5 The contribution of the ruminant livestock sector to the triple challenge

Ruminant livestock is an important source of protein and livelihoods, but is a significant contributor to environmental problems, including climate change. This chapter reviews its contribution to the triple challenge and illustrates how governments in Ireland, the Netherlands and New Zealand (countries with important ruminant livestock sectors) are navigating trade-offs and incorporate facts, interest and values in their policy process. Scientific facts, including from independent advisory groups, play an important role but are not always widely accepted by the public or stakeholders. Through consultation with stakeholders, policy makers hear from groups with different interests, including those with livelihoods at stake. Values play a role as well, including farmers' sense of belonging to a rural community, the importance of reducing climate change emissions in all sectors, as well as animal welfare, preserving landscapes, and the ethics of eating meat. Policy developments have also been influenced by court challenges and innovative mechanisms such as deliberative processes.

Key messages

- Ruminant livestock are an important source of protein and income, but are also a significant source of environmental problems, including climate change.
- Ireland, the Netherlands and New Zealand – large producers of ruminant livestock products– have policies that target the reduction of methane emissions from enteric fermentation and improving water quality.
- Ireland has used an innovative deliberative process to navigate the facts, interests and values conversation for its climate policy approach, including the consideration of how to tackle agricultural greenhouse gas emissions.
- Climate litigation in the Netherlands will have significant impacts on policy responses that target the ruminant sector.
- New Zealand has agricultural specific commitments to reduce GHG emissions and it has established a public/private partnership to achieve this.

5.1. Introduction

Ruminant livestock – a category of animals that includes cattle, sheep, goats and buffalo – play an important role in global food security and nutrition, as well as in the livelihoods of farmers and others along the food chain. Ruminants provide a diverse range of products, such as meat, milk, hides, wool, heat and energy, and play an important role in animal-powered mechanisation on farms.[1] At the same time, ruminant livestock production systems raise a number of concerns around environmental sustainability, in particular because of their impact on greenhouse gas (GHG) emissions (Gerber, 2013[1]), water use and water quality, and biodiversity (Steinfeld et al., 2006[2]). This case study summarises the main linkages between elements of the triple challenge and discusses policy responses in three countries where livestock are a significant part of the agricultural sector (Ireland, the Netherlands, and New Zealand).

Ruminants are raised in three main production systems: extensive grazing on pasture; mixed systems that combine grazing with supplementary feed; and intensive systems including feedlots used to finish cattle for slaughter. Production systems vary worldwide in terms size, livestock numbers, stocking densities, technology, and capital and labour intensity. Mixed systems rely on pasture as well as feeding supplements such as hay, silage and grains. Extensive and mixed grazing represent the majority of ruminant production systems, accounting for 87-94% of worldwide beef production (Mottet et al., 2017[3]). Herrero et al. (2013[4]) estimate that in 2000, 69% of milk and 61% of meat sourced from ruminants worldwide were produced in mixed systems. Capital-intensive feedlot systems involve high animal density and the use of concentrated feed and, in the case of beef, aim to minimise the time required to prepare animals for slaughter (Tarawali et al., 2019[5]). Globally intensive livestock operations have been on the rise with feedlot systems for beef production growing in prevalence (FAO, 2018[6]). Intensive feedlots account for between 7% and 13% of the world's total beef production (Mottet et al., 2017[3]).

Ruminant livestock are the largest user of land worldwide with an estimated one-third of the earth's surface used for livestock grazing (direct use) and feed production (indirect use) (Herrero et al., 2013[4]). Land conversion from natural habitats to grazing land reduces biodiversity and ecosystems services and releases large amounts of CO_2 (Steinfeld et al., 2019[7]). Grazing to manage pasture ruminant livestock, however, can also play an important role in contributing to landscapes, habitats and biodiversity, and can control and prevent the incursion of weeds and other invasive plant species.

Livestock productivity varies considerably around the globe. Gaps between actual and potential milk yields are evident in sub-Saharan Africa, Latin America and South Asia (Steinfeld et al., 2019[7]). For instance, in 2015 average milk yields in North America were 9.9 tonnes per animal per year, compared with 4.7 tonnes in Oceania, 1.9 tonnes in Central and South America, 1.4 tonnes in South Asia, and 0.5 tonnes in Sub-Saharan Africa (Bizzarri and Gapon, 2019[8]). Milk yields, slaughter weights and feed conversion ratios depend on many factors including genetics, animal husbandry practices, the quality of pasture, and supplementary feed. For example, feed conversion ratios can be improved through enhanced feed quality and the addition of concentrates, i.e. moving from an exclusive grazing system to a mixed system. Optimal feed strategies depend on whether ruminant animals are producing milk or meat, or are part of the breeding herd being raised until such time as they are productive. The breeding herd for ruminants contributes the bulk of emissions (Gerber, 2013[1]).

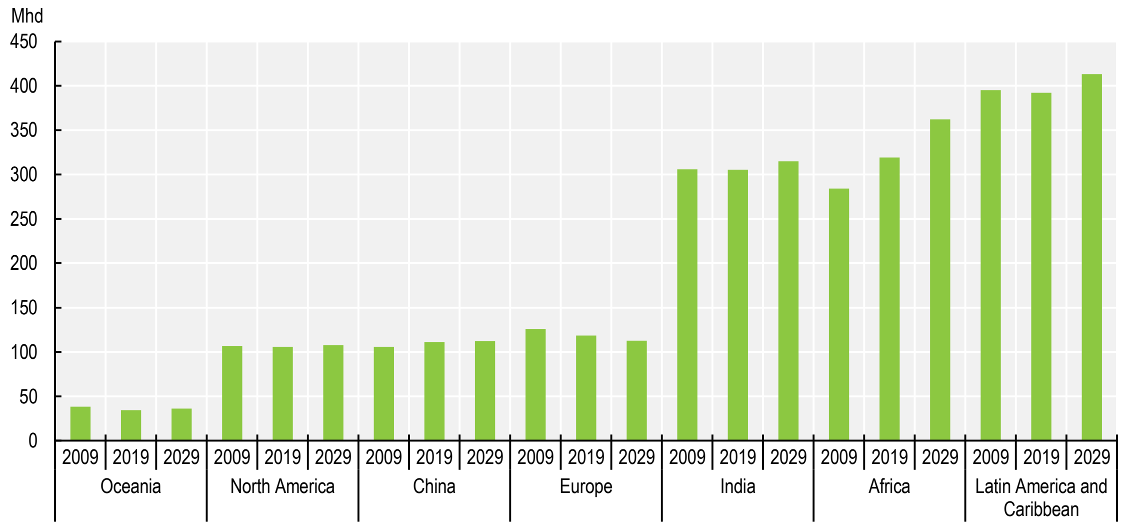
Reducing productivity gaps in a manner that avoids unintended consequence for land use is important not only for increasing food availability in regions with fast growing populations and for reducing land pressures, but also for climate change mitigation.[2] GHG emissions per unit of product or per unit of protein are much lower in highly productive systems (Havlík et al., 2014[9]). The importance of addressing productivity gaps is underscored by the fact that the largest number of ruminants are found in regions where productivity is the lowest and therefore GHG emissions per head are the largest (Blandford and Hassapoyannes, 2018[10]).

Ruminant livestock currently plays a crucial role in global food security and nutrition. A third of global protein intake and 17% of calories come from animal sources, much of it from ruminants (FAO, 2018[11]). More than a quarter of the world's 570 million farm holdings keep at least one ruminant animal, which improves these families' livelihoods, food security, and nutritional outcomes, as well as providing a mode of traction. Ownership of cattle by women in developing countries enables their economic progression and empowerment; approximately 80 million women worldwide are involved in dairy farming (FAO, 2016[12]).

With the global population set to expand from 7.7 billion in 2019 to 8.5 billion in 2030, 9.7 billion by 2050 and 10.9 billion by 2100, increasing global incomes will mean that demand for ruminant proteins will continue to grow (United Nations Population Division, 2019[13]). Total beef production is set to increase by 9% over the next decade to 2029 and total milk production will increase by 20% over the same period (OECD/FAO, 2020[14]). Higher levels of production of milk and ruminant meat are expected to come mostly from the expansion of global cattle herds, from their current level of 1.6 billion to nearly 1.8 billion in 2029. As of 2019 the largest numbers of cattle (including cows, buffalos, bulls and veal) are found in the Latin American and African regions along with India (Figure 5.1). In the ten years to 2029 animal numbers are predicted to grow in Latin America (by 5% to 413 million head), Africa (by 13% to 362 million head), and India (by 3% to 315 million head).

The growing number of ruminants worldwide has had serious environmental consequences, notably through land use change (negatively affecting biodiversity and GHG emissions), direct GHG emissions, and negative effects on water use and quality, and air quality. Direct GHG emissions from ruminants are a by-product of the digestion process, where ingested plant material begins to be digested in the rumen (the large forestomach) by microbes. This process of enteric fermentation creates methane (CH_4), belched or expelled by the animal, which has a short-lifetime (on average 12.4 years) in comparison to CO_2 which can survive in the atmosphere for centuries to millennia (Intergovernmental Panel on Climate Change, 2013[15])). While enteric fermentation is the main source of methane from ruminants, animal manure is also a significant emitter of the gas, as well as of nitrous oxide. Many factors influence the quantity of methane produced by animals, and the GHG emission intensity per unit of product from ruminant livestock varies considerably with the production system and the location of production.

Figure 5.1. Cattle inventory by region 2009, 2019 and 2029



Note: Mhd = Million head.
Source: OECD/FAO (2020), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

Because of these environmental consequences, countries have implemented different policy approaches to address the sector's use of natural resources and its contribution to GHG emissions. Countries' policy approaches to agricultural GHG emissions are discussed further in the sections below, where recent policy approaches taken by Ireland, the Netherlands and New Zealand (countries with significant ruminant livestock sectors) are described based on information provided by these same countries themselves. Broadly speaking, all three implement a mix of policies to increase efficiency in order to maintain production and reduce negative environmental outcomes. Coherent policy processes, engagement with stakeholders, and the use of scientific research are described to highlight how these countries are navigating the facts, interests and values paradigm and taking decisions to deal with the trade-offs and synergies from competing policy objectives in terms of the triple challenge. Subsequent impacts of policies on ruminant producers are explored, including governments' efforts to assist them with transition strategies towards low emission production models or to exit the sector altogether.

5.2. Food security and nutrition

Meat and milk from ruminant livestock are nutrient dense foods which are an important source of calories, high-quality proteins, and micro-nutrients (Mottet et al., 2017[3]). Under-consumption of animal proteins is linked to malnutrition and stunting with serious health outcomes globally (Adesogan et al., 2019[16]; FAO, 2018[11]). Consumption of products from ruminants is low in some regions (notably Sub-Saharan Africa) and unlikely to increase given predicted low income growth. This presents a serious nutritional challenge as the highest future population growth will take place in these regions. In OECD countries, consumption of meat and dairy is high, although demand for red meat is decreasing, while demand for dairy is stable to declining for fresh dairy products but increasing for cheese (OECD/FAO, 2020[17]). Overconsumption of red meat and processed meat has been linked to cancer and, although the science is inconclusive on the extent of the risks, national dietary recommendations for many countries advise limiting weekly intakes.

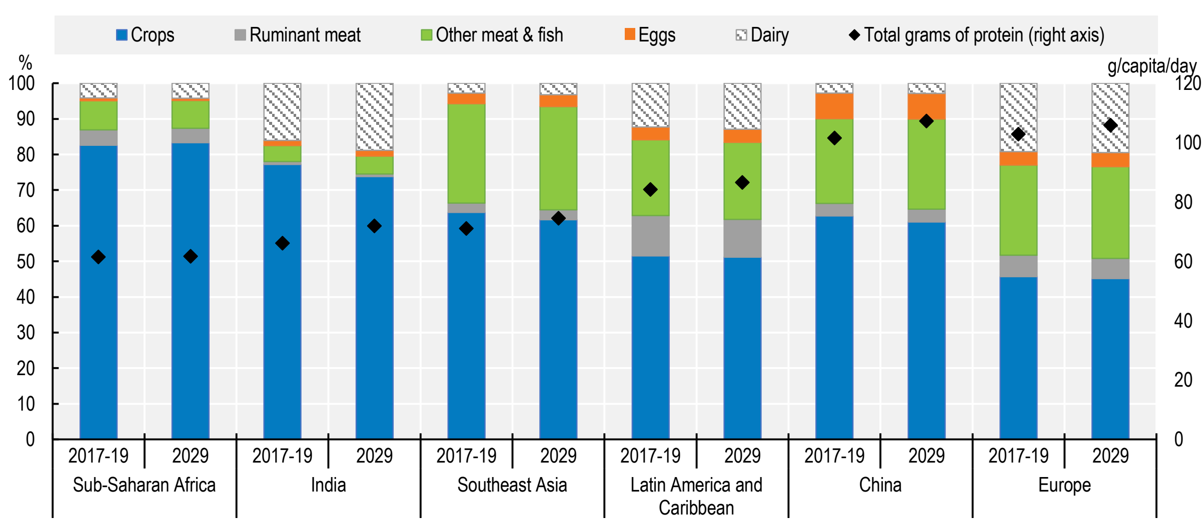
Consumption of ruminant livestock products around the world

Products produced from ruminant livestock are an important source of energy, high-quality protein and micro-nutrients, including vitamins A, B_{12}, and B_2, and calcium, iron and zinc minerals. Obtaining sufficient quantities of these nutrients from plant-based foods uniquely is challenging (Mottet et al., 2017[3]; FAO, 2018[11]). Seventeen per cent of calories and 33% of protein consumed worldwide comes from animal sources (FAO, 2018[11]).

Low intakes of animal products are associated with malnutrition leading to serious consequences globally (Adesogan et al., 2019[16]; FAO, 2018[11]). Health problems include anaemia and risks to pregnancy from lack of B_{12}. Even if calorie requirements are met, insufficient consumption of animal-sourced nutrition in the form of meat or milk by pregnant and lactating women, babies and young children can result in stunting. Stunting is linked to increased risk of infant mortality, but also lifelong consequences such as reduced IQ score, and reduced earnings of adults by 22%. Stunting is an indicator of chronic undernutrition, from which globally 151 million or nearly 25% of children under the age of five suffer (Adesogan et al., 2019[16]; FAO, 2018[6]). Children from households where women own livestock have better nutritional results than households without livestock (Adesogan et al., 2019[16]). This could be due in part to livestock's role in providing livelihoods, as discussed in the following section.

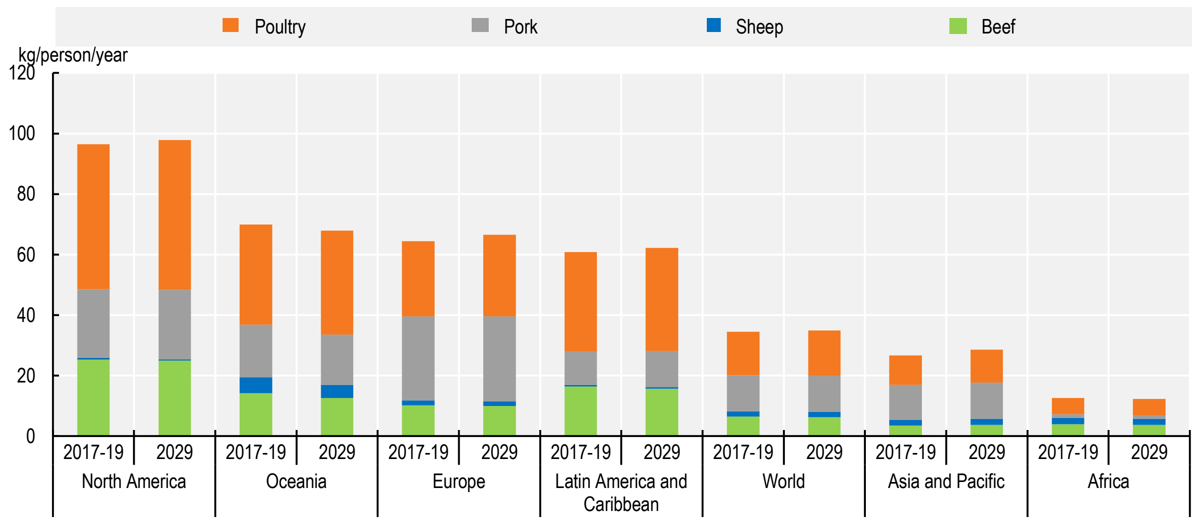
As is apparent from Figure 5.2 the importance of ruminant meat and dairy as a protein source varies by region. Populations in Sub-Saharan Africa and India get the majority of their daily protein from crops, while in other parts of the world animal proteins are the largest source of daily protein intakes. In Latin America, both ruminant meat and dairy are important sources of protein, whereas in Europe dairy is proportionally more important. In India, dairy proteins are important too.

Figure 5.2. Contribution of ruminant meat and other protein sources to total daily per capita availability



Note: Bars refer to the share of the food group in total daily per capita protein intake (left axis); Dots represent the total quantity daily per capita protein intake (right axis); Crops include arable food crops (cereals, edible oilseeds, pulses, roots and tubers, sugar)
Source: OECD/FAO (2020), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

Figure 5.3. Per capita meat consumption by region



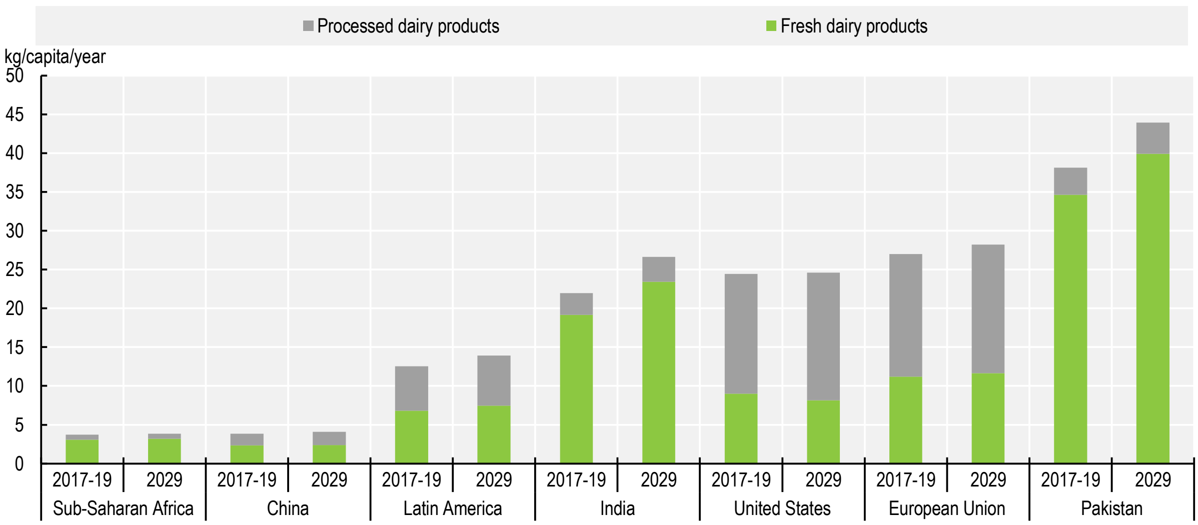
Note: Per capita consumption is expressed in retail weight.
Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

Consumption of (all types of) meat in Africa and in Asia and the Pacific is low (Figure 5.3). In terms of beef consumption, developed countries currently consume approximately three times as much as developing countries. While growing in developing countries, in particular Asia, the rate of beef consumption is on the decline in many OECD countries albeit from high consumption levels. This is particularly the case in the European and Central Asian region (OECD/FAO, 2020[14]). For example, per capita consumption of beef in New Zealand decreased from 23.3 kg per capita in 1992-94 to 15.7 kg in 2012-14 and is predicted to decrease by 11.3 kg in 2028-30. Beef consumption in Canada shows a similar decline, from 23.3 kg in 1992-94 to 19.7 kg in 2012-14, and it is predicted to decline to 16.8 kg per capita by 2028-30.

The importance of fresh dairy products to populations in Pakistan and India, and the predicted growth in demand in these countries, is evident from Figure 5.4. Low growth in dairy consumption is predicted for Sub-Saharan Africa, while demand for dairy in the European Union and the United States is predicted to remain relatively stable.

Weakening demand in developed countries for ruminant meat products is due to several factors, including concerns about the climate impact of cattle, dietary recommendations from governments to reduce red meat consumption, and animal welfare and the ethical considerations regarding eating animals. Climate and health concerns, rather than animal welfare, are behind the increasing interest in veganism observed in recent years in OECD countries (The Economist, 2020[18])

Figure 5.4. Per capita consumption of processed and fresh dairy products in milk solids by country and region



Note: Milk solids are calculated by adding the amount of fat and non-fat solids for each product; Processed dairy products include butter cheese, skim milk powder and whole milk powder.
Source: OECD/FAO (2020), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

Food versus feed and the impacts on food security

Producing livestock products requires animal feed, which in turn may compete directly with production of food for human consumption. For instance, arable land may be used for growing feed crops for animals rather than food (e.g. growing maize and soybean instead of wheat). Some land used for grazing livestock could also have been planted with food crops. Discussions of these trade-offs often focuses on beef production, emphasising the large quantities of grain fed in feedlot systems.

In feedlot production systems cattle can consume up to 20 kg of grain for each kilo of beef produced (Mottet et al., 2017[3]). However, feedlot systems are not the main method of producing beef. Grazing and mixed production systems are estimated to produce 87-93% of the world's beef. Ruminants under these production systems eat a large proportion of feed that is not edible for humans, such as grass, leaves, and crop residues (Mottet et al., 2017[3]). In 2010, of the 4.8 billion tonnes of dry matter consumed by ruminants worldwide (cattle and buffaloes, as well as small ruminants), 95% was inedible for humans (Mottet et al., 2017[3]). That said, 240 million tonnes of dry matter per year fed to livestock could have been consumed by humans (of which 210 million tonnes per year was grains) and 270 million tonnes of dry matter per year fed to ruminants was in direct competition with food production for human consumption (Mottet et al., 2017[3]).

About 560 million ha of the world's crop land is being used to produce feed crops of cereals and oilseeds instead of crops consumed directly as food (OECD/FAO, 2019[19]). Furthermore, more than 3 billion ha of land globally is used for grazing, of which 685 million ha could be used for producing crops for food (Mottet et al., 2017[3]). Inclusion of this land would increase global arable land by half (OECD/FAO, 2019[19]).

Potential negative effects on human health

Overconsumption of meat

Diet is linked to health outcomes and contributes to non-communicable diseases (NCDs). Worldwide 1.9 billion people do not have regular access to sufficient, safe, and nutritious food (FAO, IFAD, UNICEF, WFP, WHO, 2020[20]) and an even greater number are overweight or obese (WHO, 2020[21]). Afshin et al (2019[22]) investigated the dietary risk factors for the 2017 Global Burden of Disease study for the period 1990-2017 in 195 countries. According to their research, in 2017 dietary risk factors were the cause of 11 million deaths and 255 million disability adjusted life years (DALYs) globally. In terms of diet-related deaths from high processed meat and red meat consumption, these were ranked 13th and 15th out of 15 dietary risk factors attributable to deaths at the global level (Afshin et al., 2019[22]).

Many countries have national dietary guidelines providing evidence-based, context-specific advice on healthy diets and lifestyles, that take into account food production, consumption and accessibility, and socio-economic influences (FAO, 2020[23]). The dietary recommendations of developed countries often include limiting the consumption of high-fat meat products, in particular red meat and processed meats (Herforth et al., 2019[24]).

As an illustration, New Zealand's Eating and Activity Guidelines from 2015 (MoH, 2015[25]) recommend limited consumption of low and reduced fat dairy products and suggest consuming less than 500 g of cooked red meat per week. Ireland's 2017 Food Pyramid suggests that two to three servings of lean red meat (half the size of the palm of an adult hand) can be consumed weekly (FSAI, 2017[26]). Brazil's dietary guidelines from 2015 acknowledge that red meats are "excessively consumed in all of Brazil" (Ministry of Health, 2015[27]). While highlighting the benefits of red meat consumption in terms of micronutrients, Brazil's guidelines also refer to the high fat content of red meat and the link between overconsumption and the risks of heart disease, chronic diseases and bowel cancer (Ministry of Health, 2015[27]). The EU's "Farm to Fork" strategy highlights the need to reduce red meat consumption and move towards a plant-based diet to meet health and environmental objectives (European Commission, 2020[28]).

Such recommendations derive in part from epidemiological studies which have linked high levels of red meat and processed meat consumption with higher risks of cancers, cardiovascular diseases, and strokes (Abete et al., 2014[29]) (Chen et al., 2012[30]) (Sun, 2012[31]) (Sinha et al., 2009[32]) (Etemadi et al., 2017[33]). Some recent papers have challenged these findings, emphasising methodological limitations of previous studies (Zeraatkar et al., 2019[34]) (Zeraatkar et al., 2019[35]) (Vernooij et al., 2019[36]) (Han et al., 2019[37]). As with previous studies, these analyses generally find a correlation between negative health outcomes and the level of consumption of red and processed meat, but the authors state that the effects are smaller and the evidence weaker than previously found.

Antimicrobial resistance

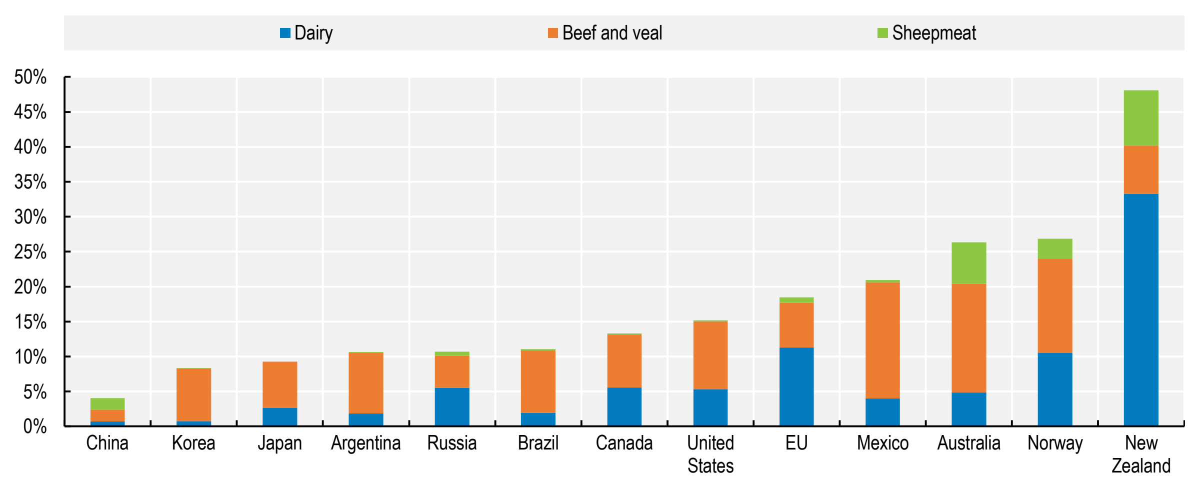
Concern is growing over the use of antimicrobials in food-producing animals and the emergence and transmission of resistant bacteria between animals and humans and vice versa (Rushton, Pinto Ferreira and Stärk, 2014[38]; Morel, 2019[39]; Ryan, 2019[40]; Godfray et al., 2018[41]). Antimicrobials are mainly used in intensive pig and poultry production systems (accounting for 80% of antimicrobial use) However, dairy cattle receive antimicrobial treatments during lactation and after calving on an individual basis. Antimicrobials are also added to feed in some intensive beef production systems to enhance growth and improve weight gain and feed efficiency (Rushton, Pinto Ferreira and Stärk, 2014[38]). However, the global use of antimicrobials as growth promoters in intensive beef production is declining. Bans on their use have been in place in the European Union since 2006, and the United States has been phasing antimicrobials for growth promotion and limiting their use for medical reasons since 2017. The European Union's "Farm to Fork" strategy includes the goal to reduce sales of antimicrobials for land animals (and for aquaculture) by 50% by 2030 (Eurostat, 2020[42]). A recent report from the World Organisation for Animal Health (OIE) indicates that as of 2018, 35 of 153 countries continue to use antimicrobials for growth promotion — down from 45 countries in the previous year (OIE, 2020[43]; Góchez et al., 2019[44]).[3]

5.3. Livelihoods

Many people are dependent on livestock for their livelihoods. Ruminant and non-ruminant livestock together contribute 40% to the global value of agricultural output and support the livelihoods and food and nutrition security of much of the world's population. More than one quarter of the world's 570 million farm holdings keep at least one milk-producing ruminant animal and only 0.3% of the world's dairy farms have more than 100 cows. Ruminant livestock is particularly important from a gender equality perspective. It is estimated that 80 million women are involved in dairy farming worldwide (FAO, 2016[12]). For rural women in developing countries, owning livestock is an important asset and one that is more readily obtainable compared to other assets (e.g. land) to which women may not have access (FAO, 2016[12]). Owning livestock provides women with opportunities to improve their economic empowerment and position in society; for example, through the ability to gain credit, increase income and exert greater decision-making power in the household and community. A quarter of the households with dairy cows (or 37 million farm holdings) are headed by women, and women are actively involved in animal husbandry, livestock management, and in selling milk (FAO, 2016[12]). Furthermore, ownership of livestock provides higher incomes and nutritional outcomes for households (Adesogan et al., 2019[16]).

Ruminant livestock plays an important role in many countries' economies (Figure 5.5). In New Zealand, dairy is the largest export earner, accounting for approximately 25% of total exports and employing 48 000 people (approximately 3% of total employment). Dairy farming and processing make up 3.1% of New Zealand's GDP (NZIER, 2018[45]). Irish dairy exports are valued at over EUR 5 billion in 2019 (with total agri-food exports worth EUR 14.5 billion in the same period) (DAFM, 2020[46]).

Figure 5.5. Relative importance of ruminant livestock in selected countries 2018



Note: Figures shows the estimated value of production of ruminant livestock commodities covered in the *OECD-FAO Agricultural Outlook*, as a percentage of total value of agricultural production.
Source: OECD/FAO (2020), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database). http://dx.doi.org/10.1787/agr-outl-data-en.

The ruminant livestock sector contributes significantly to the rural economy in some countries in terms of providing positive socio-economic outcomes. For instance, in the western half of Ireland suckler beef and sheep farming are the only food production systems suitable for the climate and terrain. In these rural areas ruminant livestock supports employment and social cohesion and preserves landscapes (DAFM, 2019[47]).

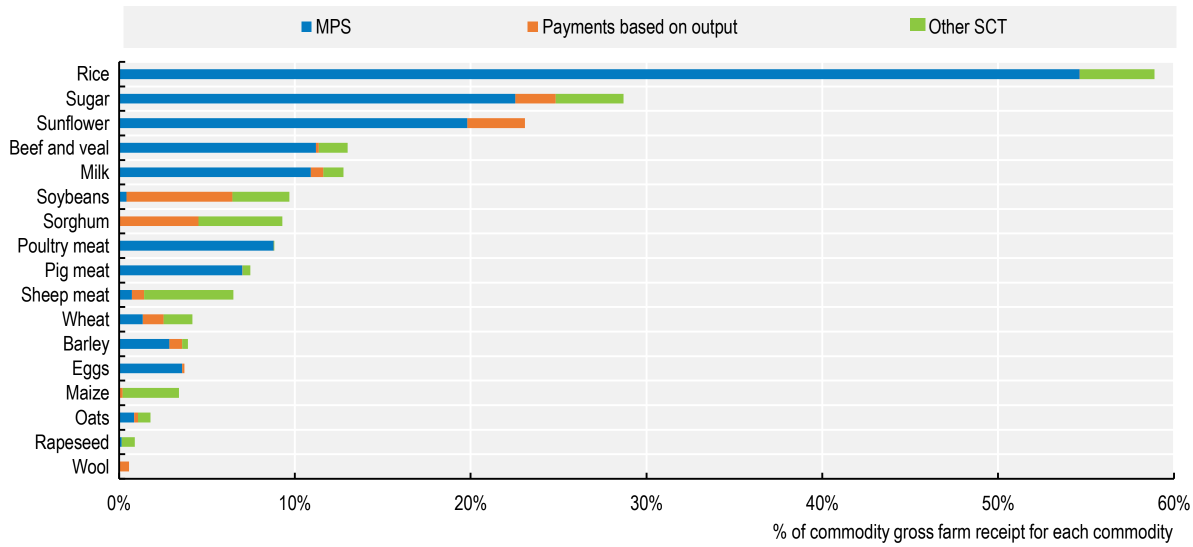
Farming as an occupation is also associated with a farmer's sense of identity, their community status, and their social and cultural capital based on their skills and perceived success (Burton, 2004[48]) (Burton, Kuczera and Schwarz, 2008[49]) (Wreford, Ignaciuk and Gruère, 2017[50]) (Burton, 2014[51]). Furthermore, remote rural communities are characterised as having highly specialised economies that make them more vulnerable to economic shocks (OECD, 2020[52]). Livestock production and meat processing activities based in rural areas create a concentration of people with a similar set of skills. This makes finding alternative employment, following for example, the closure of a meat processing plant challenging, potentially leading to out-migration. In New Zealand, many people employed in the red meat sector identify as Māori; ceasing meat industry activities could impact their communities disproportionately (Beef+Lamb NZ and MIA, 2020[53]).

Incomes of ruminant livestock producers are supported by some governments, particularly in developed countries. Among the 54 countries covered by the OECD's *Agricultural Policy Monitoring and Evaluation 2020* report, most provide income support to producers in the ruminant livestock sector (i.e. milk, beef and veal, and sheep meat) (OECD, 2020[54]). Over the period 2017-19, milk and beef and veal were among the commodities receiving the highest levels of support (Figure 5.6), mainly in the form of market price support, i.e. policies that increase domestic market prices through import restrictions or price floors. Such measures are particularly trade and production distorting. During the period 2017-19, effective prices received by producers were, on average, 13% higher than world prices for milk and beef (OECD, 2020[54]). The European Union provided the highest level of support for beef and veal on average over the period 2017-19, followed by China and Turkey. In terms of average support to milk over the same period the United States provided the highest level of support, followed by China and then Japan, and for sheep meat China provided the largest level of support followed by the European Union.

Trade in ruminant products is often restricted by tariff rate quotas for beef, cheese, butter and other dairy products, and tariffs on ruminant products are frequently among the highest compared with all other products. For instance, in the United States the highest average applied tariffs (above 100%) levied on agricultural products in 2016-2018 were for certain dairy products (WTO Secretariat, 2018[55]). In 2016, imports by the European Union of dairy products were charged the highest applied tariffs, with average applied tariffs for dairy products of 35%, and tariff peaks of 187% (WTO Secretariat, 2017[56]). Both the United States and the European Union maintain tariff rate quotas for beef and certain dairy products.

In addition to high tariffs, ruminant products are subject to non-tariff measures (NTMs) in the form of Sanitary and Phytosanitary (SPS) measures and Technical Barriers to Trade (TBT) (Greenville et al., 2019[57]). Traded ruminant products are perishable and meat and dairy are relatively high risk in terms of disease and foodborne illnesses (CDC, 2018[58]). SPS measures frequently applied to these products include certain restrictions based on an exporting country's disease status (e.g. for countries with Foot and Mouth Disease), product registration and approval, testing, certification of conformity, inspections, marking and packaging and labelling, and tolerance limits for residues (UNCTAD, 2019[59]). TBT measures (which cover different aspects of production and the supply chain) applied to ruminant products include labelling, marking and packaging requirements, and production process requirements. Standards can be trade creating as well as cost increasing – what matters is that they are science and risk based, transparent, non-discriminatory and efficient to reduce unnecessary trade costs.

Figure 5.6. Transfer to specific commodities (SCT), 2017-19



Note: Colombia became the 37th member of the OECD in April 2020. In the data aggregates used in this report, however, it is included as one of the 13 emerging economies.

Source: OECD (2020), "Producer and Consumer Support Estimates", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-pcse-data-en.

5.4. Climate change and natural resource use

Climate change

Over the period 2007-16 emissions from agriculture, forestry and other land use (AFOLU) made up 23% of total net anthropogenic emissions of greenhouse gas (GHG) emissions. By adding in other stages of the food system (storage, transport, packaging, processing, retail and consumption) this reaches to 21-37% of total emissions (IPCC, 2019[60]).

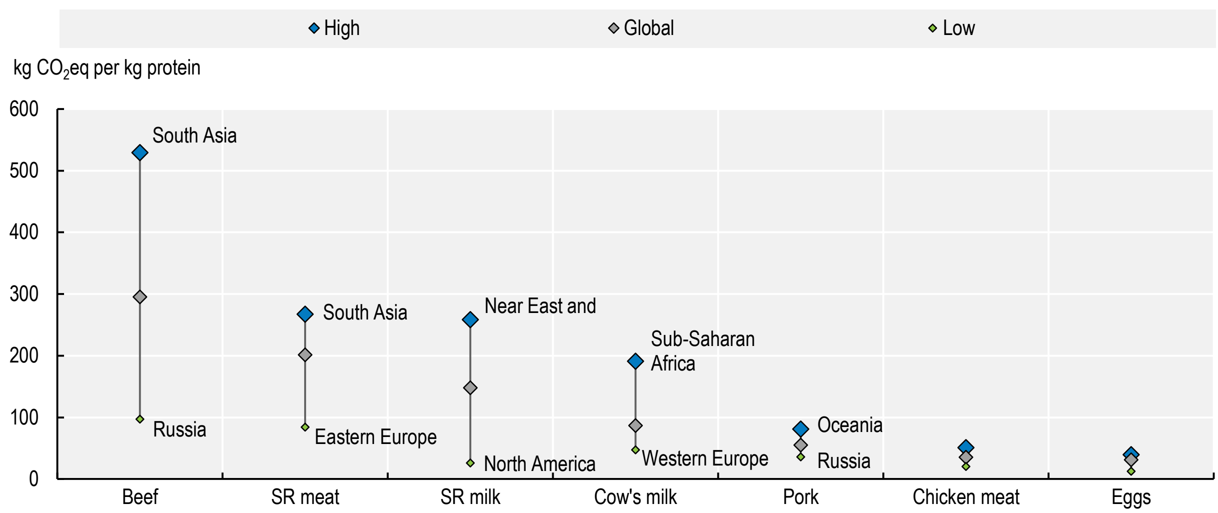
Direct emissions from agricultural production account for 12% of global anthropogenic emissions, and biological processes of ruminants are the largest source of these direct agricultural emissions (IPCC, 2019[60]). Globally, enteric fermentation accounts for 40% of direct emissions from agriculture and ruminant livestock also contribute to emissions from manure, which constitute 26% of direct emissions (other important sources are synthetic fertiliser and rice cultivation accounting for 13% and 10%). Among livestock-related direct emissions, cattle are responsible for 65%, buffaloes for 9%, and sheep and goats for 7% (Gerber, 2013[1]) (Steinfeld et al., 2019[7]). Enteric fermentation forms a significant part of direct agricultural emissions in most regions with the exception of South Eastern Asia (where rice cultivation is the major source of agricultural GHG emissions).

Over the period 1990-2014 global direct emissions from agriculture increased largely as a result of the growth in the number of ruminants and the subsequent increases in methane from enteric fermentation, expansion of extensive grazing of ruminants (increasing N_2O from manure deposited onto pasture), and the increased use of synthetic fertilisers (N_2O) (Blandford and Hassapoyannes, 2018[10]).[4]

Direct emissions of N_2O from agricultural soils are predicted to grow in significance and so this area is an important focus for ruminant livestock GHG emissions mitigation policies. Forecasts predict that emissions of N_2O from agricultural soils from synthetic fertilisers, soil cultivation, manure on pasture, and manure applied to soils will expand more rapidly than CH_4 emissions generated from livestock and rice cultivation or sources of CH_4 and N_2O emissions from manure management and burning of crop residues. As a result, in 2050 global emissions from enteric fermentation will be only 7% higher than emissions from agricultural soils, whereas in 1970 they were 60% higher (Blandford and Hassapoyannes, 2018[10]). This trend is already observed amongst OECD countries where higher agricultural soil emissions are responsible for most of the increases in GHG emissions over 2003-15 (OECD, 2019[61]).

According to life cycle assessments, emissions intensities of livestock products differ by product (Figure 5.7). Beef has the highest emissions intensity in terms of CO_2eq per kg protein produced, followed by meat from small ruminants (sheep), and milk from small ruminants. Cow's milk, pork, and chicken have global average emissions intensities of less than 100 kg CO_2eq per kg protein (Steinfeld et al., 2019[7]).

Figure 5.7. Global average emissions intensities for different livestock products



Note: Global average emissions intensities (Ei) for livestock stock products. SR: small ruminants
Source: Livestock Data for Decisions (2018) 'Livestock and Climate Change: Fact Check' based on data from FAO (2017), Global Livestock Environmental Assessment Model (GLEAM), www.fao.org/gleam/en

Globally, while GHG emissions from livestock have grown over time, their intensity in terms of GHG emissions per unit produced has been declining. Although high in terms of total emissions, the relative intensity of livestock's direct GHG emissions is lower in developed countries. For instance, the emissions intensities of beef in Europe are a third of those in Latin America and the Caribbean, and beef produced in Oceania and North America also have lower emissions intensities than those from this region (Blandford and Hassapoyannes, 2018[10]). Emissions intensities for ruminant livestock products are highest in Africa, India, and Latin America and the Caribbean, where the largest cattle herds are located (Gerber, 2013[1]) (IPCC, 2019[60]; OECD, 2019[61]) (Steinfeld et al., 2019[7]).

Advances in herd genetics, feed, and pasture quality and animal management have driven productivity gains over time, meaning the same level of production requires fewer animals and hence fewer emissions (Steinfeld et al., 2006[2]) (Gerber, 2013[1]) (Herrero et al., 2016[62]). For instance, the carbon footprint in the United States per kilogram of milk in 2007 was only 37% of the level in 1944 (Capper, Cady and Bauman, 2009[63]). Moreover, further efficiency gains in recent years have seen US milk production increase by nearly 25% over the years 2007-17, with total GHG emissions increasing by only 1% (Capper and Cady, 2019[64]).

Another important factor contributing to reducing emissions intensity is herd structure. Herds consist of productive animals producing meat or milk, and breeding herds, the replacement stock being raised until they are sufficiently mature to be productive. Breeding herds are necessary to maintain the main herd, but consume feed and produce emissions while not producing outputs; this is referred to as the "breeding overhead" (Gerber, 2013[1]). In specialised beef systems the breeding herd represents 69% of the total herd, whereas in dairy systems the breeding herd accounts for 52% (Gerber, 2013[1]) and the bulk of emissions come from these animals. Furthermore, since emissions intensities reflect animal productivity, dairy cows have lower intensities than beef because they produce both milk and meat whereas beef production systems produce only meat (Gerber, 2013[1]).

Globally, ruminants are responsible for indirect emissions from various sources, including producing feed, and producing fertiliser for application on feed crops, as well as emissions generated by processing and transporting feed, animals and livestock products. However, the most important indirect emissions are those from land use change. Pasture and arable land used for feed crops take up an estimated one-third of the earth's surface, accounting for the vast majority of total agricultural land use (Steinfeld et al., 2006[2]). Over time, demand for ruminant livestock products has led to increasing land conversion for pasture and for crops to produce animal feed (Steinfeld et al., 2006[2]). Deforestation and other habitat loss has resulted in significant biodiversity loss, as well as loss of ecosystems (i.e. pollination, pest control, and flood control) and increased CO_2 emissions from forest burning to clear land. Increased ruminant numbers have thus contributed to increased emissions and a reduced carbon absorption ability from forests (Steinfeld et al., 2019[7]). Other land-use effects include carbon emissions from desertification due to over grazing, and loss of soil organic carbon due to cultivation (Steinfeld et al., 2006[2]) (Steinfeld et al., 2019[7]). An estimated 44% of agriculture-related emissions in 2007-16 were due to land use change, much of this linked to ruminant livestock (IPCC, 2019[60]).[5]

Ruminant grazing and land management practices impact soil carbon stocks. The ability of soils to absorb carbon is not infinite and a saturation point is reached, and stocks can be easily diminished through ploughing techniques (Blandford and Hassapoyannes, 2018[10]). Furthermore, the higher temperatures from a changing climate could reduce the ability of soils to absorb carbon (WRI, 2019[65]).

Grazing by ruminants can increase or reduce soil carbon stocks (Steinfeld et al., 2006[2]) (Steinfeld et al., 2019[7]) (Henderson et al., 2015[66]) Pasture production responds positively to frequent grazing resulting in increased growth, and manure deposits add organic matter to soils (FAO, 2009[67]). However, over grazing of pastures leads to soil degradation through loss of vegetation cover, damaged soil structure (i.e. soil compaction), and increased risks of erosion (Steinfeld et al., 2006[2]) (FAO, 2009[67]; FAO & ITPS, 2015[68]). Potential for soil carbon sequestration depends also on factors such as location, soil type, land management practices, and other environmental factors (WRI, 2019[65]).

Countries are using innovative systems such as integrated livestock-crop, livestock-forest, or livestock-crop-forest to reduce the areas needed for livestock production and lower levels of emissions. An example of Brazil's Low Carbon Agriculture Plan (ABC Plan) which provides support to farmers who invest in such practices (Ministerio do meio ambiente, 2018[69]) (Henderson, Frezal and Flynn, 2020[70]) (OECD, 2020[71]). Argentina's National Forest Management Plan with Integrated Livestock (MBGI) programme aims to reduce forest degradation and livestock GHG emissions, while maintaining the productive capacity of the ecosystem and ensuring the welfare of farmers and communities (Ministerio de ambiente y desarrollo sustentable, 2016[72]).

Extensive versus intensive production systems

Emissions intensity of ruminant livestock products varies depending on whether animals are reared in extensive grazing, mixed systems, or intensive feedlots. Approximately 70% of milk and 60% of meat from ruminants globally are produced under mixed crop-livestock systems (incorporating supplementary feeds of grains, hay and silage) (Herrero et al., 2013[4]).

Several studies have examined which ruminant production system is least GHG emissions intensive and findings show generally favourable results for intensive production systems (Steinfeld et al., 2019[7]). There are a number of methodological choices which can influence results (Box 5.1) and the inclusion of cultivated feed crops tempers the extent of the efficiency gains (OECD, 2019[61]). Furthermore, feedlot beef production systems raise different issues including animal welfare concerns.

What is clear is that using energy dense supplementary feed improves feed digestibility. Shifting from a system of low inputs and low productivity based on extensive grazing to a mixed crop-livestock system incorporating the use of concentrates increases animal productivity and reduces total GHG emissions as long as the overall animal numbers and land use are reduced at the same time (Havlík et al., 2014[9]) (Herrero et al., 2016[62]; Gerssen-Gondelach et al., 2017[73]). However, in cases where grazing systems are already efficient, a low reliance on imported feed may reduce overall emissions intensity when all upstream and downstream emissions are taken into account (Styles et al., 2018[74]).

More intense production systems are associated with environmental challenges, such as managing the resulting manure which increases risks of air and water pollution. Intensification of livestock production reliant on concentrated feed, which may be imported, has led to nutrient oversupply in some regions and an inability to recycle surplus manure from animal production into crop production due to agricultural land limitations (Steinfeld et al., 2019[7]; OECD, 2019[61]).

Animal feeding strategies differ according to whether the animals are being fattened or milked, or whether they form part of the reproductive breeding herds. Meat and milk herds are more amenable to improved feeding practices that go with confinement (intensive production systems), or, in other cases cultivation of high quality pasture (for instance, in the Irish, New Zealand, and Dutch production models). The economics suit more extensive feeding practices; and while feed management still matters, the focus is on pasture rotations and feed quality with the inclusion of legumes (Drouillard, 2018[75]). However, other measures such as health, breeding, and husbandry can reduce mortality rates, improve fertility rates and, to some extent, growth rates, help to lower the breeding herd overhead and its associated emissions (Herrero et al., 2015[76]) (Gerber, 2013[1]).

Box 5.1. Measuring GHG emissions from ruminants

Greenhous gas (GHG) emissions heat the planet by absorbing energy and slowing the rate that the energy is released into the universe. Direct ruminant GHG emissions are mostly methane (CH_4) and nitrous oxide (N_2O), and these GHG gases along with CO_2 differ in their ability to absorb energy (measured by radiative efficiency, RE) and in their lifetime in the atmosphere.

- CO_2 has a relatively low radiative efficiency (RE), but a long average lifetime of centuries to millennia
- CH_4 has a higher RE, but an average lifetime of 12.4 years
- N_2O has an even larger RE and an average lifetime of 121 years (all values are based on the report by the Intergovernmental Panel on Climate Change (2013[15]).

These different GHGs need to be converted into a common unit to enable policy makers to make decisions on the aggregate effects of emissions or the overall effectiveness of mitigation strategies that target different gases. Comparisons are usually based on GWP_{100} (the 100-year Global Warming Potential of gases) which involves converting all GHG gas emissions into CO_2 equivalents, whereby one tonne of methane (tCH_4) equals 28 tonnes of CO_2 (tCO_2) over 100 years after their emissions (Intergovernmental Panel on Climate Change, 2013[15]). The GWP_{20} (the 20-year Global Warming Potential) conversion is used occasionally; under this metric, gases are evaluated based on their contribution to climate change over the first 20 years after their emission. This metric gives gases like CH_4 with short lifetime larger GWPs in comparison to gases with longer lifetimes (Reisinger and Clark, 2018[77]). Under GWP metrics, an assumption is made that warming from GHGs accumulates over time. However since CH_4 is a short-lived gas it does not accumulate in the atmosphere (in the same way as

CO_2) and so its emissions do not have to be reduced to zero to result in stabilisation of the climate (Reisinger and Clark, 2018[77]). This leads some researchers to contend that using the GWP metric and converting all GHGs emissions into CO_2 equivalent confuses long-term mitigation targets for the ruminant sector (Lynch et al., 2020[78]). Conversion metrics can also lead to different results when calculating the GHG emissions intensity for the same product (Reisinger, Ledgard and Falconer, 2017[79]). Other conversion metrics have been proposed to resolve this dynamic including the Global Temperature Change Potential (GTP) (Shine et al., 2005[80]) (Shine et al., 2007[81]), and the new GWP* metric (Cain et al., 2019[82]). However, these metric have limitations that can pose problems for policy makers. Researchers have recommended testing and disclosing conversion sensitivities for life cycle assessments of products (Levasseur et al., 2016[83]).

Quantifying the climate impact of ruminant production systems varies depending on where the assessment starts (and where it stops) and these different approaches also have implications for policy levers:

- *On-farm emissions* include CH_4 from enteric fermentation (the largest source), CH_4 and N_2O from manure, N_2O from fertilisers applied to soils, CO_2 from application of urea and lime, CO_2 from energy use (i.e. electricity and fuel), and CO_2 emitted or sequestered from land use and land use change.
- *Cradle to gate (and then to fork)* approaches include pre-farm gate emissions from, for example, the production of feed, fertilisers and other inputs used as part of the production process until the animals leave the farm. Adding in post-farm emissions from transporting and processing animals encapsulates a *Cradle to fork* or life cycle assessment approach. At what point the assessment ends is also an issue (e.g. should it capture the energy required for the manufacture of tractor tyres or the production of fertilisers?).

Water use, water and air quality, and biodiversity

Water use

Agriculture irrigation uses about 70% of global freshwater withdrawals (OECD, 2020[84]). While direct use of water by ruminant livestock is proportionally low, indirect water use for cultivating and processing feed crops and growing animal feed (including pasture) is the largest component the water use intensity for livestock products (Steinfeld et al., 2006[2]) (Gerbens-Leenes, Mekonnen and Hoekstra, 2013[85]) The environmental impact of water use by ruminant livestock varies and depends on the type of water used for the production of feed crops (rain water or surface and groundwater), and the type and scale of the system (extensive grazing, mixed or intensive feedlot).

Animal feed production requires more water than pasture. Cereal concentrates in particular require five times more water (per tonne of feed) than roughages (pastures) (Gerbens-Leenes, Mekonnen and Hoekstra, 2013[85]). With increasing global demand for animal protein, water use in livestock production, and in particular irrigation water for growing feed crops, is expected to rise (Herrero et al., 2015[76]). As grass is a significant feed input into ruminant livestock production systems, both under grazing and mixed systems, ruminant systems can be very water efficient under sustainably managed extensive grazing systems on unirrigated land that is not suitable for crop growing (Steinfeld et al., 2019[7]) (Herrero et al., 2015[76]).

Water availability varies around the world and within countries so the location of ruminant production systems and feed produced for these is important in considering the potential impact on water resources (Pfister, Koehler and Hellweg, 2009[86]). Agricultural production, markets and food security are also threatened by water insecurity, particularly water scarcity, in certain regions (OECD, 2017[87]).

Livestock production will be impacted as a result of reduced rain, or by increasing floods associated with a changing climate. Changes in the quantity of feed available and its quality, which are impacted by water availability, will influence livestock production. Animal health will be negatively impacted by heat stress, reducing the productivity of animals, and likely increasing the incidence of pest and diseases. Water demands mean that livestock will stay close to water sources, resulting in over grazing and land degradation (OECD, 2014[88]).

Water quality

Ruminant livestock production contributes to an increasing share of the nutrient balance in several OECD countries, resulting in environmental pressures. Surpluses of nutrients (i.e. nitrogen and phosphate) as measured by the nutrient balance indicator highlights the risks of soil, water and air pollution (from ammonia and GHG emissions). While nutrients are crucial for ruminant livestock systems to maintain and maximise pasture and crop growth, nutrients from livestock manure and application of fertiliser over and above utilisation requirements are undesirable. Cattle, in particular dairy cows, excrete higher rates of nitrogen and phosphate on a per kg per animal basis in comparison to other livestock species, i.e. pigs and poultry (Steinfeld et al., 2006[2]) (OECD, 2019[61]). Higher livestock densities for cattle increases nitrogen balances; this is supported by recent empirical work undertaken by the OECD which found a 1% increase in cattle density resulted in a 0.3% increase in the nitrogen balance (OECD, 2019[61]).

Nitrogen and phosphorus runoffs and discharge from animal manure and the use of synthetic fertilisers are major sources of water pollution for surface and ground water (OECD, 2018[89]). Nitrates in fresh and marine waters can result in eutrophication (or the spread of phytoplankton and algae) and acidification, harming fish and invertebrates (e.g. crustaceans) and can make drinking water unsafe if the nitrogen concentration is too high. Phosphorus pollutes surface water and promotes the growth of algae, which reduces oxygen and causes eutrophication (OECD, 2018[89]). Costs associated with treating agricultural pollution in water and damage to ecosystems are estimated to be in billions of euros (Gruère, Ashley and Cadilhon, 2018[90]).

Nutrient runoffs in extensive grazing systems can be influenced by stocking rates, how close to the water animals are located, the relative amount of rainfall, and the use of vegetative strips next to water bodies. Intensive grazing of stock on winter forage crops and holding stock for long periods in constrained areas can also negatively impact waterways (MPI, 2019[91]). Water quality is negatively impacted by ruminants directly accessing waterways. In these instances, there is a risk of pollution from soil particles (or sediment) and pathogens like E.coli from faeces (Steinfeld et al., 2006[2]). The trampling of stream banks can also lead to erosion and the destruction of habitat for freshwater plants and animals (MPI, 2019[91]).

In mixed and intensive systems, manure management creates risks for water quality. Collection, storage and application of manure can result in the leaching or draining of nutrients into water. The timing of manure spread and methods of application are crucial for reducing nutrient losses (Steinfeld et al., 2006[2]) (Herrero et al., 2015[76]) (Steinfeld et al., 2019[7]). Recycling of manure nutrients from intensive feedlot production systems can be difficult due to a lack of land on which to apply the manure, leading to nutrient pollution (Steinfeld et al., 2019[7]). Application of fertiliser used to stimulate pasture growth and the cultivation of feed crops can also lead to water pollution through nutrient run-off.

Air quality

The application of manure to soils results in the release of ammonia (NH_3). Environmental impacts of ammonia include reduced air quality from particulate matter, odour, and ozone formation that create risks to human health (asthma and respiratory problems), leaching, and run-off of nutrients into water which in turn create eutrophication, and reduce biodiversity from nitrogen deposition in the natural ecosystem (DAFM, 2019[92]; OECD, 2019[61]). Ammonia contributes to GHG emissions when it volatilises (or converts) into N_2O.

Biodiversity

The impact of livestock on biodiversity is both positive and negative (FAO, 2019[93]). In terms of habitat change, livestock contributes to habitat degradation and restoration. However, low intensity outdoor grazing of ruminant livestock can contribute to the agri-environmental public good of agricultural landscapes (OECD, 2015[94]). An example is Ireland which has 1 million ha of High Nature Value land grazed by cattle or sheep to maintain its biodiversity. Grazing pastures can also control and prevent the incursion of weeds and other invasive plant species. Livestock can play a role in recycling nutrients and contributes to soil carbon storage; however, it also contributes to nutrient pollution and emits GHGs (Steinfeld et al., 2006[2]) (FAO, 2019[93]).

Growth in demand for ruminant livestock products and the resulting increase in production has led to a substantial loss of remaining biodiversity via further land conversion for grazing and crop production. Conversion of remaining primary forests increases GHG emissions (with deforestation as the second most significant source of anthropogenic GHG emissions) and drives losses of ecosystems (IPCC, 2019[60]; Steinfeld et al., 2019[7]; Pendrill et al., 2019[95]).

During the period 2010-14, agricultural conversion and tree plantations led to net emissions of 2.6 Gt CO_2eq per year through losses of forests (Pendrill et al., 2019[95]). Cattle and oilseed production were the cause of half of these emissions. Products grown on land deforested during this period are exported mainly to China and Europe (Pendrill et al., 2019[95]).

One option to reduce biodiversity loss is the intensification of cattle production to reduce the area of land occupied by cattle (Steinfeld et al., 2006[2]) (Herrero et al., 2016[62]). However, intensive ruminant livestock systems require intake of feed crops produced off-farm and frequently imported, which may reduce biodiversity in other countries. As mentioned earlier, intensive systems also create issues with manure management that lead to negative water quality and soil outcomes (Steinfeld et al., 2006[2]) (Steinfeld et al., 2019[7]).

According to Herrero et al. (2016[62]), sustainable intensification can further avoid deforestation as it involves new technologies that use, for example, genetic modification of livestock and pastures varieties to reduce yield gaps, particularly in crop yields. Increased crop production would reduce feed costs and increase the use of grain as a supplement in ruminant feeding systems, leading to a decrease in land expansion pressure for grazing. The result would be less deforestation (Herrero et al., 2016[62]) but would not address animal welfare concerns and issues of manure management.

5.5. Policy responses

Three country examples are provided to analyse the trade-offs involved in the triple challenge. They focus on the implications for the ruminant livestock sector of the policy responses to climate change of Ireland, the Netherland and New Zealand. These countries were selected as they have large ruminant livestock sectors which are an important share of their agri-economies. They also provided information for inclusion in this chapter. Switzerland provided information concerning its new animal breeding strategy designed in collaboration with industry stakeholders to address the environmental impacts of its ruminant livestock sector (Box 5.2).

Policy development in these countries demonstrate how governments are navigating facts, interests, and values to determine policy direction. The climate change and water and nitrogen policy approaches described targeting the ruminant livestock sector have been politically difficult, and in the case of the Netherlands, have prompted farmer protests which are on-going.

Box 5.2. The contribution of Switzerland's ruminant livestock sector to the triple challenge and its 2030 Animal Breeding Strategy

Ruminant livestock are significant for Switzerland's agricultural sector. Of the over 50 000 farms, nearly 35 000 are cattle farms (dairy and beef), with over 8 000 being sheep farms and just over 6 000 goat farms (FOAG, 2020[96]). Grassland for grazing ruminant livestock uses over two thirds of the utilisable agricultural area, with the result of a minimum use of feed concentrates (FOAG, 2020[96]). In 2018, the contribution of the agriculture sector to the country's GDP was CHF 10.7 billion (or 0.7%) (FOAG, 2020[96]), to which the dairy sector contributed CHF 2.2 billion, cattle CHF 1.4 billion, and sheep and goats CHF 0.05 billion.

Switzerland's agricultural emissions in 2018 were 5.99 Mt CO_2eq, corresponding to approximately 13% of total emissions, with methane emissions from enteric fermentation contributing 55% and nitrous oxide emissions from agricultural soil contributing 25% (FOAG, 2020[96]) (FOEN, 2020[97]).

Ammonia emissions from agriculture are a major environmental challenge (Swiss Federal Council, 2016[98]). Agriculture is the main source of emissions, with approximately 93% of ammonia emissions from livestock (of which 77% are from ruminants) (FOAG, 2020[96]). The increase in herd numbers has resulted in ammonia emissions well beyond the long-term carrying capacity of the Swiss ecosystems (Kupper, Bonjour and Menzi, 2015[99]). In 2017, NH_3 emissions were approximately 51 550 tonnes, almost double the carrying capacity of 30 400 tonnes of NH_3 per year.

To address social requirements concerning animal welfare and health, maintaining genetic diversity, the environmental impact, and resource efficiency of livestock, the Swiss Federal Office for Agriculture (FOAG) developed the 2030 Animal Breeding Strategy (FOAG, 2018[100]) in collaboration with species and environmental experts, including from industry. Animal breeding is orientated towards:

- Food production meeting market requirements
- Preservation of animal genetic resources, and
- Vitality in rural areas.

Desired outcomes are elaborated for each key action areas and private actors, and government, will be able implement measures to achieve the objectives. The Strategy is to be implemented as part of the next Swiss Agricultural Policy. Producers will be compensated for results in relation to the breeding characteristics of their livestock.

While key actions from the Strategy are grouped around components of the triple challenge, i.e. the provision of food, livelihoods and biodiversity, how the impact of animal breeding on these outcomes is measured and how the policy will be evaluated is not yet clear.

Ireland

Ruminant livestock sector

The agri-food sector is Ireland's largest indigenous industry, accounting for almost 6.7% of Modified Gross National Income (GNI) in 2019 and employing 164 400 people (or 7.1% of total employment in 2019) (DAFM, 2020[46]). Two-thirds of Ireland's land area is used for agriculture and 81% of agricultural land is grass (silage, hay and pasture) used for grazing. There are approximately 137 500 farms with an average size of 32.4 hectares per holding, although farms in the southern and eastern regions are larger and more productive (DAFM, 2019[101]).

Ruminant livestock dominates Irish agriculture with beef and milk production accounting for over 61% of agricultural goods output in 2017 (Teagasc, 2019[102]). In 2020, the national herd of cattle was 7.3 million cattle, of which 1.6 million were dairy cows, while the sheep flock was 3.8 million head (CSO, 2020[103]) (DAFM, 2020[104]). The average herd size is 66 cattle (CSO, 2019[105]). Livestock are extensively grazed and fed supplements of grass silage, and while feed imports have been increasing due to the expansion of dairy production, grass and grass silage still constitute 90% or more of feed intake. Extensive beef and sheep operations are not as profitable as dairy operations, but play an important role in the rural economy (DAFM, 2019[47]). Despite their low profitability, surveys by the Irish Department of Agriculture, Food and the Marine indicate that 85% of beef and sheep farmers intend to continue farming (DAFM, 2019[47]).

Removal of the EU milk quotas in 2015 transformed the market and policy environment under which the Irish dairy sector operated — from being constrained by quota to not being limited and being able to react to market price signals. As a result, the number of dairy cows grew significantly. Milk production expanded by 54% between 2007-09 and 2018, with production in 2019 predicted to reach 8 billion litres for the first time. Annual exports of dairy products have increased from EUR 2 billion in 2007-09 to over EUR 5 billion in 2019, or about 35% of total agri-food exports (DAFM, 2020[46]).

The application of chemical fertiliser to stimulate pasture growth has been increasing in line with increasing livestock numbers. Furthermore use of nitrogen fertiliser is projected to continue to grow in coming years (DAFM, 2019[101]).

Challenges facing the ruminant livestock sector

The dominance of ruminant livestock poses important environmental challenges for Ireland, including in terms of GHG and ammonia emissions and in managing water quality. One difficulty is that Ireland is already one of the most efficient producers of dairy and beef in the European Union in terms of its carbon footprints and nitrogen efficiency, meaning that making improvements with the current herd numbers is complicated (Lanigan et al., 2018[106]; MacLeod et al., 2015[107]). Exacerbating environmental pressures are industry-set, government-adopted aspirational growth objectives for the ruminant sector.[6]

Agricultural GHG emissions make up a third of Irish emissions, setting Ireland apart from the rest of OECD countries, where agriculture accounts for 9% of total emissions (OECD, 2019[61]). Amongst OECD countries, Ireland is second after New Zealand in having the highest proportion of emissions from agriculture (OECD, 2019[61]). Unlike most other countries, Ireland has no heavy industry and agriculture forms a significant part of the national economy. In 2018, it was responsible for 19.95 Mt CO_2eq of GHG emissions, of which CH_4 emissions from enteric fermentation contributed nearly 58% (EPA, 2020[108]). Although the GHG emissions intensity of output from the bovine sector is low internationally, emissions have been increasing (DAFM, 2019[101]) and in 2016, 2017 and 2018, Ireland failed to meet its targets in the context of the EU Effort Sharing Decision (ESD) for agricultural GHG emissions (this was also the case for emissions from its transport, building, and waste sectors) (Climate Change Advisory Council, 2020[109]).[7] Non-compliance is predicted to continue due to the expanding dairy sector (EPA, 2019[110]).

Agriculture accounts for nearly all of Ireland's ammonia emissions, contributing to the eutrophication of surface waters and the acidification of soils (Government of Ireland, 2019[111]). OECD data indicates ammonia emissions have been on a slight declining trend during 2003-15 (OECD, 2019[61]). However, in 2016 and 2017, Ireland breached the ammonia emissions ceilings imposed by the EU National Emission Ceiling Directive (NECD). The NECD calls for additional reductions of Ireland's ammonia emissions to 1% below 2005 levels from 2020 onwards, and 5% below 2005 levels from 2030 onwards. Generated mainly from animal housing and the spreading of manure, if there is no abatement in ammonia emissions, these are projected to continue to increase to 2030 given the expanding dairy sector (DAFM, 2019[112]). Abatement options are outlined in a revised abatement cost curve (Teagasc, 2020[113]).

Water quality in Ireland has declined, with agriculture responsible for the deterioration of more than half of water bodies between 2013 and 2018 through primarily diffuse losses of nitrogen and run-off from phosphorous and sediment (EPA, 2019[114]). Latest reporting from the Irish Environmental Protection Agency (EPA) on compliance with the EU Water Framework Directive shows that 47.2% of the country's water bodies have moderate to bad ecological status, and that water quality is getting worse after a period of relative stability (EPA, 2019[114]). One-third of rivers and lakes and one-quarter of estuaries do not meet nutrient-based (nitrogen and phosphorus) quality standards, and over a quarter of monitored rivers have increasing phosphorus and nitrogen concentration (EPA, 2019[114]). Agriculture is responsible for 88% of nitrates and nearly 50% of phosphates reaching inland waters (ESRI, 2018[115]). Ireland did not meet its requirements under the EU Water Framework Directive to improve the ecological status of surface waters by 14% between 2009 and 2015 (DAFM, 2019[47]).

Climate change policy

Following the general election in February 2020, a three party coalition government (which included the Green Party) was formed in late June 2020. Subsequently, the government announced in its Programme for Government new climate ambitions. This included an average 7% per annum reduction in overall greenhouse gas emissions from 2021 to 2030, equivalent to a 51% reduction over the decade, and net zero emissions by 2050 (Fine gael, 2020[116]). In early October 2020, the Climate Action and Low Carbon Development (Amendment) Bill 2020 was introduced to parliament (Government of Ireland, 2020[117]). This Bill legislates the 2050 net zero target, along with the requirement to adopt five-year carbon budgets (for the years 2021-25, 2025-30 and 2030-35) setting maximum emissions for each sector (decarbonisation target ranges). These carbon budgets will be proposed to the Minister for Climate by the Climate Change Advisory Council (the Council), thereby strengthening its role. Carbon budgets will then considered by the Oireachtas Climate Committee (or Parliamentary Climate Committee), as well as by both the lower and upper houses of the Oireachtas (Parliament) as part of the approval process. Ministers with sector decarbonisation targets will be required to give an annual account of progress made to the Oireachtas Climate Committee (Government of Ireland, 2020[117]) (Government of Ireland, 2020[118]).

Actions to deliver carbon budgets and sectoral targets will be articulated in Climate Action Plans, revised annually. In late 2020, the next iteration of the Climate Action Plan will begin. This will build on the achievements and momentum of the 2019 All of Government Climate Action Plan (2019 Climate Action Plan) and will reflect the climate ambition of the new Amendment Bill and specific references it contains to the economic importance of agriculture and the special characteristics of biogenic methane (Fine gael, 2020[116]) (Government of Ireland, 2020[117]). The next section discusses the policy process leading to the adoption of the 2019 Climate Action Plan.

Policy process leading to the 2019 Climate Action Plan

Under the previous government, an All of Government Climate Action Plan was released in June 2019 (the 2019 Climate Action Plan).[8] It committed Ireland to meet the target of net zero greenhouse gas emissions by 2050 for all sectors, with the exception of agriculture. There was, however, a specific and legally binding reduction target for this sector. Cumulative emissions reduction targets for the agriculture, forestry and land use sector amounted to 16.5 Mt CO_2eq to 18.5 Mt CO_2eq between 2021 and 2030 and a further 26.8 Mt CO_2eq from land use removals. This is equal to a 10-15% reduction in emissions to reach a target of at least 19 Mt CO_2eq in 2030. These reduction targets are ambitious given that in 2018 agricultural emissions were equivalent to 19.95 Mt CO_2eq (EPA, 2020[108]).

Developing a broadly shared climate policy approach has motivated the involvement of a Citizens' Assembly, efforts to achieve cross-party consensus, and the establishment of an independent advisory group.

The 2019 Climate Action Plan was informed by engagement with Irish citizens through a Citizens' Assembly (Box 5.3). From its deliberations on climate change, the Citizens' Assembly agreed on 13 recommendations which were considered by an All Party Committee on Climate Action made up of representatives from Ireland's political parties (Joint Committee on Climate Action, 2019[119]). In March 2019, the Committee released their recommendations; reflecting a cross-party consensus, they did not endorse taxing agricultural GHG emissions, as recommended by the Citizens' Assembly.

Reviews undertaken by the independent Climate Change Advisory Council (the Council) established in 2016 under the Climate Action and Low Carbon Development Act 2015 have also informed climate policy development. Following a special assessment of climate change trends in the agriculture and land sector undertaken in 2019, recommendations from the Council to the Minister leading climate policy included, among other things, reducing the beef cattle rearing (or suckler) herd so as to mitigate agricultural emissions (Climate Change Advisory Council, 2019[120]) (Climate Change Advisory Council, 2020[109]).[9] With the Amendment Bill 2020, the Council has even greater responsibilities and, while current membership remains the same, in the future its composition will reflect a better gender balance and a higher number of scientific experts (Government of Ireland, 2020[118]).

Box 5.3. Ireland's Citizens' Assembly considers climate change

The Citizens' Assembly (hereafter, the Assembly) was established by the Irish government in 2016. It was a deliberative democratic process to have citizens consider legal and policy questions of significance to Irish society. Participants were selected in such a way that the composition of the Assembly reflected the age, gender, social class and regional make up of Irish society. The 99 members and Chairperson were mandated to consider five issues: legalising abortion; societal responses to an aging population; fixed-term parliaments; how referenda are held and climate policy. The Assembly met on 12 occasions from October 2016 to April 2018.

Over the course of two weekends in the last quarter of 2017, the Assembly met to consider how Ireland could lead in climate change policy. Their deliberations involved 26 hours listening to 15 experts and six stakeholders, as well as panel discussions and debate. As part of their preparation, Members read research papers and the summary of the 1 200 submissions it had received on topics covering all sectors of the economy. On agriculture, members heard from representatives of the agricultural, food and land use sector, followed by a panel discussion and a question and answer session.

The Assembly agreed on 13 recommendations by a majority vote. A tax on agricultural greenhouse gas emissions was recommended, with tax revenues to be reinvested in climate-friendly agriculture and incentives paid to farmers for sequestering carbon. Other recommendations pertaining to agriculture were the mandatory reporting and reduction of food waste throughout the food chain (distribution and supply), and support to plant forests and to support organic farming.

As part of its climate response, the All Party Committee on Climate Action (made up of representatives from Ireland's political parties) considered these recommendations, but did not endorse taxing agricultural emissions.

In a separate process on 15 November 2019, Ireland held a Youth Assembly on Climate with 150 delegates aged between 10 and 17 years. Of the ten recommendations from their deliberations, those pertaining to agriculture include the development of a climate labelling and pricing system for food, recommendations on increasing forestry on 10% of agricultural land, and a call to eliminate damage to ecosystems.

Source: (The Citizens' Assembly of Ireland, 2018[121]), (Government of Ireland, 2020[122]) (RTE, 2019[123]).

Figure 5.8. Process of engagement on the 2019 Climate Action Plan

Citizens' Assembly April 2018	• Topic : "How the State can make Ireland a leader in tackling climate change" • 13 questions posed and recommendations reached by majority vote • Recommended that GHG emissions from agriculture should be taxed, and revenue used to support climate friendly agricultural practices
Cross-party Committee on Climate Action March 2019	• Committee made up of representatives of Ireland's various political parties considered recommendations by the Citizens' Assembly • Report: "Climate change: A cross-party consensus for action" • 42 Priority Recommendations and 39 Ancillary Recommendations • Did not endorse taxing agricultural GHG emissions
Climate Action Plan June 2019	• All-of-government "Climate Action Plan to Tackle Climate Breakdown" • Defines sectoral targets and 180 actions • Strengthened governance structures and introduced quarterly reporting
Independent Climate Change Advisory Council July 2019	• Independent advisory body tasked with assessing and advising how Ireland transitions to a low-carbon economy by 2050 • 2019 Annual Review includes a detailed review on agriculture and land

Climate actions targeting the ruminant sector

Following public consultation, the *National Climate and Air Roadmap for the Agriculture Sector to 2030 and Beyond*, known as *"Ag-Climatise"*, is anticipated to be published in November 2020 (DAFM, 2019[47]). *Ag-Climatise* focuses on concrete actions to reduce emissions while maintaining incomes for farmers, including those producing ruminant livestock. It states that on-farm mitigation measures must be adopted urgently to achieve agricultural emissions reductions while maintaining a stable herd. It also states that if insufficient progress is made, more radical action will be required, especially from "sectors which are experiencing growth" (i.e. dairy) (DAFM, 2019[47]).

Central to its proposed actions included in the *Ag-Climatise* consultation document are those recommended in the Irish Agricultural and Food Development Authority, Teagasc's, Marginal Abatement Cost Curve (MACC) for GHG emissions (Lanigan et al., 2018[106]) (DAFM, 2019[47]) (the costs of abatement for ammonia emissions are also referenced in *Ag-Climatise* (Teagasc, 2020[113])). According to the MACC, cost-effective agricultural mitigations can achieve abatements of 1.73 Mt CO2eq per year from 2021 to 2030 if there is early adoption and high levels of uptake by producers (Lanigan et al., 2018[106]). Measures target on-farm improvements of nitrogen use, the use of low emissions fertilisers and manure spreading techniques, and improving cattle breeding genetics (DAFM, 2019[47]).[10]

Restricting cattle numbers, in particular dairy cow numbers, is not part of the current policy approach and is not supported by the Irish livestock sector, which believes this would damage the rural economy (DAFM, 2019[124]). Part of the rationale for this position is that if Ireland, with its comparatively low carbon footprint, restricts its dairy and beef production, other less efficient countries will increase theirs, resulting in a negative global result for the climate (Lanigan et al., 2018[106]).

Subsectors within the national herd may change, however, as a result of breeding programmes that are part of climate change mitigation. Increased herd fertility through breeding will reduce the number of replacement stock farmers need to keep. Sexed semen will increase herd productivity with pregnancies resulting in replacement animals (and not bulls) and improved genetics can increase feed conversion efficiency and general animal health.

In order to achieve the rapid uptake of technology and changes in farm management practices needed to reduce GHG emissions and to water quality without reducing output, ruminant livestock producers currently benefit from existing payments under the Rural Development Programme (RDP) of the EU's Common Agricultural Policy (2014-20) (Henderson, Frezal and Flynn, 2020[70]). Under the new Common Agricultural Policy (2021-27), Ireland will seek increased funding for abatement measures (Government of Ireland, 2019[111]).

Ruminant livestock farmers benefit from RDP payments under a number of different programmes described briefly here.[11] The Green Low-Carbon Agri-environment scheme (GLAS) incentivises farmers to use production methods that improve water quality, reduce GHG emissions and promote biodiversity. In 2017, 49 000 farmers were covered by the scheme, which is very popular with low-output sheep farms, which account for 52% of the participating farms (PER, 2019[125]) (DAFM, 2019[126]).

Capital investments in low emissions slurry spreading technology and farm nutrient storage are funded under the Targeted Agricultural Modernisation Scheme (TAMS II). As of July 2020, DAFM assisted approximately 2 400 low emission slurry spreading (LESS) machines under this programme. The Beef Data and Genomics Programme (BDGP) provides payments to the 25 500 participating farmers who must have the carbon profile of their farms analysed and undertake animal genotyping to accelerate the genetic improvement of their herds towards low emissions stock (DAFM, 2019[126]). Another programme, the Beef Environmental Efficiency Pilot (BEEP), was launched in 2019. Support is provided to suckler beef farmers and involves measuring the weaning efficiency of beef cows[12] to enable farmers to make culling decisions and improve beef production performance (DAFM, 2019[126]). Eligible beef farmers also received support in 2019 under the Beef Exceptional Aid Measure (BEAM) to compensate for beef price volatility and market uncertainties resulting from Brexit (DAFM, 2019[126]) (DAFM, 2019[127]). Applicants must commit to reducing production of nitrogen from livestock manure by 5% of 2018/19 levels (DAFM, 2019[128]).

Knowledge Transfer (KT) programmes promote on-farm climate mitigation management practices through farmer participation in discussion groups, facilitated by an agricultural advisor. Advisory services in Ireland have recently undergone extensive change and are now more focused on discussion groups where farmers are challenged by their peers, as opposed to receiving one-to-one advice. At present, there are approximately 18 600 participating farmers meeting in 1 100 groups, facilitated by 460 advisors (DAFM, 2019[126]). Another component of the KT programme is the mandatory Farm Improvement Plan for individual farms in consultation with an agricultural advisor (DAFM, 2019[129]). As part of the KT programme, 50 000 beef and 16 000 dairy farms have had their carbon profile assessed, with re-assessments taking place at 18-month intervals. Online tools allow farmers to compare their farm-level performance with similar farms; these comparisons highlight feed, animal and nutrient management practices that could be improved (Bord Bia, 2020[130]) (Teagasc & Bord Bia, 2019[131]) (Teagasc & Bord Bia, 2019[132]).

Complying with new regulatory requirements is expected to contribute to reducing GHG emissions and to improvements in water quality. For instance, from 1 January 2020 intensive dairy farms covered by the nitrates derogation are required to implement a set of measures that reduce their emissions profiles while contributing to reduced water pollution from nutrients, e.g. re-seeding grass with clover, reducing crude protein (or the nitrogen content) in concentrate feeds, and using Low Emission Slurry Spreading (LESS) equipment (DAFM, 2019[133]).[13] Under the nitrates derogation, granted by the European Union to its Nitrates Directive in 2018 and applicable until 2021 subject to meeting certain requirements, Irish farmers having a derogation can farm at higher livestock stocking rates (OECD, 2020[71]).[14] This nitrates derogation is critically important to the Irish dairy sector with its grass-based production system, as it enables a larger proportion of Ireland's total nitrogen application limit to come from livestock manure. The area farmed under this derogation increased by 34%, or 113 000 ha, from 2014 to 2018. Seven thousand farms that are intensively stocked (approximately 5% of all Irish farms) are covered by the nitrates derogation (DAFM, 2019[101]).

Voluntary on-farm actions included in the "Code of Good Agricultural Practice for reducing Ammonia Emissions" will also assist (DAFM, 2019[92]). [15] Improving nutrient use efficiency by recycling manure and replacing nitrogen chemical fertiliser use is an important focus of the Code, along with using low emissions manure spreading techniques (DAFM, 2019[92]).

One measure not proposed is the removal of tax subsidisation of fertiliser. No VAT is currently charged on the prices of chemical fertilisers (and pesticides) in Ireland (OECD, 2020[71]). Research indicates that charging the standard VAT of 23% would result in applications rates dropping by 33 000 tonnes per year. Furthermore, tax revenues that would be generated from applying VAT are estimated at EUR 35 million annually (ESRI, 2018[115]) (Breen et al., 2012[134]).

The Netherlands

Ruminant livestock sector

In 2018, there were an estimated 54 000 farms in the Netherlands, mostly owner-operated family businesses. Almost half (47%) of the agricultural enterprises were specialised in grazing livestock (cattle and dairy) (Wageningen University and Research, 2019[135]). As of April 2019, there were 3.8 million cattle in the national herd, of which 1.6 million were dairy cattle. Other ruminants (sheep, goat, horses/ponies) totalled 1.5 million (Wageningen University and Research, 2019[136]). In 2019, the gross production value of the dairy sector was EUR 5.5 billion, or over 19% of the total agricultural production value of the Netherlands. Given the prominent role of cattle in the agriculture sector in comparison to other ruminants, this section will focus on policies related to cattle.

The EU milk quotas constrained dairy cow numbers, so following the removal of the quota system in 2015, the national dairy herd expanded. However, since 2016, cattle numbers have contracted again as a result of the Netherland's phosphate emissions trading system, implemented in 2018 to protect water quality (discussed below). Cattle numbers in 2017 declined by 8% for dairy cattle and by 12% for non-dairy cattle (RIVM, 2020[137]). Farmers have been choosing to keep fewer calves and replacement heifers, and the average herd size per farm decreased from a peak of 160 cows per farm in 2016 to 153 in 2019, with dairy farmers keeping between 94 and 97 head of dairy cattle on average over the period 2014-18 (CBS, 2019[138]).

Challenges facing the ruminant livestock sector

As land is scarce, livestock systems in the Netherlands are efficient and intensive. High levels of input use from imported concentrated feed in the intensive dairy sector, and the resulting manure production poses environmental problems. Ground and surface water pollution, poor air quality, soil and biodiversity deterioration, and GHG emissions are the main environmental problems associated with ruminant livestock in the Netherlands (Hoes et al., 2019[139]). As a result, meeting its EU environmental commitments will be a challenge.

This challenge was one of the main drivers for the Cabinet to present in 2018 its holistic vision on the future of agriculture, nature and food in the Netherlands *'Valuable and Connected'* (MINLNV, 2019[140]) (MINLNV, 2019[141]). It addresses the triple challenge of feeding a growing population, providing a livelihood for farmers, and protecting the environment (including biodiversity). The premise is to bring agricultural models more in line with ecologically and economically vital production methods based on resource efficiency, in balance with nature and appreciated by society.

Acting on this, the programme for a Sustainable Livestock Sector was published in September 2019 (MINLNV, 2019[142]). It is based on three pillars: inspiring and experimenting, improving the conditions allowing farmers to farm sustainably, and private sector plans. The Dutch Dairy Association and dairy farmers, in partnership with other organisations, have since developed the Sustainable Dairy Chain which includes goals on climate neutrality, livestock health and welfare, preservation of grazing, and protection of biodiversity and the environment (duurzamezuivelketen, 2019[143]) (Dutch Dairy Association (NZO), 2019[144]) (OECD, 2020[145]).

Total GHG emissions in 2018 were 15% lower in the Netherlands than in 1990, but far from the 2020 target of reducing emissions by 25% below 1990 levels. Decreased GHG emissions are attributable mainly to reductions in methane and nitrous oxide, which in turn are due to reductions in cattle numbers (RIVM, 2019[146]). Long-term trends in OECD countries from 2003-05 to 2013-15 saw increases in agricultural GHG emissions attributable mainly to emissions from agricultural soils (due to fertiliser use), while enteric fermentation emissions decreased (OECD, 2019[61]). This trend is similar in the Netherlands, where in 2017 the agricultural sector was responsible for 86% of all ammonia emissions (RIVM, 2019[146]). Emissions in recent years have exceeded the ceiling under the EU National Emissions Ceilings Directive (NECD) for ammonia, as well as Dutch commitments under the Gothenburg Protocol (RIVM, 2020[137]). [16]

Moreover, various measures to increase agricultural production, such as the draining of wet areas, changes in crop choice, and use of chemical fertilisers has led to a deterioration of the country's biodiversity over the past century. As a result, the population of species that depend on agriculture continue to decrease, in particular breeding birds, insects and butterflies. Since the 1980s, various agri-environment schemes have been implemented in an attempt to reverse this trend, but these have not succeeded (Alterra, 2019[147]).

Diffuse agricultural sources negatively affect the water quality of 78% of surface water bodies. Nitrates generated by intensive livestock-rearing and dairy farming are an important source of water pollution. Nutrient concentrations in surface waters were identified by the European Commission in 2017 as a key issue in the Netherlands' implementation of EU environmental policy. Progress to reduce nutrient concentrations and eutrophication was made in 2019, but nitrate pollution is still problematic (European Commission, 2019[148]). The Netherlands is one of the few OECD countries to have reduced its nitrogen balance significantly over time and while still high compared to other OECD countries, the balance has gone from being over 300 kg/ha in 1990-92 to less than 150 kg/ha in 2012-14 (OECD, 2019[149]). Moreover, since 1990, the Netherlands has reduced its phosphate surplus while simultaneously increasing agriculture production levels (OECD, 2019[61]). To address water quality and meet the EU requirements, several regulations focussed on manure management and the nitrogen and phosphate content of manure have been implemented. These regulations effectively constrain dairy cow numbers to the previous level under the EU milk quotas.

Manure policy is based on the EU Nitrates Directive, and in addition to the four-year Nitrates Action Programmes (NAP) (the current NAP is the Netherland's sixth, covering the period 2018-2021) includes the following laws: the Manure Law, the Manure Law Implementing Decision, and the Manure Law Implementing rules. Implementing the Action Programmes also contributes to meeting the commitments under the EU Water Framework Directive.

The Netherlands has a derogation to the EU Nitrates Directive and is allowed to farm at higher livestock stocking rates, with a limit of 250 kg livestock manure per hectare (instead of the usual maximum of 170 kg per hectare). This translates into being allowed to farm two dairy cows per ha instead of only one. Continuation of the derogation is on the basis of the fulfilment of several conditions, including limiting phosphate from manure to 2002 levels. The current derogation was granted until 31 December 2019 (and a decision from the EC about its extension was due in March 2020) (RIVM, 2019[150]; European Commission, 2019[148]).

To stay within phosphate limits and retain the derogation, a phosphate emissions trading system was implemented for the dairy sector in January 2018. Free units were allocated to farmers on the basis of their July 2015 cattle numbers (Backus, 2017[151]). As a result, total phosphate emissions in 2019 from the dairy sector declined for the third consecutive year stand at 75 million kg, or 12% lower than the ceiling of 84.9 million kg set by the Dutch government for the dairy sector (CBS, 2020[152]).

Climate change policy

Agriculture accounts for nearly 10% of total emissions in the Netherlands, proportionally less than in the case of Ireland and New Zealand. Total agricultural emissions in 2018 were made up of 45% from enteric fermentation, 29% from N_2O from agricultural soils, and 25% from CH_4 and N_2O emissions from manure management (OECD, 2020[145]) (National Institute for Public Health and the Environment, 2020[153]).

At the end of June 2019, the Climate Act (*Klimaatwet*) and the National Climate Agreement were presented to the Dutch parliament and at the beginning of September 2019 the Climate Act came into force (Government of the Netherlands, 2019[154]). The Climate Act specifies a 49% reduction in overall GHG emissions by 2030 relative to 1990 levels, exceeding the EU target of 40% (under the EU's NDC submission for the Paris Agreement). A much more ambitious 95% reduction target is proposed for 2050. Under the Climate Act the government prepared a Climate Plan with specific measures to meet targets; this Act was submitted to Parliament at the end of 2019.[17]

The agriculture section of the National Climate Agreement is the basis for the Climate Plan for the sector. Achieving the agriculture emissions reduction target of 3.5 Mt CO_2eq by 2030, this will involve: reducing livestock CH_4 emissions (in particular dairy cattle and pigs, via manure and feed measures); increasing carbon sequestration in grasslands, agricultural soils, and forests; and reducing CO_2 emission in the greenhouse horticulture sector (via energy savings and sustainable production of energy). Measures proposed were developed in consultations with agriculture industry organisations and experts (OECD, 2020[145]; Klimaatakkoord, 2018[155]).

The livestock sector (dairy and pig farming) will jointly develop action plans under an "Implementation Agenda for Livestock-Climate". The Livestock Farming Development Group will monitor the sector's progress. Action plans for poultry, goat, sheep and veal sectors will also be developed (Government of the Netherlands, 2019[154]).

The Minister of Economic Affairs and Climate Policy has instituted an overarching committee to track progress, and maintain coherence and oversight of implementing actions under the Climate Act. Relevant Ministers, including the Minister of Agriculture, Nature and Food Quality, have responsibility for sector-specific implementing committees. Departments involved in developing the emissions reduction response for the ruminant livestock sector are: the Ministry of Economic Affairs and Climate Policy (Leads coordination); Ministry of Agriculture, Nature and Food Quality and Ministry of Environment.

To support climate policy development, the following institutions are undertaking data-intensive research: the Royal Dutch Meteorological Institute (KNMI), Emission Registration (ER) and Netherlands Environmental Assessment Agency (PBL). These report to the Ministry of Infrastructure and the Environment. Calculations undertaken by the PBL and the Netherlands Bureau for Economic Policy Analysis (CPB) on the effects of the commitment to a 49% GHG emissions reduction provided evidence of its feasibility.

Following court rulings on the climate policy upheld by the Supreme Court in December 2019 officials have revisited the climate change policy and in April 2020 the government announced additional measures Box 5.4).

Box 5.4. The Netherlands: Legal action against the government's climate policies

Legal action by groups demanding more ambitious climate responses has been taken against governments throughout the world. To date, climate lawsuits have been filed in 28 countries (LSE, 2019[156]).

In 2015, the District Court of the Hague (the Court) ruled against the Dutch government and required it to take stronger climate action. This lawsuit, initiated by the Urgenda Foundation, an environment group, along with 900 Dutch citizens, was the first example of a court ruling on the adequacy of a government's climate change commitments (Urgenda Foundation, 2019[157]). The Court concluded that given the State's duty to protect Dutch citizens, its climate change measures were insufficient (de Rechtspraak, 2015[158]). At the time, the Dutch climate change policy would have led to emissions reductions of 17% by 2020. The Court ordered that emissions be reduced by at least 25% below 1990 levels by 2020, as committed.

Obligated to comply with the ruling, upheld by both the Court of Appeal (in October 2018) and by the Supreme Court (in December 2019), the government has worked on a suite of measures in addition to those included in the national Climate Agreement. These were announced at the end of April 2020 (MINLNV, 2020[159]) and include a 75% scaling back of the country's three coal fired power plants operations (in operation since 2015). No additional measures for agriculture were introduced, as the Government had announced around the same time a package of measures for the agriculture sector to address the ruling of the Council of State on nitrogen. It is expected that these nitrogen measures will also contribute to GHG-emissions. Farmers will receive EUR 360 million in compensation for reducing livestock numbers. These measures and others were adopted by the government based on suggestions developed by the Urgenda Foundation in collaboration with 800 NGOs under its "54 Climate Solution Plan" (The Guardian, 2020[160]).

Source: (Climate Liability News, 2019[161]; New York Times, 2019[162]; Time, 2019[163]).

Impact on farmers of policies and their responses

Farmers have had to reduce dairy cow numbers to comply with regulations on manure management and the nitrogen and phosphate content in manure. This reduction has resulted in decreased agricultural GHG emissions, although total GHG emissions are still higher than reduction commitments. Following a ruling by the Dutch Supreme Court at the end of 2019 (Box 5.4), the government will need to take more action to cut total emissions by at least 25% below 1990 levels by 2020. This will be complicated, because, as of 2018, emissions were just 15% below 1990 levels (Climate Liability News, 2019[161]). Further reduction efforts may be required of the ruminant livestock sector.

Under the Dutch Rural Development Programme (RDP), there is funding for GHG mitigation activities by farmers. Funding activities that fall under the Agri-environmental and climate measures (AECMs) programme are a large part of the RDP budget (European Commission, 2019[164]). Furthermore, funding is being made available over the period 2020-2030 from the Climate Budget to support the ruminant livestock sector with the adoption of climate-friendly practices and innovation (Government of the Netherlands, 2019[154]).

Box 5.5. The Netherlands: Court ruling on nitrogen oxide emissions

In May 2019, the Council of State (Raad van State), the Netherland's highest administrative court, ruled that the Programmatic Approach to Nitrogen (Programmatische Aanpak Stikstof, PAS), the licensing mechanism for nitrogen-emitting activities, contravened the EU Habitats Directive. As a consequence, no new building permits have been issued since (including for intensive farm activities) if they result in an increase of nitrogen emissions (NH_3 and N_2O). To reduce such emissions, some politicians have called for the halving of livestock numbers and the withdrawal of farm emission rights. As of November 2019, the Dutch government has offered to buy old and inefficient farms and to assist other farms with subsidies to modernise. In February 2020, the government announced a suite of measures for the agriculture sector to address the ruling of the Council of State (MINLNV, 2020[165]) (MINLNV, 2020[166]). These include:

- Targeted buy-out by the government of livestock farms (on voluntary basis)
- Subsidies for innovation and the sustainability of animal housing
- A transition fund
- Facilitation of livestock farms near natural areas who want to switch to a more extensive way of livestock production
- Agricultural advisors to help farmers to implement measures to lower the emission of nitrogen and/or to advise them on other ways of production
- Establishment of a network of pilot farms

In October 2019 and February 2020, farmers demonstrated their opposition to the government measures. Protest actions included farmers driving their tractors to The Hague, creating huge traffic jams. The headquarters of the National Institute for Public Health and the Environment (RIVM) have been targeted by protesters who consider its reporting on nitrogen levels inaccurate. RIVM maintains that the agriculture sector accounts for 41% of nitrogen deposition on Natura 2000 protected areas established under the EU Habitats Directive. In mid-July 2020, Dutch farmers once again blocked roads to protest a proposal from the Minister of Agriculture to limit the protein content of concentrated feed.

Source: (Politico, 2019[167]; Arc2020EU, 2019[168]) (NL Times, 2020[169]).

New Zealand

Ruminant livestock sector

The ruminant livestock sector plays a major role in the economy of New Zealand. In 2019, revenue from dairy exports accounted for approximately a quarter of total national export revenues from all sectors (Statistics NZ, 2020[170]). The sector employs 48 000 people and accounts for around 3% of GDP (NZIER, 2018[45]). In addition, the meat processing sector employs 25 000 people and is responsible for approximately 13% of the country's total national exports revenues (Statistics NZ, 2020[170]).

As of June 2019 there were 6.3 million dairy cattle (an average dairy herd is 435 cows per farm), 3.9 million beef cattle, 26.8 million sheep and 810 000 deer (Statistics NZ, 2020[171]). These animals graze outside all year round.

Challenges facing the ruminant livestock sector

New Zealand has the highest proportion of emissions from agriculture of all OECD countries (OECD, 2019[61]) due to its high level of agricultural production, most of which is for export. It is also due to the country's lower proportion of emissions from electricity generation than most other countries, with 80% of New Zealand's electricity generated from renewable energy. New Zealand's gross GHGs emissions in 2018 were 78.9 Mt CO_2eq, 24% higher than 1990 levels due to methane emissions from dairy cattle and CO_2 from road transport (MfE, 2020[172]). Agriculture was responsible for 48% of all emissions in 2018, with dairy cattle accounting for 22.9%, sheep 11.9% and beef cattle 8.1%. Emissions from agriculture have increased by 17.1% in 2018 from the 1990 level (MfE, 2020[172]).

The increase is largely due to an increase in N_2O emissions from agricultural soils and an increase in CH_4 emissions from enteric fermentation. The 670% increase in the application of synthetic nitrogen fertiliser and an increase in dairy cow herd numbers by 85.6% over the period 1990-2018 are the key causes of increased agricultural emissions and the deterioration of water quality (MfE, 2020[172]) (MPI, 2019[91]). Over the same period, enteric fermentation emissions from sheep and non-dairy cows decreased, their numbers also declined by 53% and 19% respectively (MfE, 2020[172]). New Zealand's climate change policy and its implications for the livestock sector are discussed in the next sections.

In terms of water quality, nearly half of New Zealand's total river length is in areas with grazing farms (with 1% in urban areas). Over 70% of the total river length has nitrogen levels that may negatively affect the growth of some aquatic species and 82% of the river length in farming areas is unfit for swimming due to the risk of Campylobacter infection (MPI, 2019[91]).

Water policies announced in May 2020 (MfE, 2020[173]) strengthen policies that have been in place since 2011, and will have significant impacts on the dairy and sheep and beef industries as they aim to limit pollution from these sectors.[18] Key actions include: limits on nitrate and suspended sediment concentrations in waterways; restricting major agricultural intensification (MfE, 2020[174]); implementing stronger controls for feedlots as of 3 September 2020 and stockholding areas as of 1 July 2021 (MfE, 2020[175]); reducing excessive nitrogen use through a cap on synthetic fertilisers as of 1 July 2021; excluding stock from waterways as of 3 September 2020 (MfE, 2020[176]); and as of 1 May 2021 ensuring intensive winter grazing of forage crops meet standards (MfE, 2020[177]). These policies also aim to reduce soil loss by strictly managing activities such as: earthworks and land clearance; maintaining existing ecosystems by protecting streams and wetlands from draining or development; and controlling activities that can affect sources of drinking water (MfE, 2019[178]).

Requirements under the freshwater policy are also likely to have positive climate change outcomes. Given the costs for farmers of implementing the climate change and freshwater measures, policy makers will be focussed on avoiding the duplication of efforts.

Climate change policy

Given the significance of agriculture in the New Zealand economy, reducing agricultural emissions presents a unique challenge that requires a whole of government approach. New Zealand's overarching framework for climate change helped guide the co-ordinated policy development. This framework emphasizes international and domestic leadership on climate change, a productive, sustainable and climate-resilient economy, and a just and inclusive society.

In November 2019, the Climate Change Response (Zero Carbon) Amendment Act (the Act) passed into law with a cross-party consensus. The Act sets separate long-term emission reduction targets for long-lived and short-lived GHGs and includes a target for biogenic methane. Emissions reduction targets set out in the Act aim to:

- Reduce all GHG emissions except biogenic methane to net zero by 2050; and
- Reduce gross biogenic methane emissions by 10% by 2030 and by 24-47% by 2050 relative to 2017 levels.

The separate targets for methane recognise the different dynamics of long-lived versus short-lived GHGs. Long-lived gases (i.e. carbon dioxide and nitrous oxide) need to be reduced to net zero to limit global temperature increases, whereas methane needs to be reduced but, once stabilised, methane emissions can continue at a stable rate without adding to further warming (MPI, 2019[91]). In addition, the amount of methane reduction will depend on when technological developments are ready for farmers to use. At present, few practices and technologies are available to effectively reduce methane.

As of 2025, livestock emissions will be priced at the farm level, while fertiliser emissions will be priced at the processor level. A world-first partnership has been established between the government, the primary sector and iwi/Māori (indigenous groups) called *He Waka Eke Noa*.[19] The Joint Action Plan for Primary Sector Emissions will work towards building capability for farmers and growers to report, manage, and reduce emissions at the farm level (New Zealand Primary Sector, 2019[179]).

Supporting measures under the Joint Action Plan (to be administered by the Ministry for the Environment and Ministry for Primary Industries) include: integrating climate change component into farm plans (whole of business plans including management measures to meet water quality and biodiversity requirements) by 2025; creating tools for estimating farm-level emissions; increasing farm advisory capacity and capability; providing capacity-building tools and support for Māori landowners; providing incentives for early adopters; and potentially recognizing on-farm sequestration (e.g. small plantings, vegetation). If insufficient progress has been made in developing an appropriate farm gate emissions pricing mechanism by 2022, emissions will be priced at the processor level instead of at the farm level and will be included under the New Zealand Emissions Trade Scheme (NZ ETS).

Overall, pricing emissions at the farm level is intended to create an incentive for farmers to change their on-farm behaviour and to reduce emissions. Modelling suggests emissions reductions could be 2.45 Mt CO_2eq per year (or 6% of agricultural emissions) (Manaaki Whenua Landcare Research, 2019[180]). Issues yet to be worked through include the final design of the farm-level pricing scheme and the mechanism for the free allocation of carbon credits at the farm level (95% of emissions units will be freely allocated upon entry). Costs of implementing the farm-level scheme will depend on its final design.

Policy process leading to the commitment to price agricultural emissions

Political compromise and concessions were necessary to obtain cross-party support for the inclusion of agricultural emissions in the Climate Change Response (Zero Carbon) Amendment Act. Cross-party support was seen as crucial and was included in the Labour Party's pre-election manifesto (New Zealand Labour Party, 2017[181]). Unanimous support for the policy sends an important signal to farmers, business owners and investors that the regulations and legislation will not change with political cycles, providing them with certainty. This clear signal is significant because the time frame for implementation of 2025 was two elections away (with elections held in October 2020 and scheduled for 2023).

Under New Zealand's electoral system of Mixed Member Proportional (MMP) representation, political bargaining is essential. The previous government was a minority coalition between the Labour Party and New Zealand First Party, with support from the Green Party on key issues. Treatment of agricultural emissions in legislation was part of the coalition negotiations between the parties.[20]

Starting in May 2018, options to reduce agricultural emissions were informed by the independent Interim Climate Change Committee (ICCC). The ICCC was tasked with investigating whether or how agricultural emissions could be priced under the NZ ETS. Pricing emissions is consistent with the NZ ETS whereby emission costs are levied on sectors, including transport fuels, electricity production, synthetic gases, waste and industrial processes. Under current settings, agricultural processors (e.g. meat and dairy processors, nitrogen fertiliser manufacturers and importers) are required to report on their on-farm biological emissions under the NZ ETS, but do not pay for these.

Following consultations with farmers, growers, Māori landowners, primary sector industry organisations, NGOs, rural communities, and banks, the ICCC provided recommendations to Ministers in April 2019. It recommended farm-level pricing of livestock emissions, processor level pricing of fertiliser emissions by 2025 and, before 2025, the pricing of both at the processor level through the NZ ETS (ICCC, 2019[182]).

Farm groups were very critical of the recommended approach to include agricultural emissions in the NZ ETS, leading to the aforementioned Farmer organisations came up with an alternative proposal entitled *He Waka Eke Noa* in July 2019 (New Zealand Primary Sector, 2019[179]). Central to this proposal is that the sector does not pay for its emissions until 2025. Instead, a formal agreement should be developed between primary industry groups and government, including specific commitments to reduce agricultural emissions and move towards farm-level pricing by 2025 (rather than joining the ETS). This reflects the farmer position of wanting emissions to be counted at the farm-level in order to have control and to benefit from emissions reductions occurring on-farm.

Two options (a processor-level obligation in the NZ ETS and a formal sector-government agreement) were the focus of a four-week public consultation (through July and August 2019) (MfE, 2019[183]). Consultations included public meetings, special meetings with Māori for feedback on Māori-specific impacts, and technical workshops. Meetings were held in 18 urban and regional centres, with large attendance by farmers and industry organisations, despite it being calving season. In total, 3 976 submissions were received.

In late October 2019, the New Zealand government introduced the Climate Change Response (Emissions Trading Reform) Bill adopting a policy approach that was consistent with the proposal from farm industry organisations to work together with the sector and with Māori on a Joint Action Plan to support the implementation of farm-level pricing of emissions by 2025. Farmers will have to purchase only 5% of their emission credits with an initial 95% of credits allocated free of charge. In the future, larger shares of emissions credits will need to be purchased; this approach is consistent with that taken for other sectors. Starting from 2024, it will be mandatory for farmers to provide information on their farm-level livestock emissions. With this significant agreement reached in November 2019, the Climate Change Response (Zero Carbon) Amendment Act was passed into law with cross-party support.

By the end of 2022, the Minister for Climate Change and the Minister of Agriculture will need to report on the design of a mechanism to price agricultural emissions as an alternative to the NZ ETS. Issues that will need to be clarified are how emissions will be priced, the methodology for their calculation, the treatment of methane relative to other GHGs, and who will administer the system (New Zealand Government, 2019[184]).

Pricing of agriculture emissions will be applied at the processor level under the NZ ETS before 2025 (as initially recommended by the ICCC) should progress by the sector in preparing for farm-level pricing be considered insufficient. Monitoring progress under the formal primary sector-government agreement is the responsibility of the independent Climate Change Commission which will report back to the government in 2022.[21] The Minister for Climate Change will also report back in 2022 on an alternative farm-level emissions pricing scheme under the New Zealand Emissions Trading Scheme.

The decision appears to have satisfied the agriculture sector, yet environmental NGOs consider this response too slow and that agricultural emissions should be included under the NZ ETS. On a practical basis, a longer timeframe recognises that implementing a farm-level pricing scheme requires building farmer and grower capability. A survey undertaken by the Ministry for Primary Industries in 2018 found that only 14% of livestock farmers had estimated their livestock emissions and only 2% knew their last two years' on-farm emissions. Time is also needed to develop the emissions calculation tools as well as the administration system. Funding of NZD 122 million has been allocated over five years 2019-24 to provide information and practical assistance to farmers in terms of measuring and reporting on-farm emissions. Building capacity for measurement, reporting and verification (MRV) of on-farm GHG emissions is a useful step towards the implementation of a carbon price (OECD, 2020[145]).

Impact on farmers of policies and their responses

On-farm behaviour change has been taking place. The overall emissions intensity of the sector fell by an average of 1% per year over the period 1990-2014. Over 1990-2015, New Zealand reduced its emissions intensity, a ratio of GHG to agricultural gross value of production, by -34%, an achievement higher than the OECD average of -22% (OECD, 2019[61]). Declining emissions intensity is attributed to policies focussed on R&D and farm profitability in a responsive sector that does not receive distortionary support (OECD, 2019[61]). Some companies and industry organisations in the ruminant livestock sector have set their own GHG emissions reduction targets. However, more action is needed to meet the gross biogenic methane targets.

At this stage, the costs of implementing the farm-level scheme are not known, as these will depend on its final design. Feasibility considerations for farm-level pricing of emissions will be informed by the impacts on rural communities, including land values, profits, employment, demographics, social services and community resilience.

Economic opportunities associated with pricing agricultural emissions could include higher rates of innovation and the development of technology which could potentially be sold to other countries grappling with reducing agricultural GHG emissions. Benefits to farmers are likely to include productivity gains (MfE, 2019[185]).

Another benefit for farmers of pricing emissions is that it encourages more sustainable business models (MfE, 2019[185]). These would enhance farmers' "social licence to operate"; that is, the broad acceptance and trust of the sector and its operating methods by society, including consumers (MfE, 2019[185]). Pricing agricultural emissions can help to ensure future market access in valuable export markets.

Strict regulatory requirements in the new Essential Freshwater policy package target water pollution from the dairy sector. Complying with these regulations could lead to a reduction in cow numbers.

5.6. Conclusion

The ruminant livestock sector plays a key role in meeting the "triple challenge". The sector is a source of livelihood for millions of farmers and millions more along the value chain, providing employment in rural areas around the globe. Ruminant meat and dairy production contribute vital nutrients and vitamins to global food intake, which helps to combat malnutrition associated with the under consumption of animal proteins in the developing world. However, governments in many countries with high consumption levels recommend limiting the consumption of red and processed meat because of health risks associated with overconsumption. At the same time, the sector is facing important economic and environmental challenges through ruminant livestock's contribution to climate change and other problems such as water pollution. These challenges will only become more pressing, as global consumption of meat and dairy are projected to grow with the growing global population.

Ruminant livestock systems around the world are diverse, including in terms of productivity and environmental impact. India, Africa and Latin America are home to large herds but, in general, have lower animal productivity compared with the developed world. Improving the productivity of ruminant livestock in these regions (e.g. via animal and seed genetics, better feed quality, grazing and animal husbandry management practices) could help meet increasing demand for ruminant commodities while limiting the growth in herd numbers and the associated environmental damage, in particular GHG emissions.

Developed countries can make an important contribution by sharing knowledge and technologies to reduce productivity gaps.

Yet productivity growth alone will not suffice to reduce the environmental footprint of the agriculture sector; effective policies are needed. As the discussion of three country case studies (Ireland, New Zealand and the Netherlands) shows, introducing such policies is difficult when the ruminant livestock sector is an important source of livelihoods for farmers and those along the supply chain. Production systems are already highly efficient in these countries, thus limiting what can be achieved by closing productivity gaps (OECD, 2019[61]; Guerrero and Nakagawa, 2019[186]). Methane emissions from ruminants, however, make up a large part of their emissions profile and water quality has been negatively affected. The respective governments have struggled to address these issues, as seen by the difficulties that Ireland and the Netherlands are having to meet their EU obligations to protect water quality and reduce methane and ammonia emissions.

Different policy approaches are being taken in these countries to address these environmental challenges – which is the focus here rather than policies targeting food and nutrition security or the farmer livelihoods components of the triple challenge. To reduce manure production from dairy, the Netherlands is using a polluter pays approach through a phosphate trading scheme, which effectively constrains dairy cow numbers. A polluter pays approach is also being taken by New Zealand, with plans to price livestock emissions at the farm-level by 2025. Additionally, regulatory requirements under New Zealand's water policy will limit dairy intensification activities. Ireland, in contrast, is pursuing the rapid adoption of technology and changes in farm management practices to produce more with less GHG and ammonia emissions. Efforts are focussed on knowledge transfer and funding capital investments to improve nutrient use efficiency, along with genetic improvement of the national herd. The regulatory framework Ireland has in place for optimising nitrogen management across water, air and climate is reasonably well advanced in an international context and the Irish government has made it clear to farmers that if targets are not met, more radical action will be necessary. However, with an already highly efficient ruminant production system, it will be difficult to achieve further reductions in emissions while simultaneously maintaining livestock numbers and expanding production.

Given the important role of the ruminant livestock sector in these countries, developing effective policy responses to these challenges has not been easy, as seen in the case of their respective efforts to reduce GHG emissions. Ireland used an innovative deliberative process through its "Citizens' Assembly", whereby a representative group of 99 citizens recommended policy measures to respond to climate change, although their recommendation to tax agricultural emissions (although this was not adopted by the subsequent cross-political party process). Furthermore, an independent advisory group recently advised the government of the need to reduce the beef herd and to encourage farmers to exit this unprofitable sector as another way to reduce GHG emissions. In the new Climate Amendment Bill, this same advisory group is now be responsible for proposing carbon budgets for each sector, to be approved by a cross-party parliamentary committee.

In the Netherlands, legal challenges are driving policy changes. A court ruling that the Dutch government's climate change commitments were inadequate was a world first and has implications for ruminant livestock numbers as the Dutch government commits to making further reductions to GHG emissions as ordered. In another legal ruling, the country's approach to managing nitrogen emissions was found to be insufficient. However, measures to comply with this verdict are controversial with Dutch farmers, who have organised large-scale protests to demonstrate their opposition. Farm groups have also called into question the accuracy of nitrogen emissions as measured by the government's scientific institute.

In New Zealand, representatives from the primary industry organisations made a joint submission to the government requesting to be exempt from payments for emissions until 2025, and then have a phased in farm-level pricing of emissions, rather than becoming part of the Emissions Trading Scheme, so that farmers can benefit from the mitigation measures they implement on their farms. This approach was accepted on the proviso that sufficient progress is made by the sector in designing an allocation mechanism and preparing for its implementation.

These country examples demonstrate the difficulties for policy makers in addressing the triple challenge for the ruminant livestock sector, a sector of economic and political significance. Policy approaches that limit ruminant numbers or increase producers' costs are understandably unpopular with farm lobbies and politicians, although it may be difficult to reduce the environmental damage of the sector without such measures. Weakening consumer demand in developed countries for ruminant meat products for health and environmental reasons, along with requirements from increasingly urbanised consumers for more evidence of environmental stewardship by farmers will contribute to drive changes. It is nevertheless unlikely that these trends by themselves will suffice to address the negative environmental spillovers of the sector and so there is debate to be had over whether all ruminant livestock farmers should remain in the sector based on their competitiveness.

This raises a number of questions about possible ways forward to better policies. First, what is the role of information in creating a case for change? In terms of environmental impacts there are uncertainties around precise spillovers, the exact impacts of certain practices, and the degree to which each individual producer is responsible. These uncertainties can undermine momentum towards policy change. Countries surveyed for this chapter used several good practices to independently gather facts and information and to build a shared understanding, such as the establishment of an independent Interim Climate Change Commission in New Zealand and Ireland's use of a Citizens' Assembly, whereby participants were educated on the topic of climate change before deliberating and arriving at their recommendations. Work will continue on these advisory and extension services in all the three countries, e.g. to calculate on-farm GHG emissions and verifying farms' environmental performance and this, along with a more innovative model of advisory services, is critical for bringing about widespread and rapid change. But the ongoing difficulties with policy reform raise the question whether there are other mechanisms which could have strengthened this shared understanding. Polarisation of the debate in the context of evolving science means that the challenge is also in developing approaches and actions to address the issues fairly and in a balanced way with stakeholders all working together.

Policy interventions in the ruminant livestock sector are likely to harm producers financially by lowering their competitiveness and livelihoods, who understandably organise against such measures. In New Zealand, two methods used to reduce sector resistance were letting the sector co-determine how agricultural GHG reduction commitments will be delivered, and permitting a longer phase-in period than originally proposed. Another example is the recently announced (April 2020) financial compensation for reducing livestock numbers in the Netherlands in order to comply with court rulings. Are there other mechanisms which could be used to compensate those who stand to lose from policy reforms, thus making it less likely that producer interests mobilise against necessary policy measures?

Lastly, what is the role of values in facilitating the adoption of such policy measures? In all three countries, ruminant livestock has historically formed a major component of the rural economy and are a familiar presence in the landscape and, for many, an important element of their identity. Measures which end up limiting ruminant livestock numbers might thus also partly be resisted on non-material grounds. At the same time, it might be possible to reframe rural identities in ways that facilitate policy reform. For example, in New Zealand the case has been made that reform would support the sector's long-term economic sustainability and would enhance access to export markets. Public discourse in New Zealand considers farmers as stewards of the environment who have a "social licence" to operate based on society's trust and acceptance of their farming methods. Could such a positive framing facilitate the achievement of environmental goals?

The public may have preferences about how the trade-off between environmental goals and the presence of ruminant livestock should be struck, although information on these policy preferences tends to be scarce. Deliberative mechanisms such as the one used in Ireland could be one way to elicit these preferences, but as the Irish case illustrates, this may not by itself be sufficient to resolve the political question of to what extent and by what means the ruminant livestock sector should contribute to meeting environmental goals.

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Notes

[1] The emphasis in this chapter is on food from ruminants, and not fibre or hides or other uses derived from these animals.

[2] To avoid unintended consequences on land use pressure, policies aimed at increasing productivity need to be combined with land use measures (OECD, 2019[188]).

[3] The World Organisation for Animal Health ONE Health initiative and Global Action Plan on AMR monitors countries' use of antimicrobials using a global database and publishes an annual report (OIE, 2020[43]; Góchez et al., 2019[44]).

[4] Globally, numbers of ruminants (cattle, sheep and goats) have increased by 50% over the period 1968-2018 according to data from FAO Stats.

[5] Land-use change emissions stemming from the global food system are estimated by the IPCC (IPCC, 2019[60]) as being 4.9 ± 2.5 Gigatonnes of CO_2 equivalent (Gt CO_2eq) per year, with 6.2 ± 1.4 Gt CO_2eq per year coming from direct agricultural emissions.

[6] Food Harvest 2020 (released in 2010) and Food Wise 2025 (released in 2015) are sector strategies. The Food Harvest 2020 calls for increased growth in beef and milk production. The Food Wise 2025 sets targets for output growth for the entire agri-food sector and for the value of exports, jobs and value-added. The Food Wise 2025 does state that "sustainable growth should seek to increase the value added by the sector per unit of emissions (GHG or ammonia) produced" (Lanigan et al., 2015[191]; DAFM, 2010[197]; DAFM, 2015[198]). The next ten-year Agri-Food Strategy to 2030 is scheduled to be released in early 2021, public consultation on the direction of the Strategy was concluded in October 2019 (DFAM, 2019[190]). Public consultation was also undertaken on a Strategic Environmental Assessment of the yet to be published Agri-Food Strategy (DAFM, 2020[196]).

[7] As part of the obligations set out in the European Union's 2020 Energy and Climate Package and the 2030 Energy and Climate Framework, Ireland has committed to cut emissions from non-Emissions Trading Scheme sectors, including agriculture, by 20% by 2020 and by 30% by 2030 from 2005 levels (EPA, 2019[110]). However, emissions are predicted to be at best only 11% below 2005 levels in 2020 (Teagasc, 2019[192]).

[8] The 2019 Climate Action Plan has 180 economy-wide actions and many more sub-actions to achieve Ireland's emissions reductions in accordance with EU targets for 2030 (i.e. 30% reduction on GHG emissions based on 2005 levels).

[9] Recommendation 8.6 states *"Further expansion of the dairy herd will increase national emissions and may cause other environmental issues. Expansion is sustainable only if it takes place within a scenario in which overall agricultural emissions are declining. Accelerating decline in suckler cow numbers would be an important contribution to emissions reductions. Reductions should be facilitated by long-term and consistent supports and incentives to provide favourable environmental outcomes and alternative economic opportunities"* (Climate Change Advisory Council, 2019, p. 124[120]).

[10] An extensive literature review undertaken by the OECD found the MACC approach has limitations, and the cost-effectiveness of technical measures to mitigate GHG emissions in agriculture varied largely by location and farm type. This review also revealed there was a wide range of estimates for each mitigation practice investigated (MacLeod et al., 2015[107]).

[11] For a more detailed description of these programmes, see (OECD, 2020[145])

[12] Weaning efficiency is the calf weight at weaning relative to the cow's live weight (measured at 200 days of age) or the cost of getting the calf to weaning age. Higher live weights at weaning reduce the weight gain needed from weaning to slaughter, reducing feed costs.

[13] These mandatory requirements resulted from a review of the nitrates derogation plan undertaken by DAFM in 2019 (Government of Ireland, 2019[189]) (DAFM, 2019[101]) in advance of developing the fifth National Nitrates Action Programme (NAP) (2021-25) to implement the EU Nitrates Directive. The NAP sets annual limits on land application of manure and on levels of storage of livestock manure. These limits help prevent pollution of surface and ground water from agricultural sources. Limits also reduce N2O emissions and improve nitrogen use efficiency so contributing the reduction of GHG emissions.

[14] Farmers can farm at a 250 kg/ha livestock manure limit (beyond the usual limit under the EU Nitrates Directive of 170kg/ha annually) which in the Irish farming system is approximately three cows per ha rather than two cows, but farmers are required to meet certain conditions.

[15] To meet Ireland's requirements under the EU National Emissions Ceiling Directive (NECD) in November 2019 DAFM published a Code of Good Agricultural Practice for reducing Ammonia Emissions. Ammonia losses from slurry are significantly reduced by new protected fertiliser formulations, slurry application in the springtime and also the use of low emissions slurry spreading (LESS).

[16] Furthermore the Netherlands has committed to reduce its ammonia emissions from all sources by 13% between 2020 and 2029 and by 21% by 2030 (compared to 2005 levels) under its new NECD (2016) although it has already met these targets (Berkhout, 2019[187]). The Netherlands reduced its ammonia emissions by an average of-5.6% per annum over the period 1993-2005 and by an average of -2.4% per annum over the period 2003-15, making the largest average annual reductions per year of all OECD countries (OECD, 2019[61]).

[17] At the end of 2019, the Climate Plan was also presented to the European Commission as the Netherland's Integrated National Energy and Climate Plan (NECP).

[18] Under the new Essential Freshwater programme regulations are being introduced (MfE, 2020[173]). Public consultation on the proposed regulations was completed towards the end of 2019 (MfE, 2019[195]). Over 17 000 written submissions were received and while most supported the policy objectives, different views were expressed on how, and how fast, to meet them. New Zealand officials undertook further analysis to gain a more comprehensive understanding of their impacts of the proposals. An independent advisory panel was also set up to make recommendations to ministers alongside official advice.

[19] *He Waka Eke Noa* essentially translates to "we are all in this together".

[20] Including agricultural emissions in the New Zealand Emissions Trade Scheme (NZ ETS) is part of the 2017 Labour Party – Green Party agreement, while the 95% free allocation of emissions units upon entry of the sector to the NZ ETS is part of the Labour Party – NZ First Party Coalition Agreement (New Zealand Labour Party, 2017[194]; New Zealand Labour Party, 2017[193])

[21] The Climate Change Response (Zero Carbon) Amendment Act provides for the establishment of an independent Climate Change Commission to replace the Interim Climate Change Committee (which wound up in December 2019). The Commission is made up of a Chair and six Climate Change Commissioners, who are experts in climate science, adaptation, agriculture, economics, and the Māori-Crown relationship.

From:

Making Better Policies for Food Systems

Access the complete publication at:
https://doi.org/10.1787/ddfba4de-en

Please cite this chapter as:

OECD (2021), “The contribution of the ruminant livestock sector to the triple challenge”, in *Making Better Policies for Food Systems*, OECD Publishing, Paris.

DOI: https://doi.org/10.1787/5957da5a-en

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