entities. Although upstream POR was chosen in British Columbia and downstream in the NZ ETS case studies below, there are a number of drawbacks related to the strength of the GHG emission reduction incentive, as shown in Box 3 below.

Box 3: Design choices: Trade-offs in choosing the Point of Regulation

The table below presents the design choices in terms of point of regulation, and their implications regarding administrative costs and incentives. The point of regulation is defined by the point in the supply chain relative to the farmer, who is the direct emitter.

Point of Regulation	Administrative costs and practical considerations	Strength of GHG emission reduction and productivity incentive
Upstream from the farmer, regulating the inputs to the farming process such as fertilizer, fuel, electricity, placing the regulation on suppliers	Low / medium	Medium
"Midstream" – or farm-level -the farmer is the regulated entity	High	High
Downstream from the farmer, regulating the outputs of the farming process such as meat or dairy, placing the emissions accounting obligation on processors	Low / Medium	Low

Administrative costs and practical consideration

Administrative costs comprise, at least, the monitoring and capacity building of entities covered by the CPI. As such, in sectors with very diffuse emissions sources, such as road transport and agriculture, the cost of a midstream point of regulation (on the entity controlling the emissions) may be prohibitively high. This is especially the case in ETS, where trading mechanisms include all these entities and the training / guidance is required for their participation. For this reason, upstream (in the case of transport) or downstream POR are often preferred in such sectors. However, there are significant disadvantages in these approaches, as highlighted below.

Strength of GHG emission reduction and productivity incentive

The regulatory obligation should be placed on the entity which has control over GHG emissions. An otherwise weak indirect incentive may not deliver the GHG mitigation desired.

In the case of downstream POR, meat and dairy **processors** have no control over the GHG emissions involved in meat and dairy production. The carbon price of meat/dairy production would be an extra cost absorbed by processors or passed onto consumers. Cost pass through may increase demand for meat and dairy substitutes, depending on elasticity of demand. However, changing demand provides only is an indirect signal for farmers to mitigate emissions, and may have a variety of causes.

A midstream POR is particularly important for the agriculture sector to ensure that incentives for improvements in productivity and GHG intensity are preserved. Placing the obligation downstream on the processor may not provide an incentive for improved productivity. In this case, emissions maybe calculated based on the amount of meat or dairy processed with a fixed conversion factor to CO2e emissions. Therefore improvements in GHG intensity on the farm level (e.g. fattening lambs quicker and reducing the emissions per animal) will not be captured. If the point of regulation were the farm itself, then the carbon price incentive could incentivise improvements in productivity.

Upstream regulation involves applying a carbon price to farming inputs (fertilizer, fuel, electricity), which creates a signal for more rational use of such inputs. One advantage is that their consumption is relatively easy to monitor. However, these inputs are responsible for only a fraction of total farm emissions, as they excludes biological processes (fertilizers represent 4.4% of agricultural soil emissions in Brazil in 2010). In addition, the impact on farm productivity is unclear. For instance, policies that encourage making fertilizers costlier without support to shift to other farm practices which require less fertilizers, may result in a drop in productivity.

5 KEY CONSIDERATIONS FOR CARBON PRICING IN BRAZILIAN AGRICULTURE

In light of the previous sections, this section presents the key principles for climate policy instruments for the agriculture, and considerations regarding carbon pricing for the Brazilian agriculture sector.

5.1.1 PRINCIPLES FOR CLIMATE POLICY INSTRUMENTS IN AGRICULTURE

These principles are drawn in part from the characteristics of the agriculture sector and the challenge of reconciling productivity, sustainability and climate change objectives in this sector, as presented in Section 2.

As a starting point, policy instruments should incentivise only high quality mitigation options, which meet sustainability criteria over the long term, and have synergies with improved productivity. However, this must exist within a framework of regulatory safeguards to restrict conversion of marginal and forest land to avoid significant adverse effects in the long term.

In addition, policy instruments for the agriculture sector must be particularly sensitive to the additional costs imposed on obligated entities, for reasons of affordability and competitiveness. Cost of policies will impact the affordability of food, and therefore food security objectives. In addition, agriculture is an extremely trade exposed sector. Small changes in costs of production may have high impacts on the competitiveness of agricultural products sold into global commodity markets. In the case of carbon instruments any resulting loss of domestic production in favour of production overseas may also lead to carbon leakage, as explained further in Box 4 below.

Box 4: Trade exposure and Risks of Carbon Leakage in the agricultural Sector

Leakage is the effect whereby climate-related policies in one jurisdiction can cause production to move to other jurisdictions with less stringent greenhouse gas emission reduction policies in place. This could overall lead to an increase in greenhouse gases emitted to the atmosphere.

The issue of leakage is particularly prominent for agriculture due to its high level of trade exposure. Global agricultural commodity markets are highly competitive, with prices set at the international level. Small changes in pricing can lead to a significant impact on competitiveness, making the agricultural sector quite susceptible to production shifting from one country to another.

As such, farmers would have to make the choice of whether to absorb costs themselves, affecting their income, or pass on costs, affecting their competitive positions. This issue is particularly sensitive in countries like Brazil which depend heavily on the agricultural sector exports.

A balanced mix of policy instruments is required in order to address barriers to the adoption of GHG mitigation. Barriers include the technological, financial or capacity challenges, as presented in

Section 2.2. This point is particularly salient when looking at negative cost abatement measures which would result in cost savings, such as no-till farming practices. Once barriers are understood, such as capacity or cultural practices, a balanced policy mix which addresses these barriers can be designed. For example, in Brazil some of the key barriers identified to the uptake of new nutritional supplementation technologies and agroforestry practices related to dissemination and capacity building in these technologies and practices. (See Appendix B.). While Brazil has a successful model of funding innovation with public resources in the agriculture sector (supporting research institutes such as EMBRAPA) and significant R&D resources are invested by the private sector, more emphasis is needed on dissemination and training for these innovative technologies.

Finally, given the key challenges with controlling and measuring emissions, careful consideration needs to be given to the type of instrument adopted, and the associated penalties. CPIs rely heavily on robust measuring and reporting of emissions, however the agricultural sector faces significant challenges with measurability and monitoring of emissions (see Section 3.2). In addition, there must be a clear understanding of the kinds of abatement measures which are to be incentivised, and the extent to which the farmer can control and mitigate associated emissions. In some cases, emissions result from uncontrollable biological processes.

5.1.2 Key considerations for carbon pricing in Brazilian agriculture

Considerations are provided regarding the choice of CPI, the design of carbon pricing instruments and finally implementation requirements.

Choice of carbon pricing instruments

ETS and Carbon Tax instruments create incentives for the lowest cost, rather than highest quality, mitigation options. The carbon price signal created by ETS or CT instruments incentivizes the implementation of cost effective GHG mitigation options up to the value of the carbon price.

As the incentive for obligated entities is to implement the lowest cost abatement measure, there are no qualitative restrictions on the mitigation measures which are implemented. As shown, this can be problematic, since a narrow focus on improving GHG intensity at a farm level may have detrimental impacts on sustainability and overall climate change mitigation. The example of nutritional supplementation shows that diverting protein from the human supply chain may lead to an increase in GHG emissions in the long term, although at the farm level it may result in GHG mitigation. While in theory regulatory safeguards could act as a filter on what mitigation options are selected, there are no practical examples of this.

Crediting mechanisms allow for qualitative restrictions on incentivised mitigation options. The mechanisms under implementation in Australia and B.C. impose qualitative restrictions on the projects which can generate carbon credits. The offset standards in the voluntary carbon markets are a good model for high quality emission reduction projects which provide co-benefits, as shown in Box 5 below.

Box 5: High quality emission reductions: examples of offsets in the Voluntary Carbon Markets

In order for an offset to be issued to the voluntary carbon market, a project must adhere to a methodology defined by an offset standard. These methodologies outline the permitted (and not permitted) activities to achieve emission reduction. The methodologies also set requirements which focus on maximising potential co-benefits and preventing any co-costs. Projects are validated and verified by independent organisations (referred to as Designation Operational Entities (DOEs), auditors or Validation and Verification Bodies (VVBs).

As an example of a certification standard which seeks to promote co-benefits, the Gold Standard methodologies for emission reductions are accompanied with the following categories of sustainability requirements for agricultural projects (other requirements exist and sub criteria are described in brackets):

- Preserving adaptive capacity of project participants
- Ensuring Do-No-Harm Sustainable Development including social (food security, people and local communities working conditions, occupational health and safety, no discrimination, anti-corruption, women) and ecological (GMOs, biodiversity, soil fertility and conservation, fertilisers, chemicals and pest management, water resources, waste, animal welfare and livestock management) aspects
- Stakeholders are able to influence the process through a consultation processes and input and grievance mechanism
- Monitoring the commitment to Do No Harm through establishment of a sustainability monitoring plan

A list of Offset standards and methodologies developed in the Voluntary Carbon Market, relevant to the agriculture sector, can be seen in Appendix C. .

While crediting mechanisms and RBF support rather than penalize farmers, they tend to have a limited emission reduction potential. Crediting mechanisms such as Australia's provide funding for high quality GHG emission reductions. However, existing project-based mechanisms limit the scope of potential emission reductions to the project-level, although attempts are being made to introduce scaled-up and sector wide mechanisms.

In addition, it should be noted that Brazil's INDC indicates that in the future Brazil will not recognize the international sale of credits, signalling that Brazilian credits can only be used to contribute towards Brazilian climate targets. This may potentially limit international demand for Brazilian agricultural credits in the future.

Hybrid CPIs may address the key challenges of CPIs in agriculture. "Carrot and stick" approach, where a carbon tax is combined with a crediting (or other financing) mechanism, may provide both the productivity incentive and support for achieving it. Careful design is required to provide the correct incentives. In the meat industry, a carbon tax could be based on a productivity indicator such as the animal growth rate (reporting age and weight for example), regulated at the level of the farmer. As such the most efficient farmer pays less tax. In addition, this efficiency incentive could be combined with support for achieving these measures or other mitigation options, for instance by recycling the revenues raised into a crediting mechanism. An important caveat is that such incentives would need to be combined with robust safeguards (environmental and sustainability checks, as per the EU CAP – see 0).

Two examples that are worth mentioning are:

- **Carbon tax and rebate system.** B.C. is considering a new tax and rebate (carrot and stick) mechanism in order to provide incentives for improvements in GHG intensity as well as productivity, in a manner which mitigates adverse distributional impacts. Note however that the impact on sustainability is unclear.
- **A targeted carbon levy linked to funding for high quality mitigation options.** The Australia Institute, which studied but ultimately did not recommend the adoption of an ETS in the agriculture sector, recommends a 'carbon levy'. The levy would be based on an activity measure which broadly correlates with emissions (e.g. livestock numbers), with rebates in exchange for implementing mitigation options. The abatement options could have quality restrictions and be prioritized according sustainability and productivity criteria. The advantage of this "carrot and stick" approach is that it does require a high level of accuracy in emissions estimates, rewarding good and penalizing poor practice. It could incorporate a 'no-regrets' standard with payments benchmarked to carbon prices to minimize distortion in land-use choices (Saddler, 2008).

Design of carbon pricing instruments

The point of regulation should be chosen considering practical feasibility, and the strength of the GHG emission reduction and productivity incentives.

The agricultural sector in Brazil has a very high number of diffuse emission sources, covering vast and varied geographic territories. Administering a scheme which involves the monitoring of emissions at farm-level from all these sources is potentially too costly.

However, design aspects may mitigate these requirements. For instance, restricting the obligated entities to commercial rather than subsistence farming, would reduce the number of individual farms which need to be monitored, although also lowering the volume of GHG emissions covered by the instrument. Nonetheless, the geographic spread in Brazil would still be significant.

While downstream or upstream designs may be more practical, not placing the obligation on the farmer may weaken the GHG mitigation incentive. Worse, a downstream point of regulation may not create an incentive for improvement in productivity, since improvements in GHG intensity are not taken into account. In the case of upstream, the compromise is that only a very limited scope of GHG are included.

The affordability and competitiveness impacts created should be mitigated by CPI design or complementary policy. Negative distributional and competitiveness impacts have been key drivers in New Zealand's decision to exclude agriculture from the ETS, after significant consideration. The story in B.C. is similar, where agriculture representatives successfully lobbied for the carbon tax on inputs to be removed due to adverse impacts, despite the existence of numerous safeguards.

Nonetheless, an ETS/CT can be designed in a number of ways to restrict the impact on farmers, and reduce the risk of carbon leakage. New Zealand planned to have phased free allocation of allowances, and is now considering an ETS with a physical size threshold for participation, to exclude small farmers. Further examples are explored in Box 6 below. A similar threshold mechanism in Brazil would need to take into consideration that in Brazil, physical farm size does not always correlate with the level of emissions. Brazil has a number of small scale but intensive farming operations. Further, carbon tax mechanisms can be designed with rebates or recycling, to mitigate impacts and incentivise best performance, as the B.C. example below shows.

Box 6: Addressing Carbon Leakage through CPI design

Governments around the world have considered several approaches to reduce the effect of leakage. These include changes to the design of the tax / ETS to relieve the costs borne by sectors that are very trade exposed. Design options include the exemption of the sector, the distribution of free allowances, recycling of revenues generated in the CPI for compensation. In addition, phasing of the introduction of the CPI so that entities have time to adapt to the obligations delays the costs.

Border Carbon Adjustments (BCAs) to protect national markets

Some countries which have implemented CPIs are considering the adoption of border carbon adjustments (BCAs) on imported goods. The rationale is to protect the competitiveness of national producers in the local market, so that it is not flooded with products as a consequence of carbon leakage. BCAs consist of posing either a carbon tax or emission allowance obligation on imports.

California has put in place a border carbon adjustment policy for the electricity sector. Electricity importers will need to pay for carbon allowances when the source of their electricity emits more than 25,000 t CO2e per year. If the source is unspecified a default emission factor is used in combination with a transmission loss correction factor. California is currently considering to expand the border carbon adjustment for cement, where either (Partnership for Market Readiness, 2015; PMR, 2015):

- Importers are fully subject to the ETS and all its requirements (this would require an adjustment in the level of the cap)
- Importers would pay a carbon price that is calculated by multiplying their emissions by current allowance price. This would be a system that allows less market flexibility.
- Creating a separate cap for allowances for importers, but it will be a challenge to set this cap at the right level to ensure importers are restricted equally to domestic producers.

Border carbon adjustments for the agricultural sector could both cover the agricultural inputs such as electricity, fuel and fertilizers or the imports of agri-food products (Golub et al., 2013; Lee, McCarl, Schneider, & Chen, 2007). New Zealand’s ETS design considered imposing a carbon cost on imported fertilizer, which would effectively be a BCA. This was motivated in part due to the high trade exposure of the fertilizer production sector, increasing its risk of leakage (Ministry for Primary

Industries, 2012a).

While the application of BCAs on agricultural produce is a mechanism to protect the competitiveness of products being sold in the local market, this would not support the competitiveness of exported agricultural produce in Brazil, which are an important part of the economy. In addition, the implementation of BCAs are seen as controversial given their implications for trade policy.

It should be noted that any policy that relates to import control will have to be approved by the World Trade Organisation (WTO) according to the provision of non-discrimination. To assess whether a BCA complies with WTO regulation, the WTO refers to the comparable mechanism, i.e. a BCA is allowed when it is used on imports from jurisdictions that do not have comparable legislation to reduce emissions in place when comparing it to the importing country (WTO & UNEP, 2011). This falls under the so-called GATT's general exceptions of the WTO and assessing the eligibility of the BCA scheme for these exceptions might add a large administrative burden to the scheme. Additionally, a 'good faith attempt' to create a multilateral agreement needs to be carried out as well, before a country can consider being eligible for the exception rules of the WTO, adding even more complexity (Cosbey, 2008). This seems to suggest that this forms a serious barrier to implementation of a BCA. However, the methods of implementation and design details of the considered BCA are crucial in the WTO assessment (WTO & UNEP, 2011).

CPIs can be designed to support innovation in agriculture. In the case of Brazil, disseminating innovative techniques is key to meeting the sustainability, productivity and climate objectives. However, the carbon price signal imposed through ETS/CT may not provide direct incentives for innovation, if farmers do not have access to or understanding of new technologies. In this case, revenues raised in the CPI can be recycled for dissemination and support schemes. In addition, note that CDM and similar crediting mechanisms are possible mechanisms for technology transfer.

Brazil has a successful example of supporting R&D research through EMBRAPA. Another example is the EU's European Innovation Partnership on agricultural productivity and sustainability, which aims to improve the competitiveness and sustainability of farming in Europe by integrating different funding streams. By, for example, combining grants from the Horizon 2020 programme for research and innovation with grants from the European Rural Development policy, this initiative aims to encourage supply chain collaboration (EIP-Agri, 2016).

Implementation requirements

CPIs must be implemented as part of a policy mix which addresses barriers to implementing mitigation measures. Table 6 provides an overview of the key barriers to implementing the selected mitigation options.

If these barriers to mitigation options are not addressed, carbon pricing effectively becomes a tax on production, harming affordability and competitiveness of the produce. Barriers can be addressed through the introduction of supplementary policy measures or in the design of the CPI. Regarding the latter, it may be possible to include only large or commercial farming units. Such farmers tend to have higher existing capacity for implementation, such as access to technologies and understanding of their application. Regarding supplementary measures, in the example of no-till farming farmers may require capacity building in this new technique, and financial support to cover the capital costs of machinery. (Note, this is separate from the additional capacity building of participants required to support them in complying with the CPI, such as guidance and training on trading under an ETS).

Extra effort is required to establish robust MRV and data systems for the agricultural sector, given measurability and monitoring challenges. As shown in Section 3.2, the nature of agricultural emissions presents unique challenges for measurability and monitoring. Emissions cannot easily be estimated by proxies such as land size or volume of production, although the New Zealand government is trying to do so (Case study in Section 3.3). Since robust data and MRV systems are a cornerstone of any CPI, extra effort needs to be made to solve this challenge.

Policy mix for addressing barriers to GHG mitigation in Agriculture

Due to the challenges described above associated with implementing CPIs, these instruments, such as ETS and CT, should be applied as part of a policy mix. An effective policy mix includes both: (1) incentives for GHG emission reduction (such as applying a carbon price) and (2) supplementary policies addressing barriers to this incentive. Table 7 presents a policy mix which can supplement an ETS/CT. These measures are explained in more detail in Section 6, which considers alternative climate policy instruments for agriculture. Note that in all cases, revenues from the CPIs can be recycled to support the implementation of supplementary instruments.

Table 10 –Supplementary policy instruments to CPIs for GHG mitigation in agriculture

Barrier	Supplementary Policy Instruments
Cultural and capacity barriers. Cultural resistance, combined with low capacity issues, may create significant barriers to changing long standing agricultural practices.	**Advisory services.** As will be seen in Section 6, advisory services are a key component of a best practice policy mix for agriculture. The EU requires every member state to have an advisory service available to all farmers. The service includes information and guidance on regulatory compliance, technical information on improving business efficiency and detailed information on the application of mitigation and adaptation activities. **Collaborative development of GHG mitigation plans.** It is best practice to work with farm sector representatives to understand and address the barriers faced. Giving them responsibility for the development and implementation of GHG mitigation plans

	increases the chances of successful outcomes.
Financing barriers. As highlighted in Section 2.2, a number of mitigation options have high upfront costs, requiring funding and financing.	**Dedicated/subsidised credit lines.** As we have seen, there are a number of credit lines already targeted at the agriculture sector in Brazil. Access to this credit could be conditional on meeting sustainability criteria and compliance with environmental safeguards. **Crediting mechanisms.** As shown before, crediting mechanisms can be introduced alongside CT/ETS and provide a source of funding mitigation options. **Results based financing.** As per the case study on the multilateral BioCarbon Fund, in Section 5.4, there are many examples of incentive payments for beneficial activities. For example, payments for environmental stewardship make up 20% of total payments to farmers through the Common Agricultural Policy. **Financial/fiscal support.** This includes a range of measures such as grants, subsidies and tax rebates. **Government sponsored programmes to focus on implementing specific GHG mitigation options**. Programmes can be developed to e.g. subsidise the implementation of anti-methanogen vaccines, alongside appropriate training for the measure.
Technology barriers and support for innovation. Innovation is fundamental for sustainable intensification, and GHG mitigation.	**Targeted financial support.** An OECD paper emphasises the need for targeted financial support for innovation, refocussing rural credit support from distortive, short term lending for working capital for commercial producers, to projects that explicitly incorporate technological innovation. **Supporting R&D capacity.** Supporting the capacity of R&D institutes, such as EMBRAPA, through funding and similar measures. Finally, working with farmers to support the adoption of innovation, through capacity building programmes.

Source: Ricardo Energy & Environment.

6 ALTERNATIVE CLIMATE POLICY INSTRUMENTS FOR AGRICULTURE

In light of the limited experience of CPIs in the agriculture sector, the scope of this report was expanded to include alternative policy instruments for climate change mitigation in agriculture. These instruments have been selected based on a review of international best practice regarding policies to incentivise the relevant mitigation options (identified in Section 2.2). Four categories of policy instruments are identified (Gerber et al., 2013):

- **Policies that promote knowledge exchange and advice and support services.** These usually provide farmers with examples of improved practices and technologies, increase the knowledge base and capacity for their application and provide advice for market opportunities. These include trainings, demonstrations, knowledge networks and communication strategies.
- **Policies that promote research and development.** These are focused on building an evidence base for new practices and technologies and increase their possibility for applicability and affordability.
- **Financial incentives** can include subsidies for abatement options, but also CPIs such as carbon taxes and ETS.
- **Regulatory approaches** can include specific mitigation targets or quotas for sectors or farmers and mandating the use of technologies and practices.

Table 11 provides an overview of the main policy instruments (dark blue) and necessary supplementary measures (light blue) for each priority mitigation option, as well as the key examples which are elaborated further in this section. Table 11 shows that the most commonly used measures are financial incentives, followed by knowledge exchange, advice and support services. Financial incentives function in a way similar to crediting and RBF mechanisms.

Table 11 - Overview of policies to incentivise five mitigation options

Priority mitigation option	Alternative policy instruments			
	Knowledge exchange, advice and support services	**Research & development**	**Financial incentives**	**Regulatory approaches**
Nutritional supplementation	EU CAP gives out information on appropriate use of feed supplements (Martineau et al., 2017)	The EU gives out grants for research on feed supplements that reduce methane emissions (Martineau et al., 2017)	In theory, this is a possible policy option although no examples exist (Green Growth Institute, 2010).	The EU monitors the usage of additives (Martineau et al., 2017)
Genetic improvement of livestock.	Examples from the Irish Farm Carbon Navigator programme where farmers receive payment to undertake a half-day training courses (Martineau et al., 2017)	Both in Scotland and Ireland grants are provided to use beef herd data to analyse how performance can be improved (Department of Agriculture Food and the Marine, 2015; Martineau et al., 2017).	Example from Ireland where payments are made to farmers to collect performance data on their herds and incentivize selection of the highest performing cattle (Martineau et al., 2017)	
Improved pasture and grassland nutrient management.	Example from the Focus on Nutrients programme in Sweden. This programme includes innovative trainings and advisory approaches (Martineau et al., 2017).		In the EU CAP farmers receive payments for maintenance of the soil organic matter and for activities to limit soil erosion and nitrogen application to land (European Commission, 2017a)	The EU encourages efficient use of nitrogen application through its nitrates directive. This directive limits the allowed application of nitrogen per hectare of land (European Commission, 2010)
Agroforestry: integrated cropland-livestock-forestry systems.	The EU CAP has an advisory service available with information on how to implement agroforestry in an appropriate manner (Martineau et al., 2017)		The EU CAP provides both capital and management payments for agroforestry (Martineau et al., 2017)	For example, Forest codes can be used for retention of agroforestry systems.
No-till farming	The EU CAP provides farm advisory systems which provides either free or heavily subsidized advice on productivity or best practice (Martineau et al., 2017)	The EU is undertaking more research in the area of zero-tillage. This is focused on collecting monitoring information and data to demonstrate the effectiveness of these measures (Martineau et al., 2017)	Examples include area payments for zero-tillage management of land and capital grants for machinery required to convert to zero tillage systems in the EU CAP (European Commission, 2017a) Other examples include US grant funding for equipment and seeds (USDA, 2017) and in Australia conservation tillage counts as a refundable tax offset (Australian Government, 2017)	

Main relevant policy options	Supplementary measures	No example identified

Source: Ricardo Energy & Environment.

For each mitigation option, this section will provide an overview of: the nature of the relevant incentives, supplementary measures, implementation requirements, the barriers addressed and evidence of effectiveness (where available). Examples will be given from international experience with these policy options. In particular, the following chapters will draw on experience from the **European Union's Common Agricultural Policy (CAP)**, as outlined in Appendix 0.

6.1.1 Policies for support use of nutritional supplementation (ionophores, fat supplementation, probiotics, propionate precursors)

As explained in section 2.2, there are several supplements which may be added to livestock feeds in order to reduce CH_4 emissions. Such additives may work in a direct manner by reducing the conversion of carbohydrate to CH_4. Alternatively, some supplements work in an indirect manner by improving animal performance and thereby reducing emission intensity per animal. In this section we will therefore distinguish between policies that encourage:

- Methane conversion reducers, including probiotics, propionate precursors and fat supplementation.
- Growth promoters, that reduce the animal's lifespan and thereby emission intensity per animal.

Only few examples exist of policies that encourage the use of nutrition supplementation to reduce methane emissions. Within the EU, there are no examples available where EU funding has been used to encourage the use of feed additives (Martineau et al., 2017). The EU restricts the usage of certain antibiotics and growth promoters, such as ionophores, which means that these products can also not be imported when farmers have applied those supplements.

Nature of the incentive

In general, wherever food supplements are encouraged, these incentives usually take the form of **financial incentives** including subsidies and tax rebates (Green Growth Institute, 2010). The choice of individual farmers to use feed additives typically depends on the costs and economic impact on the farmer when using them. Therefore, when implementing these financial policies it is important to acknowledge the need to vary the level of subsidies depending on the impact of the feed supplement on productivity. For example, lower levels of rebate will be necessary for growth promoters because of their positive impact on productivity compared to methane conversion reducers. Growth promoters will already increase the level of income for a farmer and thereby their capacity to purchase the supplements, whereas many methane conversion reducers (e.g. propionate precursors) have no significant impact on increasing income for the farmer per tonne of carbon emissions reduced (Martineau et al., 2017).

Supplementary measures

Most policy examples focusing on encouraging the use of feed additives emphasize the importance of supplementary measures. The EU CAP, for example, refers to demonstration activities and information to encourage the adequate use of feed supplements (Martineau et al., 2017). This is focused on the importance of knowledge transfer to know how and when to administer the feed additives.

Additionally, the support for building cattle accommodation could be important for policies encouraging feed additives. This supplementary measure may be necessary because of the difficulty in administering the supplements in ranch systems, such as in Brazil (Green Growth Institute, 2010). Therefore, support for building systems where feed intake is controlled is crucial for a successful policy to encourage the use of feed additives. Examples of this exist in the US where the increase in use of Ionophores was mainly experienced in feed lot systems (Hersom & Thrift, 2012).

Implementation requirements

As described above, setting up **farm and forestry advisory services** is crucial to ensure adequate infrastructures is in place to disseminate and monitor the usage of additives. Additionally, a **regulatory infrastructure** distributing payments and monitoring the usage of additives is required.

Barriers addressed

Firstly, subsidies to encourage feed supplements are designed to overcome the high costs associated with certain feed additives, including fat supplementation, propionate precursors, ionophores and probiotics.

However, feed additives also face barriers related to technological and socio-cultural aspects. While the technology of feed additives is well developed, some of the supplements might not be readily available to farmers. This might be due to financial barriers, but also due to other restrictions, dissemination of the products, knowledge about their existence and function or public concerns about using inputs in livestock feed (Martineau et al., 2017). Capacity building and dissemination of the measures are required in order to support the farmer. Some of the suggested supplementary measures address this barrier. Moreover, ionophores require further research into their long term effectiveness and the palatability and more research is needed on the effectiveness of probiotics. Policies that promote research and development of these supplements and can build the evidence base for their effectiveness are therefore also needed to address these barriers (Martineau et al., 2017).

One of the greatest barriers in Brazil is that a relatively small proportion of the beef herd are managed in a manner that makes administration of feed additives possible. Cattle in ranch systems require little, regular supplementary feed. Administering feed additives to animals spread over large areas with any degree of accuracy is very difficult. Animals managed in housed systems (in confinement) are easy to administer additives to as they are simply added to the daily ration. Encouraging the intensification of livestock production in confined systems may be one solution, but there are significant risks and costs associated with this.

Costs: capital expenditure is high for the construction of buildings to house animals and machinery required to harvest and conserve forage and feed livestock.

Risks: Management of animal manure and slurries present environmental risks and also create a new source of emissions from manure management (both methane and nitrous oxide). Air Quality impacts from ammonia and water quality impacts of nitrates and other diffuse pollutants are significant issues and are very costly to mitigate and remediate. There are many examples of this including across the EU.

Verified results of policies

No examples exist in the literature of verified results of financial incentive policies to promote the use of feed additives to reduce GHG emissions from cattle. The main success factors for policies, however, do seem to depend on individual decisions influenced by the economic impact on the farm business (Martineau et al., 2017). This implies that financial incentives can play an important role, but more evidence is needed to see how they can be most effective.

Another method to incentivise the use of feed supplements is by lifting regulations. In 1976 the US approved the use of the ionophore Monensin. Following this change in regulation, most feedlot cattle were using it within years (J. B. Russell & Houlihan, 2003).

6.1.2 POLICIES TO SUPPORT GENETIC IMPROVEMENT

Nature of the incentive

This section will specifically focus on policies that support genetic improvement of livestock through **financial incentives**. Examples of policies come from Scotland and Ireland, where a programme of work has been implemented where payments are made to farmers to collect performance data on their herds. This also includes carbon auditing the farm to benchmark GHG emissions and assess improvements (Martineau et al., 2017) . Both these programmes are aimed at improving the productivity of animals rather than breeding ruminants that are genetically predisposed to produce less methane. The objective of the genetic selection is to improve productivity and thus improve GHG intensity.

Ireland, as a major world beef producer, has implemented a programme on beef data and genomics, which aims to improve the quality of the Irish beef herd and reduce GHG emissions per kg of beef produced (Department of Agriculture Food and the Marine, 2015). The programme is designed in such a way where a more efficient (in terms of GHG emissions per kg of beef) will produce more calves during its lifetime than other cows. This programme is based on the collection of detailed information about the cow herd, which can subsequently be used to create a genomics breeding database which ranks animals on their efficiency. Farmers can use this database to select cows and bull replacements. All farmers who joined the programme in 2014 are now committed to a six-year programme where data on herds, such as genotypes, are recorded and they have to only make herd replacement with high efficiency ratings. Participants are also obliged to use the Farm Carbon Navigator, which is a tool to help estimate GHG reductions and financial savings through improved farm efficiency. This tool can help farmers to set emission reduction targets and benchmark their farms. Farmers receive payments for participation in the programme. These payments are based on the time required for data recording, costs of genotyping, and the costs of herd replacement after deductions are made for economic benefits for the farm from the scheme. Then a standard coefficient is used to convert these costs per animal to an annual hectare based agri-environment climate payment. This payment is now set at 142.50 euros per hectare for the first 6.66 hectares and 120 euros per hectare above that.

Scotland has also launched a programme to promote the genetic improvement of the beef herd. This is the 'Beef Efficiency RDP scheme', which was implemented in 2016. This scheme aims to bring about genetic, economic and environmental improvements in the beef breeding and finishing sector (Martineau et al., 2017).

Supplementary measures

Advisory services and research facilities are needed in conjunction with this policy measure. For example, farmers in the Irish programme must take a half-day training course about the programme and on using the Farm Carbon Navigator. They receive a payment of 166 euros for undertaking this training (Department of Agriculture Food and the Marine, 2015; Martineau et al., 2017).

Implementation requirements

The implementation of these types of schemes are difficult due to the long timescales that are required. They also heavily depend on a good and broadly applied data recording system. To date, almost no country collects data on individual animals and their efficiency of emissions per unit of production. An initial database is therefore crucial for successful implementation of this policy measure (Martineau et al., 2017).

Barriers addressed

The main barriers of this mitigation option are the understanding of appropriate breeds, capacity building and dissemination of measures. The policy measures mentioned above, including the genomics programme and the Farm Carbon Navigator in Ireland, are addressing exactly these barriers related to a lack of data availability. However, other barriers related to communicating benefits and getting long term commitment from farmers has been challenging. For example, in Scotland long term commitment from farmers has been low despite the payments available (Martineau et al., 2017).

While the above described programmes were based on breeding animals for increased productivity, breeding programmes for low methane emissions in ruminants have only recently started. These programmes need to overcome several technical barriers, including maintaining lower levels of methane emissions during the lifetime of the animal, as this is also influenced by the microbial population of the rumen, not just the genotype of the animal. Moreover, the new lower methane breeds are likely to be more expensive than conventional breeds, at least initially. It is impossible to estimate at this stage to what extent these costs may be offset by other economic advantages that may be enhanced during the breeding programme (e.g. more efficient feed conversion or higher yields of meat or milk per head). It is not possible to estimate the timescale of implementation by farmers, because this depends on when these improved breeds are becoming commercially available. However, this is likely to be in the medium term (Martineau et al., 2017).

It does however show that breeding programmes focused on low methane producing animals face more barriers than those focused on productivity improvements.

Verified results of policies

Most policies relating to improvement of genetics of the herd or breeding programmes have only recently started and have therefore not produced any verified results yet. However, in Ireland already 29,000 farmers joined the first round of data improvements and made six-year commitment to making cattle replacements with high rankings. The programme is worth 52 million euros per year to Irish farmers leading to some short-term significant data improvements.

6.1.3 Policies to support Improved pasture and grassland nutrient management

Policies that support improved pasture and grassland nutrient management include the encouragement of land rotation, control of weeds and pests with herbicides and efficient use of fertilizers.

Nature of the incentive

The main examples of policies encouraging nutrient management come from the European Union and its Common Agricultural Policy (CAP)**,** where farmers receive **payments** for maintenance of the soil organic matter and other environmental services such as limited soil erosion and limiting nitrogen applications to land (European Commission, 2017a). Additionally, the development of soil and nutrient management plans is a requirement for area payments based on environmental indicators within the CAP. The soil and nutrient management plans can identify practices that optimise the use of nutrients from a range of sources. It is important to note that policies in the EU are in place to meet water quality objectives relating to nitrates (N) in water courses. There is a cap on N applications of between 180kg/ha and 250 kg/ha which allows farmers to still apply the economic optimum N if done so at the right time and to the right crop. When promoting nutrient applications to increase productivity - it is likely to be the case that increased N applications are required depending on the current baseline. In this situation there will be an increase in Nitrous Oxide emissions, but reduce the land requirement per unit of production.

Besides financial incentives, also **regulatory approaches** are used in Europe. The EU encourages efficient use of nitrogen application through its nitrates directive. This directive limits the allowed application of nitrogen per hectare of land (European Commission, 2010).

An example of a regulatory approach comes from an agro-environmental programme in Finland (Martineau et al., 2017). Within this programme it is mandatory for every participant (or beneficiary) to plan, report and monitor their fertilizer use. Every five years the Finnish government then carries out a soil mapping and analysis exercise and thereby promotes the increased accuracy in fertilizer application and the use of cultivation plans by farmers that also record basic data. This planning and monitoring approach enables farmers to consider specific farm needs when implementing environmental management measures (Martineau et al., 2017). This is also a policy planned for implementation in Scotland. This is based on the idea that development of soil and nutrient management plans is a requirement of area payments for environmental schemes.

Supplementary measures

For both the financial incentives and regulatory approaches described above, it has been argued that knowledge and advisory services are crucial to have a successful implementation. An example of such an advisory service comes from the 'Focus on Nutrients' programme in Sweden (Martineau et al., 2017). This is a programme financed by both funds from the Swedish government and the EU. This programme includes innovative trainings and advisory approaches. It has become a well-established system among the farming community, with more than 8,000 members in 2011. The 'Focus on Nutrients' programme is voluntary, free and individually tailored to farms that have more than 50 hectares of land or 25 livestock units. When a farmer joins, his farm is visited by qualified advisors to identify particular practices to be adopted by the farmer. Between the beginning of the project in 2001 and 2011, a total of 40,000 farm visits were carried out by 250 advisers as part of the effort to reduce nutrient losses.

Implementation requirements

The implementation aspects required for improved nutrient management mostly consist of ensuring sufficient infrastructure is place for the supplementary knowledge and advisory services as is in place for CAP and described in section 6.1.1 and Appendix 0.

Barriers addressed

Financial incentive policies can help farmers to overcome the high upfront costs of creating nutrient management plans, requesting technical advisory input and carrying out reporting and soil analysis on their land. In the longer-term however, improved nutrient management can bring about savings for individual farmers through reduced need for fertilizers and longer-term improvements in soil quality that can increase farm productivity (Martineau et al., 2017).

The barriers related to cultural resistance are addressed by regulatory approaches that mandate reduced use of nitrogen on the land. However, changing existing approaches and management systems is difficult and often faces cultural resistance among farmers, even when productivity benefits have been clearly demonstrated. Good advisory services, as outlined for Sweden above are therefore key to addressing all the barriers associated with improved nutrient management.

The techniques of soil and nutrient planning are well understood by the scientific and advisory community but uptake among farmers is not known and may be lower among smaller or economically marginal livestock farms (Martineau et al., 2017).

Verified results of policies

The examples above demonstrate successful uptake of the suggested policy measures and thereby reductions in GHG emissions from agriculture. The Finnish example of mandatory MRV, was implemented in 2000 and over the years this approach has led to increased awareness and capability of farmers for nutrient management (Martineau et al., 2017). Moreover, it has also enabled longer term planning with a contribution towards consistent environmental goals (ENRD (European Network for Rural Development) - European Commission, 2013).

Through the advisory service in Sweden, nine out of ten farmers now implement nutrient management measures suggested by the service. Data shows that farmers are more resource efficient, have decreased nitrogen and phosphorus leaching by 800 and 30 tonnes per year respectively since implementation of the scheme (Greppa Naringen, 2011). This demonstrates that even a voluntary advisory scheme can have far-reaching impacts on emission reductions.

6.1.4 Policies to promote agroforestry, particularly integrated cropland-livestock-forestry systems.

Policies to promote agroforestry include the practice whereby trees or shrubs are integrated with the production of crops or livestock. This section focuses on the combination of forestry with livestock production with a specific emphasis on policies that encourage the expansion of agroforestry systems, rather than the retention of them, as retention can be covered through a forest code.

Nature of incentive

The main policy measures used for promoting agroforestry and integrated livestock-forestry systems include **financial incentives** in the forms of capital and management payments to incentivise actions.

For an individual farmer the adoption of an agroforestry system brings about significant change. It will require upfront investments and it can lead to loss of productivity in the short-term. However, in the longer term it can lead to increased productivity from trees, crops and livestock. The upfront investments include the costs of the tree crop and income lost in the first year from the arable crop or grass no longer grown on that land. This requires significant commitment and motivation from individual farmers to adopt this practice (Aertsens, De Nocker, & Gobin, 2013). The adoption of these practices also require new skills, techniques and equipment to apply new management systems of the land and protect the new trees from damage by machinery or livestock (Calfapietra, Gielen, Karnosky, Ceulemans, & Scarascia Mugnozza, 2010). Both the unfamiliarity of farmers with these new practices and the perception of reduction in productivity in the short-term, make the component of technical advice and support in policy systems promoting agroforestry crucial.

Examples of policy schemes providing both capital and management payments for agroforestry and advisory services come from CAP in the EU (Martineau et al., 2017).

Supplementary measures and implementation requirements

As described above, measures around knowledge transfer and advisory services are an integral part of the policy package for agroforestry, due to the perception of farmers that productivity will decrease when adopting these practices. Moreover, in CAP it has been reported that farmers may be concerned that agroforestry might reduce their CAP direct payments. A clear, transparent way of communicating the advantages and disadvantages of a financial incentive scheme for agroforestry is therefore important to motivate farmers to adopt new practices (Martineau et al., 2017).

Barriers addressed

Barriers for uptake have been agreed to be due to a lack of practical experience and absence of reliable advice on the economics of new agroforestry systems. Moreover, agroforestry systems are less flexible than traditional arable cropping and therefore also harder to adopt. No evidence exist also that advisory services and payments that cover costs of tree planting have overcome these barriers in a significant way to reduce GHG emission from the agricultural sector.

Verified results

Agroforestry has not yet been widely used in in most EU countries and uptake has been growing slowly.

6.1.5 Policies to promote no-till farming

The mitigation action of zero tillage is considered with respect to its potential for sequestering carbon in the soil. Zero tillage systems are well understood and a diverse set of mechanical cultivation options are available to apply this new management system (Martineau et al., 2017; McVittie, 2014).

Zero tillage (ZT) or No-till, is the elimination of all soil tillage. It includes mechanisms whereby seed is drilled directly into uncultivated soil. Recent reviews and meta analyses have queried the effectiveness of using ZT as a means to sequester soil carbon (Van den Putte, Govers, Diels, Gillijns, & Demuzere, 2010).

However, the method of zero tillage has a large impact on the cropping system of the farm and thereby economically impacts the farm’s performance. Upfront investments are needed for new field equipment for zero tillage systems, while operational costs might be lower than usual practices and no significant impacts have been reported on production levels. Although in some cases, such as soybeans, increased production levels have been measured. Moreover, ZT usually brings about savings in fuel and labour costs, while costs for crop protection, including herbicides to kill weeds, increased application of slug pellets and fungicides, are increased. Moreover, if zero tillage replaces fallow in the rotation it will be possible to grow crops every year and thereby increase production levels (Martineau et al., 2017).

Nature of the incentive

Examples of policies that have been used to promote the application of zero-tillage measures include measures to overcome barriers to up-front investments such as:

- **Area payments** for land managed in this way. This would be potentially difficult and costly to verify and monitor (Martineau et al., 2017).
- **Capital grants for machinery** required to convert to zero tillage systems (specialist seed drills). There are productivity and economic benefits of no-till systems in the right circumstances so the catalyst of a capital grant for equipment should be enough. There is no need for ongoing management payments.

Examples of application of these policy options include:

- The European Union provides farm productivity grants to farmers to invest in equipment such as seed drills. However, it has been argued that in the EU this has been a natural evolution of good practice, not necessarily incentivised by policy. There are however examples from CAP (measure 4.1) where capital grants are given to farmers for investment in agricultural holdings (Martineau et al., 2017; Werner et al., 2015).
- The US has grant funding available for equipment and seeds. The government also provides loans at favourable interest rates to encourage these types of investments (USDA, 2017).
- In Australia conservation tillage counts as a refundable tax offset. Between 2012 and 2014 farmers could apply for a 15% refundable tax offset when they purchased new conservation seeding equipment. This was called the "*Conservation Tillage Refundable Tax Offset (RTO) initiative [and] was part of the Carbon Farming Futures program. It was designed to encourage conservation tillage practices in Australian agriculture."* (Australian Government, 2017).

Supplementary measures

As with the other policy options, knowledge transfer and advisory support are crucial to the effectiveness of this policy. Examples of such services come from the CAP farm advisory systems, which provides either free or heavily subsidized advice on productivity or best practice in relation to zero-tillage activities for farmers (Martineau et al., 2017).

Implementation requirements

As the knowledge transfer and advisory support is crucial for this policy measure, the infrastructure supporting these schemes are requirements for successful policy implementation. These include having trained technicians in place, developing guidance materials for farmers and having courses for farmers available in different geographies (Martineau et al., 2017).

Barriers addressed

As described above, these policy measures all address the barriers of high upfront costs or investments to adopt zero-tillage measures. However, other barriers include challenges around monitoring to demonstrate effectiveness. The policy measures described so far have not addressed these barriers yet (Martineau et al., 2017).

Verified results

There is disagreement on the effectiveness of this policy measure to incentivise farmers to take up zero-tillage farming methods and thereby reduce GHG emissions. The key reason for this disagreement is the lack of monitoring information and thereby data to demonstrate whether the measures and policies have been effective (Martineau et al., 2017).

6.1.6 Other: Demand side policy options

Besides the production-focused policy measures, there are also policy options available that are focused on the consumer-end to reduce GHG emissions from the agricultural sector. These include certification instruments and advocacy and awareness raising tools.

Certification is used to increase transparency in the supply chain and help consumers align their preferences with emission profiles of products. The ultimate aim of certification schemes is that consumer demand for lower-emission products will drive producers to adopt mitigation measures. Similarly, advocacy and awareness raising policies aim to increase consumer demand for lower-emission products (Martineau et al., 2017).

Recently international NGOs have held campaigns for moratoriums on buying products from recently deforested areas or from areas with minimal environmental and social certification standards (Gardner, Godar, & Garrett, 2014). However, no evidence exists that these incentives have been effective in reducing emissions from the agricultural sector. In contrast, some studies have even suggested that these initiatives have led to undesirable impacts such as strengthening power imbalances within the Brazilian agricultural sector. This demonstrates the need for incorporating social and environmental safeguards when applying these consumer-focused measures to the Brazilian agricultural sector (Martineau et al., 2017).

Finally, some countries have been considering a meat tax. Scientists' analysis published in the journal of Climate Change states that such a tax has recently been modelled by the EU with tax rates proportional to the average GHG per unit of food sold (Ripple et al., 2013). However, social justice, equity and food access issues need to be carefully considered when setting this tax rate to prevent perverse incentives. Of particular concern to Brazil would be the distributional impact on farmers such a tax could cause.

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APPENDICES

A. POLICY INSTRUMENTS IN BRAZILIAN AGRICULTURAL SECTOR

The main objectives planned for the Agriculture sector (PPA 2016-2019) and its instruments are presented in this section (PPA, 2015). The credit, insurance and price support instruments have been categorised according to the following objectives:

- Productivity and innovation for growth and competitiveness
- Equity and social protection
- Environmental protection and sustainability

PRODUCTIVITY AND INNOVATION FOR GROWTH AND COMPETITIVENESS

Table 12 - Brazilian policy instruments for agricultural productivity and innovation for growth and competitiveness

Instrument(s)	Type	Description	Secondary objective(s)
Moderfrota **Pronanmp** **Plano ABC**	Credit	Funding of operational costs (including commercialisation) 149.5bn BRL; funding of capital investment: 34bn BRL; main programmes - Moderfrota (modernizing the farm tractor fleet), Pronamp (support for medium producers, split into support for operational costs and capital costs of new investment, 8.5%p.a.); Plano ABC (see below – low carbon farming);	Environmental protection and sustainability (Plano ABC)
Moderinfra **Moderagro**	Credit	Moderinfra finances, with 8.5% pa, the development of sustainable agriculture irrigation systems and fruticulture in temperate climates Moderagro - aims to support and foster the production, processing, industrialization, packaging and storage of products. The interest rate charged for this program is 9.5% pa. However, there is less bureaucracy to access this credit line. Also finances actions on animal defence and traceability, soil recovery.	Environmental protection and sustainability

Agricultural insurance policy	Insurance	Offers the farmer the opportunity to insure their production at a reduced cost through financial assistance from the federal government. There is the Family Agriculture Insurance (SEAF).	Equity/ social protection
Trade policy	Trade Tariffs	Regarding agricultural trade policy, Brazil's trade regime is subject to WTO disciplines and free trade agreements with almost all South American countries. The level of agricultural protection (average MFN tariff of 10%) is somewhat below average (14.1%), but Brazil's position as a large net agro-food exporter implies that its own import tariff regime has limited importance for most parts of the agricultural sectors. Regarding foreign markets, key export markets are protected by Tariff Rate Quotas, and face SPS restrictions. Significantly, a tariff and non-tariff protection for capital and intermediate goods is relevant for agriculture because it increases investment costs into advanced technologies, equipment and technology transfer, affecting technological innovation and adoption.	Sustainability

Equity and Social Protection

Table 13 - Brazilian policy instruments for equity and social protection in agriculture

Instrument(s)	Type	Description	Secondary objectives
Minimum price guarantees – (AGF; PEP; PEPRO;	Domestic price support	Federal government agrees to purchase the product at the minimum price if the market price falls below this price. Another mechanism to prevent the federal government from forming high inventories, government provides loans to producers so they can stock the products and sell them in the off season. Subsidy of 2.7bn BRL from public resources.	n/a

PROP)			
PRONAF	Credit	National Program for Strengthening Family Agriculture (Pronaf), finances individual or collective projects that generate income for family farmers and settlers. The program has the lowest interest rates on rural finance (rate varies between 2.5% and 5.5% in nominal terms, hence heavily subsidised – probably the lowest in any sector in Brazil).	Environmental protection and sustainability.
Food Acquisition Program **(PAA)**	Domestic price support?	Food Acquisition Program (PAA) is an action of the Federal Government to collaborate in the fight against hunger and poverty in Brazil and, at the same time, strengthen family farming. In short, the federal government acquires part of the food from family farmers, settled agrarian reform, indigenous communities and other traditional peoples and communities, for the formation of strategic stocks and distribution to the population in greater social vulnerability.	n/a
Land reform policy	n/a	Land reform is being undertaken by the Min. of Development	n/a

ENVIRONMENTAL PROTECTION AND SUSTAINABILITY

Note that the provision of credit and insurance support the compliance with environmental zoning and Forestry Code requirements.

Table 14 - Brazilian policy instruments for environmental protection and sustainability

Instrument(s)	Type	Description	2nd objective (implicit)
PRONAF ECO PRONAF Floresta	Credit	National Program for Strengthening Family Agriculture (Pronaf) finances. 12 existing credit lines in PRONAF (see above), it is worth mentioning the two that have a direct relationship with sustainable agriculture: o Pronaf Eco - investments in techniques that minimize the impact of the rural activity on the environment, o Pronaf Floresta: Financing investments in projects for agroforestry systems	Equity/ social protection.
Low Carbon Agriculture Program (ABC)	Credit	Financed approx. 12,5billion BRL (2010-1016) so far. Provides credit to finance practices that contribute to the reduction of GHG by reducing deforestation, increasing agricultural production on a sustainable basis, and adapting rural properties to environmental legislation. The credit also covers the expansion of the area of cultivated forests and the recovery of degraded areas. Interest rate of 7.7% pa on the crop year 2017/2018 ABC could have a larger demand but it faces challenges such as lack of knowledge of the technologies and credit lines and bureaucratic aspects of the loan, and there are many other sources of credit available.	Productivity and innovation
Research and	R&D	Embrapa, with other partner institutions, has one of the largest research portfolios in the world to	Productivity and

development		reduce the impacts of climate change on agriculture. Research portfolios were established in areas of great strategic importance: irrigated agriculture, biological nitrogen fixation, integrated cropland-livestock-forestry systems (ICLFS), climate change, pasture, and the impact of the use of agrochemicals on the environment. Also the development and innovation in the interface between agriculture and the environment.	innovation
Forest Code	Command and control Payment for environmental services	**Forest Code** covers a number of areas **-** of greatest relevance to Agriculture are: - The **Legal Reserve** - the percentage of each property or rural possession that must be preserved, varying according to the region and the biome (type of forest cover). -Environmental regularization program, requiring **monitoring** of rural properties. A registry is set up for this purpose (Cadastro Ambiental Rural). Finally, there are plans to implement a **program to support and encourage the preservation and recovery of the environment**, which includes incentives for adoption of technologies and good practices that combine productivity (agriculture and forestry) with reduction of environmental impacts. The incentives mentioned are: payment or incentive to environmental services (PES) as compensation to ecosystem conservation, improvement, management of environmental services, and, including credit, tax and other benefits. However, this program has not been legislated to date.	n/a

B. GHG EMISSIONS AND MITIGATION OPTIONS FOR THE BRAZILIAN AGRICULTURE SECTOR

In 2014 around 25% of current GHG emissions in Brazil came from agriculture. Within the agricultural sector in 2014, 60% of emissions were from enteric fermentation (methane), followed by 35% from agricultural soils (nitrous oxide) (Food and Agriculture Organization of the United Nations, 2017; OECD, 2015). Other sources of emissions include manure management, rice cultivation, prescribed burning of savannas and field burning of agricultural residues (UNFCCC, 2005).

Figure 6 overviews emissions per type of activity from the agricultural sector from 1970 to 2014 (SEEG Brasil, 2014). The figure shows that emissions from enteric fermentation have evened out since 2010. Methane emissions from agriculture in Brazil have only grown by 2.2% between 2005 and 2012, while the total emissions from agriculture grew by 6%. The cattle population in the country grew by 1.5% per year over the same year, which means that the productivity per head of cattle has increased by 2-3% per year and emissions per kg of produce from cattle have decreased (OECD, 2015; SEEG Brasil, 2014).

Regarding agricultural soils, major productivity improvements have been achieved through the use of improved machinery. However, the emission intensity has not improved significantly over the same time period due to higher use of fertilizers (OECD, 2015).

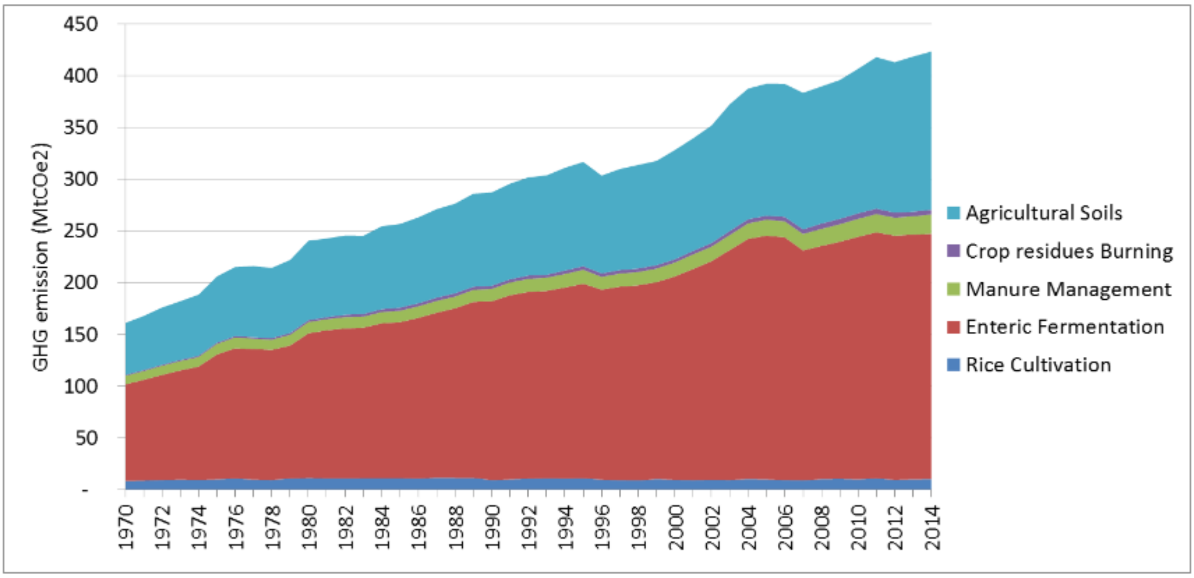

Figure 6 - GHG emissions from agriculture in Brazil from 1970 – 2014

Growth of emissions by 2030

A study by the Global Green Growth Institute (GGGI), for the identification of low carbon development options for Brazil presents the expected evolution of GHG emissions in Brazil between 2005 and 2030 (Green Growth Institute, 2010). Emissions from agriculture in Brazil are expected grow in absolute terms by approx. 30%, but due to growth in other sectors, will remain 22% of the total emissions in 2030.

The FAO projections expect that the main emission sources that will contribute to the growth are cattle rearing, synthetic fertilizer application and manure left on pasture (Food and Agriculture Organization of the United Nations, 2017). The assumed driver for this growth is mainly increased demand due to a 25% population growth worldwide from 2005 to 2030 and global development that will increase per capita GDP. Moreover, the growth in beef consumption is based on the assumption that eating habits in the world will change towards 2030 with a higher consumption of animal protein worldwide. Therefore, cattle rearing is expected to contribute to 37% of the expected growth. Soil emissions under these assumptions are expected to increase the most of all with 90% to 2030 (Food and Agriculture Organization of the United Nations, 2017).

Priority mitigation options for Brazil

The table below presents a short list of most relevant mitigation options for the Brazilian agricultural sector. This is based on the mitigation options presented in a 2010 study by the GGGI (Green Growth Institute, 2010), and includes the options with greatest abatement potential and feasibility (including cost, and technology potential). The selection was confirmed by CEPEA's team, and excludes manure management, rice management (shallow flooding), rice management nutrient management. Agro-sylviculture is mentioned below because it is a subset of agroforestry, however it is not considered a priority due to limited the abatement potential, as stated.

Table 15 - Overview of priority mitigation options for Brazil

Category of mitigation option	Mitigation options and technologies	Key considerations for Brazil	Abatement potential and costs
Direct mitigation of enteric fermentation - Improved efficiency of ruminal fermentation	Possible mitigation options identified in the study include - anti-methanogenic vaccines, genetic improvement and nutritional supplementation. **Nutritional supplements** were considered the most feasible for Brazil, as these are already available in the Brazilian market. While a number of nutritional supplements are presented (including probiotics and propionate precursors), the most attractive for Brazil are **ionophore** supplements.	**Barriers** • Further research is needed into the effectiveness of ionophores in the long term, and the palatability; • Study identified limitations in the distribution system for Brazil; • Although there is already some familiarity with the use of ionophores in Brazil, there is still relatively low uptake • Capacity building on the use of the technology will be required. **Cost -benefit is excellent** due to efficiency and productivity improvements – provided a market is available.	Abatement potential is high (33MT CO_2e in 2030) and cost is low for dairy farms (negative abatement costs) but more expensive for beef farming.

Intensification of cattle farming	**Improved pasture and grassland nutrient management.** This includes land rotation, control of weeds and pests with herbicides. Matching with efficient use of fertilizer to reduce N2O emissions per output (– e.g. limestone, then nitrogen, / phosphorus/ potassium). **Use of nutritional supplements.** Feeding animals with supplements containing salt (Especially in the rainy season), protein supplements (in the dry season), or concentrated feed such as silage/fodder Genetic Improvement of livestock – using best livestock for the region will improve productivity.	None mentioned.	Abatement potential is very high - ~65MT/ CO_2e in 2030 Costs • Improved pasture management are low (negative abatement costs) • Nutritional supplements is low for dairy farms (negative abatement costs) but more expensive for beef farming. • Genetic improvement – n/a
Agroforestry (Silvopasture and agrosylviculture)	A land use management system in which trees or shrubs are grown around or among crops or pastureland, e.g. integrated cropland-livestock-forestry systems Agrosylviculture is most applicable to coffee cultures in Brazil.	**Barriers** Although examples of applications exist– integration of eucalyptus and cattle, of forest lands with coffee/banana/cacao, this is limited. Further research is required, into plant / forest genetics; animal management; tree management, and to understand agroforestry systems which are adequate and support productivity. Agrosylviculture - Significant debate as to whether there are possible productivity improvements for main crop **Co-benefits** include Additional income from forestry.	Overall high abatement potential for "integrated systems" category, approximately 18MT CO_2e in 2030, at a low cost (negative abatement cost). Agrosylviculture more limited abatement potential than silvopasture. The focus will be on integrated cropland-livestock-forestry systems.

		For Silvopasture, benefits include productivity improvements for cattle farming and crops / woodland, and Improvements of carbon in the soil.	
No-till farming	Less tillage could potentially reduce erosion and increase moisture and nutrient retention, and improve carbon stocks in the soil.	**Barriers** - High upfront costs CAPEX - Already well known in 50% of relevant agriculture lands with intermediate crops, concentrated in the south of Brazil, however, capacity/ understanding may be limited in the remaining regions - Fragmented agriculture practices - Different potentials by region **Benefits** include complementarity with productivity and beneficial to farmer – less machinery, improvement of soil quality, maintaining soil moisture.	Abatement potential is high - 30MT/ CO_2e in 2030 Costs are low (negative abatement costs). Cost of more herbicides traded off with less mechanisation.

C. OVERVIEW AND COMPARISON OF CARBON PRICING INSTRUMENTS

This section provides an overview and comparison of Emissions Trading Schemes (ETS), Carbon Taxes (CT), crediting mechanisms and results based financing mechanisms (RBF).Crediting mechanisms and RBF are introduced as they may be considered an alternative to ETS and CT for introducing a carbon price signal into a sector.

Crediting mechanisms are policy instruments that generate and issue emissions reduction certificates (called credits or offsets) to installations that reduce emissions, energy use or improve energy intensity below a predetermined benchmark level or "baseline". A well-known example is the Clean Development Mechanism (CDM). Each credit represents one ton of CO_2e abated and enables the purchaser to offset the same amount of GHG emissions, e.g. when faced with a reduction obligation under an ETS.

Crediting mechanisms are primarily a mechanism for channeling climate finance into GHG mitigation projects and are voluntary for participants. They also enable knowledge and technology transfer. They require a source of demand, through national or international carbon markets or voluntary offset markets, as described in Appendix 2. While Brazil's INDC submission excludes the possibility of international sale of credits, demand could come from compliance buyers who purchase credits to meet their obligations under an ETS or Carbon Tax. Voluntary purchases by companies or individuals seeking to offset emissions could also be possible in Brazil.

Results based financing. This is a funding mechanism to attract national or international funds for the purchase of environmental commodities, such as carbon credits or emission allowances. It can substitute or complement sources of demand from carbon markets.

Advantages and disadvantages of carbon pricing instruments. Table 16 below provides an overview of the advantages and disadvantages of these CPIs according to four basic criteria. These criteria were chosen to highlight the key differences in these CPIs **effectiveness** (emission reduction potential), **acceptability** (sources of funding) and **feasibility** (readiness requirements). RBF is not included as a standalone CPI, because it is best understood as a mechanism to channel financing into crediting mechanisms, as explained below.

Table 16 - Overview of the advantages and disadvantages of these CPIs

CPI	Compliance	Emission reduction potential	Source of funding for emission reductions	Readiness requirements on participants	Readiness requirements on administrators
ETS	Mandatory	Potentially high, as this is a mandatory mechanism which can cover entire sectors.	Participants themselves fund the cost of compliance. Options for compliance include investing in emission reduction measures, purchasing offsets or purchasing additional allowances.	Very onerous. Costs include capacity building, monitoring GHG emissions, costs of implementing measures, verifying and reporting outcomes, compliance with trading requirements. Larger participants generally have greater capacity.	Very high. Obligation and legislation, monitoring and oversight of compliance registry and trading platform, enforcement.
Carbon Tax	Mandatory	Potentially high, as above.	As above, however the option to purchase additional allowances is not available.	As above, with the exception of trading requirements.	As above, with the exception of trading requirements.
Crediting mechanism	Voluntary	Potentially low. Project based variants only reduce emissions from individual projects in a sector. Scaled and sector wide variants may increase the emission reduction potential.	Participants are compensated for the cost of delivering emission reductions through the sale of emission reduction credits. Possible sources of funding / demand for credits includes compliance markets (ETS or CT systems), voluntary markets, or Results based financing (RBF) mechanisms.	Simpler. Project developers must develop verifiable projects according to standards, and report on emission reductions. Simpler requirements mean smaller entities can participate. Scaled-up variants are intended to reduce the costs of participation for project developers.	High. Requires the establishment of a regulatory entity capable of monitoring and approving emission reduction projects. In addition, scaled-up variants shift costs from participant to administrators.

CARBON MARKETS OPPORTUNITIES

Existing carbon markets can be broadly categorized into voluntary markets and compliance markets. Compliance markets are those driven by government regulation, which allow the purchase of emissions reductions from elsewhere (credit/offsets) to comply with regulatory targets. Voluntary markets refer to the purchase of emissions reductions (credits/offsets) to meet voluntary carbon reduction efforts.

Compliance markets

The Clean Development Mechanism (CDM) exists under the Kyoto protocol along with Joint Implementation (JI). CDM projects result in Certified Emissions Reductions (CERs) while JI results in Emission Reduction Units (ERUs). Both markets face weakening demand and falling prices. It is unlikely in the short term (pre 2020) that demand for Kyoto credits will increase. The CDM pipeline could issue 3,500 MtCO2e between now and 2020 but this doesn't take into account weakening demand. As a result of a weakening market CERs were priced at 0.4 USD/tCO2e in 2015 and the ERU at 0.01 USD. How CDM or JI fit within the new mechanism defined in the Paris Agreement is yet to be determined (World Bank, 2016b).

Up until now Brazil has been an active participant in the CDM. At one stage CDM credits could be considered the 16th most important export item for Brazil (Environmental Finance, 2017). The country has the third highest number of CDM projects, accounting for 4.4% of the total, but it falls far below India (20.3%) and China (49.6%). The majority of demand has come from the EU ETS. Most projects have been in the renewable energy and waste management (Torres, Fermam, & Sbragia, 2016). Of relevance to agriculture are projects related to biomass electricity generation or animal waste management. 740 Brazilian CDM projects are contained in the database collated on the CDM Pipeline website (UNEP DTU Partnership, 2017), 124,194 kCERs have been issued for these projects, where 1 CER = 1tCO2e this equals 124 MtCO2e. Not all projects have issued CERs and none in 2016. It is likely that the fall in price has resulted in this slowdown of the market.

The Paris Agreement allows for the trading of emissions but at this stage how this will interact with existing mechanisms is uncertain (Torres et al., 2016).

Voluntary Carbon Markets

The provision of offsets or credits for the purposes of reducing emissions is ultimately dependent on the existence of a buyer for the carbon reduction. This section is based on the Ecosystem Marketplace Report Unlocking Potential – State of the Voluntary Carbon Markets 2017 and provides a review of the current global marketplace for carbon (Hamrick & Gallant, 2017).

In terms of offsets traded, the voluntary carbon market decreased by 24% between 2015 and 2016. Such a finding is not unusual in a market which experiences extreme volatility. Volatility can in part be explained by the links between the voluntary market and the compliance markets (where a government agency can set carbon reduction standards). If voluntary offsets are allowed to be converted into compliance markets, volumes traded in voluntary market can fall.

The average price for an offset was 3.0 USD/tCO2e with the total market value being 191.3M USD. The carbon price in the voluntary market ranged between 0.5 USD/tCO2e to more than 50 USD/tCO2e in 2016. This range demonstrates that an offset does not only represent the tonne of carbon avoided, but also co-benefits including poverty alleviation, health benefits or biodiversity benefits. That said, the majority offsets by tonnes of CO2e are sold between the 0-1 USD / tCO2e range. Although as many transactions occurs at over 12 USD/ tCO2e range. Most offsets are sold in the secondary market, where intermediaries sell offsets to buyers.

The majority of projects in the voluntary offset market use a third party to provide independent certification of their offsets. Different standards have different processes and different objectives (i.e. having a particular focus on a particular co-benefit or environmental or development objective).

Forestry and land use is the largest type of offset project by total value with an average price of 5.1 USD /tCO2e, although by volume renewable offsets are a larger share of the market. Agriculture is not a specific category of offset. Offsets which influence land use will inevitability have some interaction with agriculture, in changing the incentive structure surrounding how land is managed. As a result the most relevant (if not directly related) types of offsets for agriculture are REDD+ which has the highest volume of trading in terms of emissions avoided, and an average price of 4.2 USD/CO2e, grassland/rangeland management which on average had 6.9 USD/tCO2e but extremely low volumes of trading either in value or emissions avoided.

The admission of offsets for the purposes of compliance (and expected admission) can drive the locations for offsets. But where this is not expected the location of offset project is driven by factors other than emission reduction potential (biodiversity or poverty alleviation for example). In Latin America and the Caribbean forestry and land use projects were the most popular. Brazil has the fifth largest offset market in terms of volumes of emissions offset (3.2MtCO2e in 2016), while having the second largest market in terms of value of transactions at 9 million USD in 2016.

99% of offsets are certified by an independent standard. Verified Carbon Standard (VCS) represent 58% of the market, Gold Standard 17%, CDM 8%, Climate Action Reserve 8%, and American Carbon Registry 3%. Other standards exist and have specialties, such as the Carbon Farming Initiative (discussed below). Currently there is an oversupply of offsets in the voluntary carbon markets.

National policies surrounding climate action are key drivers of the voluntary offset market. If a country counts all offset activity towards it's national target, the international market for offsets would not function (these offsets would not be allowed to be counted against the buyer's emissions). Brazil may take this approach and have made no indications about the scope for a domestic voluntary offset market.

It is generally assumed that the compliance market is larger than the voluntary market. But with only 21 CDM projects coming to the market in 2016 and no CERs issued this dynamic may have changed. Although it still unclear how compliance markets will evolve as a result of Paris Agreement.

International versus domestic demand

Prior to a fall in prices, CDM projects could be considered to be the 16th largest export from Brazil (Environmental Finance, 2017). But the current status of an international market for CDM, REDD+ and other carbon markets is unclear as a result of the following policy announcements.

In the INDC submitted by Brazil as part of the lead to the Paris conference, the following statement was provided with respect to carbon markets: “Brazil will not recognize the use by other Parties of any units resulting from mitigation outcomes achieved in the Brazilian territory that have been acquired through any mechanism, instrument or arrangement established outside the Convention, its Kyoto Protocol or its Paris agreement” (Federative Republic of Brazil, 2015).

This is underlined by Decree 8,576 November 26th 2015, which stated that REDD+ could not be used to fulfil mitigation commitments by other countries (Presidencia da Republica Casa Civil Subchefia para Assuntos Juridicos, 2015).

These statements appear to be led by concerns about the use of REDD+ credits resulting from the Paris Agreement. It is not clear if the same level of stringency would be applied to credits generated by other sectors.

Offset methodologies

The following methodologies are provided by various offset standards in the voluntary and compliance markets.

Table 17 - Offset methodologies

Offset Standard	Relevant Methodologies Provided / Activities covered
Gold Standard (Gold Standard Foundation, 2017)	Low Tillage Smallholder Dairy Cool Farm Tool (in development)
Plan Vivo (Plan Vivo, 2017)	Small-Holder agriculture Monitoring and Baseline Assessment' methodology
VCS (Verified Carbon Standard, n.d.)	Sustainable Agricultural Land Management (developed by BioCarbon Fund) Soil Carbon Quantification Methodology Quantifying N2O Emissions Reductions in Agricultural Crops through Nitrogen Fertilizer Rate Reduction Sustainable Grassland Management (SGM) Adoption of Sustainable Grasslands through Adjustment of Fire and Grazing Avoided Ecosystem Conversion
CDM (United Nations Framework	GHG emission reductions through multi-site manure

Convention on Climate Change, 2014)	collection and treatment in a central plant GHG emission reductions from manure management systems Methane recovery in animal manure management systems Methane recovery in agricultural activities at household/small farm level Offsetting of synthetic nitrogen fertilizers by inoculant application in legumes-grass rotations on acidic soils on existing cropland Methane emission reduction by adjusted water management practice in rice cultivation Avoidance of methane and nitrous oxide emissions from sugarcane pre-harvest open burning through mulching Reduction of N2O emissions from use of Nitrogen Use Efficient (NUE) seeds that require less fertilizer application Strategic feed supplementation in smallholder dairy sector to increase productivity Methane recovery in agricultural activities at household/small farm level
CFI/EMF (Australian Government Department of the Environment and Energy, 2015)	Beef cattle herd management Destruction of methane from piggeries using engineered biodigesters Destruction of methane generated from dairy manure in covered anaerobic ponds Destruction of methane generated from manure in piggeries Estimating sequestration of carbon in soil using default values Fertiliser use efficiency in irrigated cotton Reducing greenhouse gas emissions in beef cattle through feeding nitrate containing supplements Reducing greenhouse gas emissions in milking cows through feeding dietary additives Sequestering carbon in soils in grazing systems
American Carbon Registry (American Carbon Registry, 2017)	Reduced Use of Nitrogen Fertilizer on Agricultural Crops Rice Management Systems Avoided Conversion of Grasslands and Shrublands to Crop Production Grazing Land and Livestock Management
Climate Action Reserve (Climate Action Reserve, 2017)	U.S Livestock Rice Cultivation

	Nitrogen Management Grassland

FRENCH PLANS FOR A CARBON TAX

French plans for a carbon tax

In 2010 France decided to abandon its plans to introduce a carbon tax on the sectors that were not covered by the EU ETS (agriculture, transport, building use, waste management). The proposal for the carbon tax, planned to come into effect on the first day in 2010, was ruled unconstitutional by the Constitutional Court. This decision was based on 1) the reduced rates and exemptions would result in exclusion of 93% of CO2e and 2) compensation for households was considered to be a breach of tax equality.

The original plan was to apply a tax on fossil fuel consumption (including oil, gas and coal, but excluding electricity) at 17 euros per tonne of CO2e. The plan was to increase this to 100 euros by 2030. The tax was designed so that the agricultural sector would only be charged 25% of the initial rate of the carbon tax. Tax was planned to be recycled via a tax cut for businesses levied by local authorities and an income tax rebate to households.

It has been argued that when the idea for a carbon tax was first introduced, public support was quite strong. However, slow progress was made on the design of the tax and then the financial crisis happened. This caused public support to decrease dramatically. Strong opposition from farmers ultimately led to the government to decide to exclude the agricultural sector in September 2009. The plan was to do this via compensation payments (D. Butler, 2009; Lomas, 2009).

In 2014 however the French parliament decided to implement a carbon tax on the use of gas, heating oil and coal. While the transport, fishing sector and industries covered in the EU ETS are exempt from this carbon tax, fossil fuel use in the agricultural sector is included (Croquette, 2017).

EU COMMON AGRICULTURAL POLICY (CAP)

The Common Agricultural Policy (CAP) covers all agricultural support programmes and subsidy systems in place in the European Union. The payment scheme under the CAP comprised approximately 71% of the total EU budget back in 1984 and 39% in 2013 (in 2014 approximately 59 billion euros per year (European Commission, 2017a)). The CAP plan for 2014 to 2020 is forecasted to include 38% of the EU budget (Commission, 2017). The objective of the CAP is "*to increase agricultural productivity by promoting technical progress, ensure a fair standard of living for farmers, stabilise markets, ensure the availability of supplies and to ensure reasonable prices for consumers*" (Massot, 2017; Matthews, 2014).

The CAP has undergone significant changes and reforms since its inception in 1957 transitioning it away from its production focus.

Currently, the CAP is split into two pillars:

Pillar 1- includes direct area-based payments to farmers based on their adherence to certain compliance standards financed by the European Agricultural Guarantee Fund (EAGF). These direct payments are made to farmers on an annual basis to support the stability of farm revenues in volatile markets and uncertain weather conditions and support trade promotion. It consists of for example uniform payments based on the quality or 'tier' of land (e.g. each hectare of land categorised as high quality arable land will earn the same payment). Farmers need to adhere to standards in order to earn the area payments. Standards include references to food safety, animal and plant health, climate considerations, environmental measures, water resource management, animal welfare and soil conditions. This means that payments to farmers are now decoupled from producing specific products, hence a shift away from a previously production-focused policy system. The Land Parcel Identification System (LPIS) is a database system that comprises all farmland and can check payments made to farmers based on the land owned.

Achieving the cross-compliance standards will earn the farmer 70% of the payment, also referred to as the basic payment per hectare (Sgueo & Tropea, 2016). The level of this payment is dependent on economic and administrative criteria of the region and decisions made by member states. Secondly, greening payments can be earned as supplementary support for providing environmental services. These include crop diversification, maintenance of ecological focus areas and conservation of permanent pasture. Member states are obliged to use the remaining 30% of the national direct payment budget for this greening component. Member states have little flexibility in choosing P1 standards. There are minimum requirements for all Member States. Pillar one takes up about 75% of the total CAP budget. Additional direct payments can be spent by member states to support young farmers with their first 90 hectares of their farmland.

Pillar 2 – comprising approximately 25% of the CAP budget in the EU includes payments for optional, voluntary activities around environment and rural development measures and is allocated by the European Agricultural Fund for Rural Development (EAFRD) (Augère-Granier, Marie-Laure, Sgueo, 2016). This pillar is focused on creating a sustainable farming sector that simultaneously also protects its competitiveness and innovative character. The objectives of this pillar include knowledge exchange, enhancing farm revenue, food safety, ecosystem protection, resource efficiency and social inclusion. Each member state must draw up a rural development plan every 7 years. Member states can then decide themselves how it addresses the priorities of the second CAP pillar and it has to set quantified targets and create an action plan of measures to achieve those. The EAFRD then decides its allocation of funds for these measures for each member state. In general most pillar 2 funds are spent on physical assets (22.6%), agri-environment climate activities (16.8%) and areas facing natural or specific constraints (16.3%). It therefore covers both capital payments for actions beneficial for the environment to cover costs of equipment and technologies and management payments that cover costs of productivity and income loss.

Cross cutting measures

- The 2014-2020 plan includes a monitoring and evaluation framework covering both pillars. This framework aims to provide information on policy implementation, report on verified results and impacts (Augère-Granier, Marie-Laure, Sgueo, 2016).
- The CAP budget also includes a reserve for crises in the agricultural sector (0.7% of total budget in 2014)
- In 2003 along with its other reforms, the CAP introduced the Farm Advisory System (FAS). This system supports farmers to "*better understand and meet the EU rules for environment, public and animal health, animal welfare*" (European Commission, 2017b). From the 2007 all member states were obliged to implement a FAS and offer advisory services to farmers. Pillar 2 payments can be used to help farmers to make use of these advisory services or can help the member state to set up such a system. The EU hereby wanted to guarantee that each farmer can seek advice on all cross-compliance requirements tailored to their specific situation.

Institutional set-up

The large budget of the CAP along with its complex allocation structure of payments requires a good institutional set up to allocate, verify and monitor payments. The following institutions support the EU CAP:

- As described above payments of pillar 1 are made by the EAGF and for pillar 2 under the EAFRD.
- The Integrated Administration and Control System (IACS) checks the operation of the CAP and payments made to farmers. It also checks whether activities are actually implemented correctly. Each member state therefore has its own IACS. It includes several databases including (European Commission: Agriculture and Rural Development, 2017):
    - The Land Parcel Identification System (LPIS) is a database system that comprises all farmland and can check payments made to farmers based on the land owned.
    - Farmer's register
    - A animal database for animal based aid schemes
    - Database for identifying payment entitlements for basic direct payments
    - IT systems to facilitate aid applications and support the national administration for controls and cross checks.

Reducing emissions in dairy farming in the Netherlands

The agricultural sector in the Netherlands is responsible for approximately 14% of Dutch GHG emissions, of which half comes from the dairy sector. The Netherlands had a total cattle population of 4.1 million animals in 2014. Since 1990 GHG emissions from the dairy sector have reduced by 18% through measures such as milk quotas, manure management policy and more efficient farms (Rijkswaterstaat Leefomgeving, 2016).

Policies and measures for GHG reduction in Dutch Agriculture Sector

The Dutch "Covenant of Clean and Efficient Agriculture Sector" (Ministry of Infrastructure and the Environment, 2013) establishes a number of voluntary targets. These include a goal of 30% reductions in GHG emissions from agriculture in 2020 compared to 1990 (Natuur en Milieu, 2015). In addition, there is an annual energy efficiency improvement target of 2% over 2011-2020, and targets for the use of renewable energy by 2020.

CO_2 emissions

The main policies and measures to achieve the CO_2 targets include (Ministry of Infrastructure and the Environment, 2013):

- Long-term agreements with the agricultural processing industry and innovation
- Energy savings and use of renewable energy in the horticulture sector
- In other sectors, focus on energy savings and co-fermentation, biomass as energy source, encouraging precision soil cultivation

CH4 and N2O emissions

There are a number of cost effective measures farmers can take to reduce GHGs on a voluntary basis (Ministry of Infrastructure and the Environment, 2013). These include:

- Best Management Practices for reducing N20 to reduce nitrogen flow on farms
- Improved cattle feed to reduce CH4 emissions
- Manure management measures, including its use for renewable energy

Additionally, a report from the Dutch Government from 2016 (RVO, 2016) outlines other incentives that have been given to Dutch dairy farmers in the last years to reduce CH4 and N2O emissions, these include:

- Incentives for longer lifespan of dairy animals (the in the Netherland is dairy not meat production). These have in general been called animal welfare measures, as they improve the health of dairy cattle to extend their lifespan. While animal welfare standards may have decreased over the last two decades in the Netherlands due to increase confinement, the measures to extend lifespan and thus health of animals have counteracted this.
- Prevention of manure anaerobic digestion that creates higher emissions and measures for farmers to use most of the manure produced on the land to reduce emissions.
- The Netherlands has introduced the 'manure management law' in 2014 which regulates the application of manure in the soil and trading or disposal of manure by farms. In case a farm does not use the manure produced on the farm, it needs a license to process, trade or dispose of the manure. This regulation aims to promote the processing of as much manure as possible on the farm itself, to reduce GHG emissions (Planbureau voor de leefomgeving (PBL), 2017; van Bruggen & Faqiri, 2015).
- Research for the genetic improvement of livestock. Selecting the most appropriate traits in livestock is good practice and will lead to long term improvements in productivity and health of the cattle to reduce the carbon intensity of the herd.
- Less import of feed, more domestic feed production

N20

Promoting precision soil cultivation using GPS technology.

EU level policy

In addition, up to 2015 there was an EU milk quota limiting the number of dairy herds in the NL. The milk quota was introduced in the entire EU because in general a lot more milk gets produced than consumed (because of subsidies), the milk quota gives farmers the right to produce a certain amount of milk to prevent too much overproduction.

In the current EU CAP plans 6 billion EUR will be allocated to the Dutch farming sector and rural areas from 2016-2020 (European Commission, 2016). The EU allows the Netherlands to be flexible in how this budget will be spent. However, one new aspects in the budget to 2020 are the greening rules. Within this system, 30% of the budget allocated under direct payments need to be linked to practices with environmental benefits or have associated climate benefits. The EU CAP provides a lot of finance to the Netherlands to reduce emissions under pillar 1. See 0 - International Experience with GHG Mitigation and Carbon Pricing in the Agriculture Sector

Results achieved 1990-2012

According to a case study by the Global Research Alliance on Agricultural Greenhouse Gases (2017) from 1990-2012, the Netherlands experienced an overall reduction of CH4 emissions from dairy farming in this period (RVO, 2016). However, a number of factors caused fluctuations in the emissions from dairy farming during this period:

Decreasing emissions from enteric fermentation per kg of milk produced. The EU milk quota served as an efficiency incentive, as farmers were incentivised to maintain production volumes with fewer animals. The measures taken to increase the productivity of each cow include breeding programmes and increased individual feed intake.

Absolute reduction in the size of the cattle herd in the Netherlands. This was driven mainly by the milk quota. Considering only mature dairy cattle, this decreased from 1.9mn in 1990 to 1.5mn in 2012.

Increased emissions associated with manure management. At the same time, there was increased manure production per animal (increased feed intake), and in addition, the new practice of confining the herd year-round. Both these measures are associated with an increased emission factor coming from manure.

Lessons for Brazil

The Netherlands did not impose a carbon price in the dairy farming sector. Instead, a combination of voluntary and mandatory emission reduction targets were put in place, supported by a number of policy instruments. These measures include command and control regulations (e.g. the manure management law, EU milk quota), financial subsidies and incentives (EU CAP budget, support for renewable energy), voluntary long term agreements with industry, and research and development (genetic improvement).

It is important to note that the measures presented here are focused on the Dutch dairy sector, and in some cases, lessons are not applicable to Brazil where the main output of cattle farming is meat. One example is that the Dutch government sought to provide incentives to increase the life expectancy of cows, as a GHG mitigation measure, whereas in Brazil an early termination would decrease the carbon intensity per kg of meat produced.

Nonetheless, there are some lessons which are applicable for Brazil:

- Limiting the size of the cattle herd in Brazil may provide an incentive for improved productivity. However, whether this improves the GHG intensity of production of meat depends on which measures are put in place to increase the productivity.
- The case study shows that confinement may not necessarily lead to reduced emissions from manure management. Nonetheless confinement may give rise to other opportunities for (sustainable) intensification, for instance through the ability to implement feeding programmes.

- It is also important to note that certain risks were not taken into consideration in this case study. For instance, the potentially negative impact animal welfare associated with year-round confinement.