

KEY MESSAGES OF CHAPTER 7

- The livestock sector should be part of any solution to climate change: its GHG emissions are substantial but can readily be reduced by mitigation interventions that serve both development and environmental objectives.
- There is a strong link between emission intensity and resource use efficiency. Most mitigation interventions will result in increased resource use efficiency along the sector's supply chains.
- Supportive policies, adequate institutional frameworks and more proactive governance are needed to fulfil the sector's mitigation potential and promote its sustainable development.
- Extension and capacity-building policies can facilitate the transfer and use of more efficient practices/technologies that are readily available. Financial incentives are important complementary policy tools, particularly for mitigation strategies that increase risks and costs to farmers.
- Research and development is vital for increasing the availability and affordability of effective mitigation options. Significant additional research is also needed to develop more accurate and affordable measurement methods, to demonstrate success through piloting and provide new technologies for mitigation.
- Practices/technologies that mitigate by improving production efficiency are key to mitigation interventions in least affluent countries, as they can minimize trade-offs between mitigation, food security and rural livelihoods.
- Efforts should be pursued to ensure that existing provisions and rules at regional, national and international levels, within and outside the UNFCCC, provide stronger incentives to mitigate livestock sector emissions and ensure that efforts are balanced through the different sectors of the economy.
- Recent years have seen interesting and promising initiatives by both the public and private sectors to mitigate the sector's emissions, and, more generally, to address sustainability issues.
- Due to the size and complexity of the global livestock sector, concerted and global action by all stakeholder groups (including producers, industry associations, academia, the public sector, intergovernmental organizations, and non-governmental organizations) is needed to design and implement cost-effective and equitable mitigation strategies and policies.



IMPLICATIONS FOR POLICY-MAKING

Livestock matters to climate change. The sector contributes 7.1 gigatonnes CO₂-eq to global anthropogenic GHG emissions – a contribution that can be readily reduced by up to one-third – placing the sector as an integral part of any solution to climate change.

Supportive policies, adequate institutional frameworks and more proactive governance are needed to fulfil the sector's mitigation potential, and promote its sustainable development.

Livestock plays a critical role in achieving food security, especially in harsh agro-environmental environments; however, its growth and the related use of natural resources are mostly driven by urban consumers in emerging economies. With demand for livestock products projected to grow by 70 percent by 2050, concerns about the unbalanced nature of this growth and its attendant environmental and socio-economic consequences are increasing. To date, most of the increase in demand has been met by rapidly growing, modern forms of production while hundreds of millions of pastoralists and smallholders, who depend on livestock for survival and income, have little access to emerging opportunities for growth. In addition, there is increasing concern about the impact of production growth on natural resources of which the sector is a large user; it is, for example, the world's largest user of agricultural land.

Policy-makers need to focus on mitigation strategies that serve both development and environmental objectives. Much of the mitigation potential in the sector is achievable by using available practices that improve production efficiency, which can reduce emissions while supporting social and economic goals such as food security and income generation; (Box 4 summarizes the main emission reduction strategies identified in this assessment). In turn, mitigation policies that focus on strategies that are able to deliver private benefits, are likely to enjoy greater success and uptake.

This chapter explores where the main available mitigation strategies can be used, and which policies could support their adoption. The role that existing policy frameworks at international and country levels currently play is also discussed, along with options for accelerating mitigation in the livestock sector.

7.1 A BRIEF DESCRIPTION OF MITIGATION POLICY APPROACHES

Mitigation policy approaches available to policy-makers are not unique to climate change or to livestock; they are broadly the same for most environmental management and development issues:

- *Extension and agricultural support services:* this suite of approaches facilitates practice

BOX 4. MAIN EMISSION REDUCTION STRATEGIES

While mitigation interventions will obviously need to be tailored to local objectives and conditions, broadly defined available mitigation options can be recommended for monogastrics and ruminants:

- Interventions for ruminant production:
 - *at animal level*: optimize feed digestibility and feed balancing, achieve better animal health, and improve performance through breeding.
 - *at herd level*: reduce the proportion of the animals in the herd dedicated to reproduction and not to production. This can be achieved by improving feeding, health and genetics (all having an effect on fertility, mortality and age at first calving), but also through herd management practices aimed at reducing age at first calving, adjusting slaughtering weights and ages, and adjusting replacement rates in the dairy herd.
 - *at production unit level*: In grazing systems: improve grazing and grassland management to increase feed quality and carbon sequestration. In mixed systems: improve the quality and utilization of crop residues and fodder, enhance manure management.
 - *at supply chain level*: increase the relative beef

production supplied by herds producing both meat and milk, adopt energy efficient practices and equipment, encourage waste minimization along supply chains.

- Interventions for monogastric production:
 - *at animal level*: improve feed balancing, animal health and genetics to increase feed conversion ratios and reduce N and organic matter excreted per unit of product.
 - *at production unit level*: produce or source low emission intensity feed (reducing land-use change arising from feed production, improving crop fertilisation management as well as the efficiency of energy use in feed production and processing), adopt energy efficient practices and equipment, and enhance manure management.
 - *at supply chain level*: foster energy efficiency and use of low emission intensity energy, reduce waste generation along supply chains and increase recycling.

change for mitigation and development by providing access to improved practices/technologies, knowledge and capacity for their application, and information about emerging market opportunities. Commonly used approaches include communication, training, demonstration farms and networks to facilitate linkages among sector stakeholders.

- *Research and development*: research and development is necessary to build the evidence base for mitigation technologies/practices. It can play an important role in refining existing technologies/practices to increase their applicability and affordability, and is also

necessary for increasing the supply of new and improved mitigation technologies/practices.

- *Financial incentives*: includes either ‘beneficiary pays’ mechanisms (abatement subsidies) or ‘polluter pays’ mechanisms (emissions tax, tradable permits). These are economically efficient mechanisms for incentivizing the adoption of mitigation technologies/practices.
- *Regulations*: includes assignment of mitigation targets for farmers/sectors, as well as more prescriptive approaches such as mandating the use of specific mitigation technologies and practices.

- *Market friction instruments*: includes instruments that seek to increase the flow of information about the emissions associated with different livestock commodities (e.g. labelling schemes). This can help consumers and producers to better align their consumption and production preferences with the emission profiles of these commodities.
- *Advocacy*: includes the raising of awareness about livestock's role in tackling climate change to influence and promote mitigation policy development for the sector (e.g. through intergovernmental representation of this issue in the UNFCCC negotiation process).

In line with the mitigation assessments in this report, this chapter focuses on policies to support supply-side mitigation options. While demand-side mitigation approaches that directly target consumers of livestock products are also important, they are considered not within the scope of this report.

7.2 TARGETING OF MITIGATION POLICIES

The potential to mitigate GHG emissions exists in all subsectors and regions. While more research is needed to better understand this mitigation potential, the emission profiles developed in this assessment provide a first indication of where mitigation policies might be targeted. For instance, policies may have the largest impact if they target sectors and regions where emission levels and emission intensities are the highest.

Subsectors with high emission intensities

Mitigation policies focusing on the high emitting ruminant sectors, particularly in least affluent countries, could have the highest impact. Emission profiles show that cattle alone account for two-thirds of the sector's emissions. When all ruminants are considered together, this share increases to 80 percent. At the global level, specialized beef meat production is most emission-intensive (67.8 kg CO₂-eq), followed by small ruminant meat (23.8 kg CO₂-eq) and dairy meat (18.4 kg CO₂-eq), and the emission intensities

are consistently lower in most affluent countries. Monogastric production not only contributes a smaller share of total emissions, it is also much less emission intensive: the average emission intensities of chicken and pig meat are 5.4 kg CO₂-eq and 6.1 kg CO₂-eq, respectively.

Subsectors with high emission levels

Mitigation policies focusing on subsectors where emissions intensities are comparatively low but absolute levels of emissions are high would also be highly effective. In these situations, small additional reductions in emission intensity can still yield sizeable mitigation outcomes. This is, for example, the case for milk production in OECD countries and pork production in East Asia.

Hot spots along the supply chains

Policies targeting emission "hot spots" along the sector's supply chains would also likely be more effective. For example, the analysis highlighted the importance of emissions from energy consumption along the chains as an important source of emissions (about one-third of total emissions in pork supply chains). Incentives to increase the sourcing of low emission intensity energy and improve energy use efficiency could, therefore, be an effective mitigation option for this subsector.

The LCA approach, which makes it possible to trace emission sources related to all facets of livestock production, can help identify "hot spots" to customize and target policies accordingly.

Further analysis required on mitigation potential

Naturally, the presence of high emissions in a particular sector or region does not guarantee that mitigation policies targeting these sectors will be effective. Further technical analyses are needed to assess the potential for mitigating these emission sources.

The effectiveness of mitigation policies will also depend very much on barriers to adoption, particularly in the ruminant sectors of less affluent countries where much of the global mitigation potential is found. These barriers include investment

and other adoption costs, capacity constraints and risk. In the following sections, these issues and their impact on policy design are discussed within the context of the main mitigation strategies identified in Chapter 6. Further research to overcome these barriers and identify mitigation strategies and policies that can deliver environmental, social and economic benefits will be essential to achieving the mitigation potential of the livestock sector modelled in this study.

7.3 MAIN MITIGATION STRATEGIES AND THEIR POLICY REQUIREMENTS

Closing the efficiency gap

GHG emissions represent losses of energy, nitrogen and organic matter for the livestock sector (Chapter 4). There is thus a strong link between emission intensity and resource use efficiency, and most mitigation interventions will result in increased resource use efficiency along the sector's supply chains.

As a result, the large mitigation potential that can be found in closing the gap between the producers with highest emission intensity and those with the lowest (Chapters 5 and 6) can be achieved by the transfer and use of existing technologies that increase production efficiency. Several types of policies can support the effective transfer of technologies and practices.

Policy requirements

Policies fostering knowledge transfer

Policies targeting knowledge transfer are particularly important for stimulating the adoption of efficient technologies and good management practices by farmers. For example, extension activities can be used to facilitate change in practices by providing access to knowledge and improved practices and technologies. These may include farm visits by extension agents, the establishment of demonstration farms, farmer field schools and farmer networks to promote peer-to-peer knowledge transfer, sector roundtables and the brokering of linkages among sector participants. Ex-

tension activities need a coherent and integrated approach to building sector capacity in order to ensure the successful application of existing and new mitigation practices. There is also a role for policies to create and enhance enabling conditions for the transfer of technologies, including infrastructure development and the strengthening of supporting technical institutions.

Enabling conditions for technology transfer and innovation

Generally, innovation is driven by entrepreneurs pursuing market opportunities (World Bank, 2006), and knowledge and technologies seem to work best when their introduction is complemented by infrastructure and institutional development, partnerships and policy support (IFPRI, 2009). Research and development can play an important supporting role by generating knowledge and evidence about technologies and practices, giving farmers and practitioners greater confidence about their mitigation effectiveness and production impacts. Pilot projects to test the effectiveness and feasibility of novel technologies and practices in different agro-ecological and socio-economic contexts are an important part of this strategy. So, too, are regulations and economic policies to direct research, development and the diffusion of new technologies along livestock supply chains.

Removing barriers to and creating incentives for efficiency improvement

Financial instruments, such as low interest loans and microfinance schemes, may be needed to complement extension policies and support the adoption of new technologies and practices. These instruments are required when practices require upfront investments and their adoption is constrained by ineffective or missing capital markets and financial services, which is a common constraint to technology use in developing country contexts. These types of instruments may therefore be required even where the mitigation options promoted are profitable and producers are willing to bear the costs related to technology transfer.

There may also be other barriers to adoption, including producer aversion to change and increased risks associated with adoption, as well as opportunity costs for adopting mitigation practices instead of other investments that farmers may be contemplating. These factors will increase the minimum rate of return producers would be willing to accept before investing in these mitigation practices and will require higher levels of support and incentives.

This may include subsidies to support the adoption of more efficient technologies and practices that may not be profitable for all farmers. Mitigation subsidies can be designed to cover part (e.g. cost-sharing mechanisms) or all of the mitigation costs incurred by farmers. Subsidy instruments may stand alone (i.e. funded by government), or they may be supplied through offset schemes where these mechanisms exist (e.g. the Clean Development Mechanism and the Carbon Farming Initiative in Australia).³⁷

Policy-makers need to pay close attention to the constraints faced by farmers in differing socio-economic contexts. Livestock supply chains are heterogeneous and face differing adoption constraints and challenges. This is particularly true in developing countries where there is often a continuum of farmers ranging from those who operate in poorly functioning markets (for inputs, outputs, credit and land) whose main motivation is subsistence, to those who specialize in livestock and are integrated into more economically efficient markets. The transfer of practices and technologies through the use of extension and policy incentives is much more likely to be effective for the latter group than for subsistence farmers, who will often be unable to obtain the same economic returns from adoption (Jack, 2011). Mitigation policies must, there-

fore, be tailored to match the differing motivations and market contexts of farmers.

Additional research on costs and benefits of mitigation practices

Significant additional research is needed to further assess the costs and benefits of mitigation practices, to help policy-makers understand which policy options are better placed to incentivize their uptake.

Only a handful of GHG mitigation assessments have explored the economics of practices that improve production efficiency (including USEPA, 2006; Beach *et al.*, 2008; Moran *et al.*, 2010; Schulte *et al.*, 2012; Whittle *et al.*, 2013; Smith *et al.*, 2007; McKinsey, 2009; Alcock and Hegarty, 2011). While a significant share of these practices is estimated to be profitable, findings vary considerably, depending on which mitigation options are assessed and which species and regions they are applied to. For example, genetic alterations to beef and dairy cattle to improve production and fertility have been estimated to be profitable in the United Kingdom of Great Britain and Northern Ireland (Moran *et al.*, 2010), as have genetic improvements for beef cattle in Ireland (Schulte *et al.*, 2012), and breeding for higher ewe fecundity in some sheep enterprises in Australia (Alcock and Hegarty, 2011). Conversely, some feeding and grazing strategies for improving herd efficiency were estimated by USEPA (2006) to be profitable in some cases (e.g. intensive grazing for cattle in the United States of America and Brazil), but prohibitively expensive in others (e.g. concentration inclusion in dairy cattle diets in the People's Republic of China). More systemic research is needed to provide a more consistent understanding of the costs and benefits of these practices in different production contexts.

Policies required to address potential risks

Constraints on sector emissions

Policies to constrain sector emissions may be needed when efficiency improvements cause production to expand and thus induce higher emissions. For example, some efficiency enhanc-

³⁷ While it is also possible to incentivize the adoption of mitigation practices with a financial penalty such as an emission tax (based on the 'polluter pays' principle), this is likely to be a politically unpopular policy approach which, to the authors' knowledge, has not been used to regulate agricultural GHG emissions before. Moreover, financial penalties would reduce farm incomes and increase food prices, and possibly exacerbate hunger and poverty in developing countries where emission intensities and, therefore, the financial penalties imposed by such policy instruments, would be the highest.

ing practices may create incentives for farms to increase their herd size, if doing so allows them to extract higher returns on their investments. Alcock and Hegarty (2011) argue that such incentives arise when ruminant producers invest in pasture improvement. The same issue is present on the industry scale, where mitigation practices that increase profits (either because the practices are themselves profitable or because incentive policies make them profitable), can attract new entrants to industries, increasing output and potentially also emissions (Perman *et al.*, 2003). These mitigation options may, therefore, be more effective if countries choose to introduce supporting policies to constrain emissions in the sector (e.g. through tradable or non-tradable emission permits).

Regulations on land use clearance

Regulations to prevent land use clearing may be needed when efficiency improvements lead to production expansion and further land clearance for pasture or crop production. Improvements in production efficiency can have strong ramifications for land-use change, because they can lower the amount of inputs required, including land for grazing and feed production, to produce any given level of output. In this respect, farm efficiency improvements can be considered a necessary condition for preventing the conversion of forest land into agriculture land for livestock. But again, where efficiency improvements are profitable, it is possible that their adoption can lead to an expansion in production and land use. However, it is difficult to assess and anticipate the net direction of land-use change following such improvements (Lambin and Meyfroid, 2011; Hertel, 2012). Given this uncertainty, supporting regulations to prevent land use clearing would help to safeguard against cases where improvements in production efficiency might unexpectedly encourage deforestation.

Safeguards against potential negative side-effects

Production efficiency improvements can provide environmental co-benefits, in addition to GHG

mitigation, by lowering the natural resource requirements of the livestock sector. However, policy safeguards ought to be used to avoid negative environmental (e.g. soil and water pollution from animal wastes), animal welfare and disease side-effects, where productivity improvements lead to land intensification (i.e. a move towards greater animal confinement and importation of higher energy feeds). One example of such a safeguard is the European Union's integrated pollution and control directive³⁸ which, among other things, requires producers to obtain a permit to establish piggeries with more than 750 breeding sows. This permit requires the producers to comply with environmental criteria such as treatment of waste, distance to settlements and water flows, and ammonia emissions. Ethical concerns about animal welfare may also introduce important trade-offs with measures to enhance production efficiency.

Loss of non-food goods and services

A single-minded focus on production efficiency can introduce trade-offs with other livestock services that are important in more traditional farming systems. Developing country farmers often keep some animals for non-food production functions, including risk mitigation, financial services, draught power and provision of manure for crops. Efficiency improvements that are based solely on saleable commodities could result in lower herd sizes in some cases, and thus reduce some of their ancillary services (Udo *et al.*, 2011). Unless they are able to be cost-effectively substituted with mechanization, use of artificial fertilizers, and banking and insurance systems, these lost services would be detrimental to farm household livelihoods.

Grassland carbon sequestration

Grazing land and pasture management practices that increase soil carbon stocks can significantly mitigate CO₂ emissions and may present opportunities for profitable investment in mitigation.

³⁸ Directive 2010/75/EU of the European Parliament and of the Council, 24 November 2010.

Recent global modelling work led by FAO estimates that an annual carbon sequestration potential of 409 million tonnes CO₂-eq is possible in just over one billion ha of the world's grassland area (Chapter 5). In 46 percent of this area, this can be achieved by increasing both grazing pressure and grass consumption. And in a further 31 percent of this area, reducing grazing pressure was shown to increase grass production and consumption. In addition to mitigating CO₂ emissions, these practices increase soil health and grass production and provide environmental co-benefits (e.g. biodiversity and water quality), particularly where the restoration of degraded grasslands is involved.

Further research

Further research is needed before this strategy can be supported on a large scale. While there is relatively abundant experimental and modelling evidence demonstrating the effectiveness of this strategy in some locations, there is a paucity of pilot projects and economic assessments which are needed to support the design of technical itineraries and to verify the long-term viability of this strategy. Concerns relate to the permanence of the sequestration of carbon in grassland, which is conditional on long-term management practices and climate (Ciais *et al.*, 2005); for example, the loss of soil carbon stocks in European grasslands have been observed in cases of severe drought. The sequestration process is also likely to face saturation levels that will limit the sequestration rates over the long term. Thus, there is a strong case for research and development policies to further assess mitigation potentials and develop appropriate institutional frameworks for underpinning the application of carbon sequestration practices in grasslands on a landscape scale over the long term.

Measurement methodologies

Further efforts are needed to develop and improve measurement methodologies. Compared with other mitigation strategies, soil carbon sequestration faces stronger challenges related to measurement. Direct measurement of soil carbon

stocks requires soil sampling which, on a landscape scale, can be prohibitively expensive (FAO, 2011a). Methodologies for estimating changes in soil carbon stocks, based on the measurement of management activities, are being developed to improve the affordability of measuring carbon sequestration at a landscape scale (VCS, 2013), but further research is needed before policy-makers, farmers and carbon market participants alike can confidently invest in this mitigation strategy.

Non-permanence risks

Another challenge for implementing grassland soil carbon sequestration projects and policies is the risk of non-permanence; the risk that sequestered carbon is later released into the atmosphere if sustainable management practices cease. This can be caused by the conversion of grassland to arable lands or the resumption of unsustainable grazing practices. By contrast, reductions in supply chain GHG emissions are permanent and therefore do not face non-permanence risks.

The implications of carbon stock measurement challenges and non-permanence risks for the eligibility of carbon sequestration in existing policy frameworks, at international and national levels, are explored later in this chapter.

Institutional innovations on land tenure

Given that the viability of carbon sequestration practices depends on being able to establish them on a landscape scale, institutional innovations are needed for equitably aggregating individual household's carbon assets, in ways that allow both the community and individual households to derive benefits from soil (Tennigkeit and Wilkes, 2011). Land tenure can also present significant challenges for carbon sequestration practices in grasslands, particularly in the many rangeland areas that are communally managed without clear ownership or access entitlements. In these situations, there can be difficulties in establishing improved management practices, in the ownership of soil carbon assets, and in the ongoing monitoring of practices to manage non-permanence risks.

Extension, financial and regulatory incentives

Policies based on extension and financial and regulatory incentives will also play an important role in stimulating the adoption of grazing management practices. Again, the economic attractiveness of the various practices for enhancing soil carbon stocks will help to inform which combination of these policies is better placed to support these practices.

Sourcing of low emission intensity inputs

Input production is often an important source of emissions. This is particularly true for feed which contributes significantly to emissions, especially for monogastric production where it accounts for about 60 percent and 75 percent of all pig and chicken emissions, respectively. The main feed emissions are N₂O from fertilization (with manure or synthetic fertilizers) and CO₂ from land-use change. Energy is a further input associated with high emissions in monogastric systems and different energy sources also have different emission intensities. Therefore, producers could also mitigate by switching to less emission intensive energy sources.

The LCA framework is an extremely useful instrument for supporting the sourcing of low emission intensity inputs by producers, because it can trace supply chain emissions that are embodied in production inputs. The LCA framework can also be used to design sourcing strategies that have an overall mitigation effect and avoid unintended increases in emissions upstream and downstream of the livestock supply chains. For example, enteric emissions from ruminant animals can be lowered by increasing the proportion of high digestibility feeds in their feed rations. However, if the production of these feeds results in high emissions, then their inclusion in feed rations can cause total livestock supply chain emissions to increase (Vellinga and Hoving, 2011).

Policy requirements

Policies are needed to encourage producers to mitigate their emissions by switching to low

emission intensity feeds, energy and other inputs. These policies include labelling and certification schemes to inform livestock farmers about the emission profiles of these inputs. The schemes will naturally be more effective when coupled with stronger policies to incentivize farmer purchases of low emission inputs and regulate the use of very high emission intensity feeds. Such policies could help to lower crop sector emissions, particularly where there is an absence of mitigation policies in the crop sector.

Adapting accounting rules

Emission accounting rules, such as those specified for the UNFCCC national GHG inventories, would present challenges for the input sourcing as a mitigation strategy (the UNFCCC framework is discussed in Chapter 7).

For example, emission reductions from cutting back on imported high emission feed would not be eligible for the importing country under these accounting rules; and national governments are unlikely to implement policies that do not contribute to their national mitigation targets. Similar obstacles would be present at the sectoral level within a country (Schulte *et al.*, 2012) because the same accounting rules assign upstream emissions to the sectors producing those inputs (e.g. reduced feed emissions are assigned to the crop sector).

In these cases, international and intersectoral policies and supply chain accounting rules that can assign emission reductions upstream of the farm to the livestock sector would be needed. Governments might be flexible about which national sectors are credited with emissions, as long as they can still count towards meeting their national mitigation goals. However, crediting domestic sectors with emission reductions located abroad will be more problematic.

The choice between regulating emissions at the livestock farm level or upstream in the energy or crop sector of origin will also have an effect on the coverage and cost-effectiveness of the policy. Naturally, a policy that targets all livestock and crop farm emissions will cover more emissions than

one that excludes the non-feed part of crop sectors' emissions. However, it may be more pragmatic to apply the mitigation policy to livestock farms only because, by engaging a smaller number of producers, administrative costs for government and firms might be lower.

Need for information on emission intensity of inputs

It is likely that efforts to reduce the life cycle emissions of animal products will be driven by supermarkets and consumers more than by governments, for the reasons explained above. As discussed, labelling and certification programmes can help to incentivize mitigation by informing consumers (including livestock producers as consumers of input products such as feed and energy) about the emission attributes of products at different stages along livestock supply chains. The success of these programmes will largely depend on having broadly accepted metrics and methods to compute emissions and reasonably accurate information about the emission intensities of inputs and products. An emission quantification framework, such as the one developed by the LEAP,³⁹ could fill this need by guiding low-emission, input-purchasing decisions by livestock producers.

Technological breakthroughs

Although the adoption of advanced mitigation technologies and practices that are still under development were not assessed in Chapters 5 and 6, it is very likely that high additional mitigation potential can be achieved through new technological developments.

Research and development

Pursuing a research and development strategy could accelerate the availability of promising options. There is a range of mitigation options that have high potential, but require further testing and development before they can be considered viable. A prime example is the use of anti-meth-

anogen vaccines which is very promising due to their wide applicability across all ruminant systems, including in some grazing systems where there is minimal contact between animals and livestock farmers (FAO 2013c). According to some studies (USEPA, 2006 and Whittle *et al.*, 2013), if this technology was further developed and made commercially available it would have the potential to be a relatively low-cost mitigation option. Other promising options, which also require additional research and development, include the genetic selection of cattle with low (enteric CH₄) emissions, and the use of nitrates as mitigating agents in animal diets (FAO, 2013c).

Financial and regulatory incentives

Further, while research and development initiatives are essential for the provision of new and improved mitigation options for the sector, financial and regulatory incentives can also drive mitigation technology development by the private sector. By making emissions costly or mitigation profitable, these policies will motivate the livestock industry to search for and develop less emission-intensive practices and technologies.

Supportive policies for adoption of new technologies and practices

Naturally, the same policy approaches that were outlined to support the transfer and use of existing mitigation options will also be needed to support the adoption of new practices/technologies once they become available.

7.4 EXISTING POLICY FRAMEWORKS FOR MITIGATION THROUGH LIVESTOCK

While research into practices and technologies for the mitigation of agricultural emissions has matured into a large body of valuable work, there has been much less progress in developing effective mitigation policies. At the global level, mitigation policies for all sectors, including agriculture, is primarily driven by the Kyoto Protocol to the UNFCCC. There are also regional, national and subnational policies and programmes for livestock

³⁹ www.fao.org/partnerships/leap

that are both linked to and independent from the Protocol. However, the mitigation incentives that are currently provided by this collection of policies and programmes are quite weak.

This section presents a summary of existing mitigation policy frameworks that are relevant to the livestock sector.

The Kyoto Protocol

The Kyoto Protocol to the UNFCCC establishes legally-binding mitigation targets for developed country signatories. However, there are some major limitations to the effectiveness of the Protocol. The first is that not all of the Protocol's Annex I⁴⁰ countries (affluent countries) are party to the Protocol. The largest of these is the United States of America which has never ratified the Protocol. Canada withdrew in 2011, while Japan, New Zealand and the Russian Federation have not committed to targets in the Protocol's second commitment period (2013-2020). Second, the Protocol does not impose legally binding targets on non-Annex I countries (low income countries). As a consequence of these limitations, the 37 Annex I countries that have binding targets in the Protocol's second commitment period (2013-2020), accounted for a paltry 13.4 percent share of global anthropogenic GHG emissions in 2010 (UNEP, 2012). With regard to livestock, these countries accounted for a similarly low 16 percent share of direct⁴¹ global emissions from livestock in 2005.⁴²

Another limitation is that only two Annex I countries, namely Denmark and Portugal, have elected to report carbon stock changes associated

with grazing land management under Article 3.4 of the Kyoto Protocol. All the other countries preclude it from their national GHG inventories and national mitigation targets. The challenges with measuring carbon stock changes and non-permanence risks contribute to countries' reluctance to nominate this as an eligible mitigation source.

The role of carbon markets

Carbon markets, in which carbon emission permits and reductions can be traded, have been put in place by a number of countries and jurisdictions to curb GHG emissions. Putting aside the lack of concerted political commitment to reduce emissions, which affects the penetration of all mitigation policies alike, Newell *et al.* (2011) report that carbon markets have, in general, functioned reasonably well, and are slowly growing rather than shrinking.

Despite this progress, carbon markets currently provide very limited mitigation incentives for the sector. They either do not include livestock sector emissions or provide only a limited coverage. This is partly due to difficulties in accurately and cost-effectively measuring emission reductions. However, with continued research and development to improve measurement methodologies and the ongoing evolution of market-based instruments, the role of carbon markets should increase over the long term.

Kyoto Protocol-compliant carbon market mechanisms

Countries with binding targets under the Kyoto Protocol can determine the suite of policies they use to meet these targets. To date, very few carbon market mechanisms have been established at the national or international levels. These include the EU Emission Trading Scheme, the Australian Carbon Pricing Mechanism and the New Zealand Emission Trading Scheme.

The volume and value of emissions traded on the Kyoto-compliant markets as a whole grew by 114 percent and 31 percent, respectively, between

⁴⁰ The United Nation Framework Convention on Climate Change divides countries into three main groups according to differing commitments: Annex I Parties include the industrialized countries that were members of the OECD in 1992, plus countries with economies in transition. Non-Annex I Parties are mostly developing countries. Certain groups of developing countries are recognized by the Convention as being especially vulnerable to the adverse impacts of climate change, including countries with low-lying coastal areas and those prone to desertification and drought. Annex II Parties consist of the OECD members of Annex I, but not the economies in transition Parties.

⁴¹ Enteric CH₄ and manure-related N₂O and CH₄ emissions.

⁴² Estimated using the GLEAM model, but based on UNFCCC inventory accounting rules for livestock.

2008 and 2011. (Peters-Stanley and Hamilton, 2012; Hamilton *et al.*, 2010). The volume and value of emission allowances traded in the EU Emission Trading Scheme, the world's largest and most liquid carbon market, grew by 153 percent and 47 percent, respectively, over the same period. However, the combined effects of the current global recession and lower than projected emissions have caused an oversupply in EU emission allowances, and prices have been falling since 2008 (Newell *et al.*, 2012).

Furthermore, these market-based mechanisms have not played a role in the mitigation of livestock emissions because none of them includes agriculture, except for the Carbon Pricing Mechanism in Australia which is linked to a carbon offset scheme known as the Carbon Farming Initiative.

Clean Development Mechanism (CDM)

The Clean Development Mechanism (CDM), established under the Kyoto Protocol, is an offset scheme that allows developed countries to meet their national mitigation obligations by funding mitigation projects in developing countries. While all the main mitigation sources from the livestock sector can be included in the CDM projects, this instrument offers limited opportunities for livestock emissions mitigation.

The trade of certified emission reductions derived from carbon sequestration on agricultural lands is not permitted in compliance markets such as the EU Emission Trading Scheme; and these regulations effectively prevent demand for soil carbon sequestration projects in the CDM (Larson *et al.*, 2011). While projects that reduce enteric and manure emissions do not face this obstacle, the only livestock projects that have been registered are manure management projects related to biogas use and reduction. This reflects the fact that there are fewer implementation and measurement issues for practices that reduce CH₄ emissions from stored manure than there are for other livestock mitigation practices. There are currently 193 manure management projects registered un-

der the CDM, with an estimated annual mitigation potential of 4.4 million tonnes CO₂-eq.⁴³

High transaction costs due to the design of the CDM, measurement challenges and the frequent need to coordinate actions of multiple land users are reported as an obstacle to the establishment of agricultural land use projects in the CDM (Larson *et al.*, 2011). These factors raise the costs of participation in the CDM, particularly for smallholders.

While Larson *et al.* (2011) have reported that the CDM as a whole was on track to exceed its initial expectations, an oversupply of CDM credits combined with concerns about their credibility and restrictions on the use of CDM credits in the EU Emission Trading Scheme caused a large fall in credit prices at the end of 2012, casting some doubt over its future (Newell *et al.*, 2012; Marcu, 2012, Wilkes *et al.*, 2012).

Voluntary carbon markets

Contrary to Kyoto-compliant markets, voluntary carbon markets offer widespread eligibility of livestock sector mitigation options, including soil carbon sequestration. However, with a low supply of credits, transactions related to the sector have so far been very limited.

The voluntary carbon market is small compared with the Kyoto-compliant market.⁴⁴ In 2011, a volume of 95 million tonnes CO₂-eq was transacted in the world's voluntary carbon markets, compared with 131 million tonnes CO₂-eq and 94 million tonnes CO₂-eq, in 2010 and 2009, respectively (Peters-Stanley and Hamilton, 2012; Peters-Stanley *et al.*, 2011; Hamilton *et al.*, 2010). In 2009, close to half of all transactions took place on the

⁴³ This figure was estimated by summing the emission reductions, stated by project participants, from each individual project accessed through the CDM online registry. See <http://cdm.unfccc.int/Projects/projsearch.html>.

⁴⁴ In 2011, the value of transactions on the voluntary carbon market was worth US\$576 million, compared with US\$3.3 billion in the primary CDM market, and US\$147.8 billion for the European Union's Emission Trading Scheme (ETS). In terms of CO₂-eq quantities, the voluntary market transacted 95 million tonnes CO₂-eq compared with 291 million tonnes CO₂-eq in the primary CDM market and 7 853 CO₂-eq in the European Union's ETS (Peters-Stanley & Hamilton, 2012).

Chicago Climate Exchange (CCX)⁴⁵ (Hamilton *et al.*, 2010). However, with the closure of the CCX in 2010, over-the-counter (OTC)⁴⁶ transactions picked up the slack and their share of transactions dramatically increased to 97 percent.

Credits from agricultural soil projects have typically comprised a small share of total OTC transactions, ranging from 0 to 3 percent between 2009 and 2011. OTC transactions of livestock CH₄ credits have also accounted for relatively small shares, ranging between 2 percent and 4 percent over the same period. On the other hand, credits linked to reduced deforestation accounted for larger shares of between 7 percent and 29 percent in this period (Peters-Stanley and Hamilton, 2012; Peters-Stanley *et al.*, 2011; Hamilton *et al.*, 2010).

A major constraint to the supply of soil carbon credits in voluntary markets is the lack of robust accounting methodology for CO₂ removals from grassland activities. Two methodologies have been validated for this purpose under the Verified Carbon Standard (VCS), which is the most commonly applied standard, covering 43 percent of all voluntary carbon market credits in 2011 (Peters-Stanley and Hamilton, 2012); although it is not clear that either of these are suitable for the cost-effective measurement of sequestered carbon on the landscape scale. FAO is developing a VCS methodology which, at the time of writing, is undergoing its second and final independent validation. Once validated, this methodology, which relies heavily on the use of biogeochemical modelling to lower soil sampling requirements, will provide a cost-effective solution to the measurement of soil carbon stock changes in grasslands on a large scale.

In addition to the limitations and uncertainties raised about carbon markets in the above section on compliance markets, carbon sequestration projects on agricultural lands face greater obsta-

cles than other types of agricultural mitigation projects when engaging with market mechanisms. Concerns about the permanency of carbon sequestration and the credibility of related credits increase the complexity of accounting rules and reduce demand for these credits (Larson *et al.*, 2011). This issue, combined with the greater challenges of measurement and coordination, particularly where land is communal or where there are open access tenure arrangements, can make soil sequestration projects less attractive to investors.

Nationally Appropriate Mitigation Actions (NAMAs)

Nationally Appropriate Mitigation Actions can provide further incentives for mitigation but, so far, the inclusion of the livestock sector has been fairly limited. NAMAs include voluntary policies and actions to be undertaken by non-Annex I Parties to the Kyoto Protocol to reduce GHG emissions, which may be funded domestically or by industrialized countries.

As part of the Copenhagen Accord, non-Annex countries were invited to communicate information on NAMAs at the 15th session of the Conference of the Parties to the UNFCCC (COP 15) in 2009. A number of countries responded and provided information to the UNFCCC Secretariat on their proposed targets and actions. Among the NAMAs submitted to date, only six countries have explicitly included livestock as part of their mitigation strategy (Brazil, Chad, Jordan, Madagascar, Mongolia and Swaziland). Of these, only Brazil has submitted a quantitative target (Box 5).

National GHG inventories

While not a policy instrument per se, accurate national GHG inventories established in accordance with the IPCC Inventory Guidelines (IPCC, 2006), provide critical support for national mitigation policies by establishing GHG emission baselines for sectors and for identifying possible emission reduction pathways (Smith *et al.*, 2007). The IPCC guidelines provide methods for estimating emissions by sources and removals by sinks for differ-

⁴⁵ CCX operated as a cap and trade programme, with an offset component, between 2003 and 2010. It was relaunched as the Chicago Climate Exchange Offsets Registry Program in 2011, but trade levels have remained very low since 2010.

⁴⁶ OTC transactions refer to the decentralized private exchanges in which buyers and sellers interact directly through a broker or an online retail "storefront" (Peters-Stanley and Hamilton, 2012).

BOX 5. BRAZIL'S NAMA AND PROGRESS IN ITS LIVESTOCK SECTOR

In its NAMA submission, Brazil has taken a global leading role in the mitigation of GHG emissions from the livestock sector, committing to a range of ambitious mitigation targets over the ten-year period from 2011 to 2020.¹ These include actions to directly reduce livestock sector GHG emissions and increase removals in grasslands: restoring grazing land (estimated reduction: 83–104 million tonnes CO₂-eq by 2020); and integrating crop-livestock farming (estimated reduction: 16–20 million tonnes CO₂-eq by 2020).

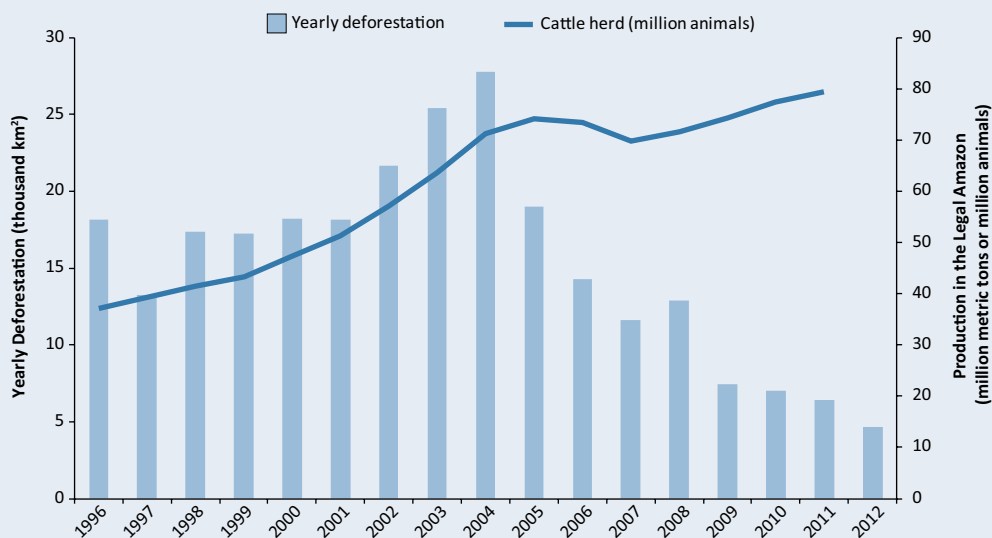
In its NAMA, Brazil also committed to a range of actions that will have an indirect but still substantial mitigation impact for its livestock sector, either by limiting deforestation that may be attributed to the sector, or by increasing mitigation in areas that are devoted to feed production for the sector. These actions include:

- reducing deforestation in the Amazon (estimated reduction: 554 million tonnes CO₂-eq by 2020);
- reducing deforestation in the Cerrado (estimated reduction: 104 million tonnes CO₂-eq by 2020);

- no-till crop planting (estimated reduction: 16–20 million tonnes CO₂-eq by 2020); and
- biological fixation of N (estimated reduction: 16–20 million tonnes CO₂-eq by 2020).

In support of these pledges, the Brazilian government established the ABC programme, which provides a credit line for special loans to finance various mitigation practices outlined above, as well as from animal waste treatment, which is estimated to generate a further 6.9 million tonnes CO₂-eq in emission reductions by 2020. The ABC programme has an estimated a budget of R\$197 billion.²

While large future gains in mitigation in livestock are anticipated from the ABC programme, strong recent growth in cattle productivity has already allowed Brazil to increase the size of its cattle herd in the face of declining rates of deforestation in the Legal Amazon, since 2004.



Source: IPAM apud. Bastos, 2013.

¹ http://unfccc.int/files/meetings/cop_15/copenhagen_accord/application/pdf

² <http://www.agricultura.gov.br/desenvolvimento-sustentavel/plano-abc>

ent sectors, including livestock, that vary according to their degree of complexity. Using the simplest Tier 1 methods, default emission factors can be applied to total numbers of animals, which vary by species and according to which broad region they are located in and, in the case of manure emissions, according to annual average temperatures. While Tier 1 methods are simple to use they are relatively inaccurate and shed no light on possible mitigation pathways. The IPCC guidelines also outline more sophisticated Tier 2 or 3 methods for estimating GHG emissions, which incorporate variations in animal size, function, feed management and other production factors which drive emissions. These methods allow more accurate estimation of emissions and, more importantly, the identification of pathways for emission reductions. Nevertheless, there is still significant scope to improve the utility of these methods for identifying mitigation opportunities in the livestock sector, especially in regard to measuring the link between feed quality and enteric emissions (FAO, 2013c). There is, therefore, a key role for further research and development to support more accurate national inventories by assisting countries that are currently using simple Tier 1 methods to switch to Tier 2 and Tier 3 methods, and to develop more accurate approaches with greater utility for identifying mitigation solutions.

Research and development, extension and climate funds to support mitigation

Funds in support of mitigation

In addition to carbon markets, there is a range of complementary sources of mitigation finance. These include multilateral funding sources such as the Green Climate Fund,⁴⁷ the World Bank, and the Global Environment Facility,⁴⁸ as well as

⁴⁷ The Green Climate Fund is a mechanism for affluent countries to support adaptation and mitigation in developing countries that was established at COP 16. It aims to mobilise US\$100 billion per year from both public and private sources by 2020. (http://unfccc.int/cooperation_and_support/financial_mechanism/green_climate_fund/items/5869.php).

⁴⁸ The GEF brings together 182 countries in partnership with multiple stakeholders to address global environmental issues, including climate change, offering grants for technical assistance and knowledge transfer (<http://www.thegef.org/gef/whatisgef>). It is the world's largest and oldest multidonor financing mechanism for mitigation.

domestic funding sources such as national development banks and nationally sponsored climate funds (e.g. the Spanish Carbon Fund),⁴⁹ which are making increasing contributions to mitigation finance (Venugopal, 2012). There may also be good opportunities for the public sector to design financial instruments to attract private sector co-investment into mitigation projects, perhaps by managing risks that the private sector is not willing to take on (Venugopal, 2012).

Research, development and extension initiatives

As mentioned, significant additional research and development is needed to build the evidence base for existing and new mitigation practices and technologies. There are some existing research projects and initiatives at international and country levels playing this role, which could be expanded. One of the main research initiatives at a global level is the Global Research Alliance (GRA) on agricultural GHGs, which focuses on the research and development of technologies and practices to increase food production without increasing emissions. It was launched in December 2009 and now has more than 30 member countries. The GRA builds on increasingly strong research programmes developed at national level, and thus has access to numerous scientists and engineers to create cross-cultural and multidisciplinary teams to deliver innovative and practical solutions. Research efforts are organized across different agricultural subsectors, and include a livestock research group that aims to find solutions to reduce the GHG intensity of livestock production systems and increase the quantity of soil carbon stored in grazing lands (GRA, 2013). There are several country-led initiatives that are supporting research, development and extension efforts in this area, some of which directly support the GRA. For example, the Canadian Agricultural Greenhouse Gases Program (AGGP), which focuses on knowledge creation and the transfer of

⁴⁹ <https://wbcarbonfinance.org/Router.cfm?Page=SCF>



Credit: ©FAO/Ishara Kodikara

technologies for mitigation.⁵⁰ A similar but larger initiative is the Australian Carbon Farming Futures program, which will provide US\$397 million to fund a range of research, demonstration and extension activities to help farmers benefit from the country's Carbon Farming Initiative (CFI): filling research gaps into new technologies and practices for mitigation; research in real farming situations; extension and outreach activities; and tax offset for farmers purchasing conservation tillage equipment.⁵¹ Another knowledge-based initiative is the Scottish Climate X Change,⁵² which is a centre of expertise based on the collaboration of the country's leading research and higher education institutes. The centre uses this academic network to generate evidence and provide advice to all sectors including agriculture farmers about climate mitigation and adaptation practices. The New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) is a further notable initiative for generating knowledge, practices and technologies for GHG mitigation in agriculture.⁵³

In addition to the GRA there are other important international initiatives that are investing in

research, develop and extension activities. For example, the AnimalChange project is a research project involving 25 public and private partners from European and non-European countries, which seeks to develop and provide evidence for mitigation and adaptation strategies appropriate at farm, country and regional scales in the European Union, Latin America and Africa. The project has a €12.8 million budget over four years, and is mostly funded by the European Commission.⁵⁴ Another important international initiative is the Global Methane Initiative (GMI), a multilateral partnership established to foster international cooperation for reducing CH₄ emissions and advancing the recovery and use of CH₄ as a clean energy source. More than 40 countries collaborate in the initiative in coordination with the private and public sectors, researchers, development banks and non-governmental organizations. The GMI targets five major CH₄ sources, including agriculture where it focuses on anaerobic digestion systems for manure management. It focuses on developing strategies and markets for the abatement and use of CH₄, and engages in capacity building, information exchange and site-specific resource assessments to promote the adoption of mitigation technologies.

⁵⁰ <http://www4.agr.gc.ca/AAFC-AAC/display-afficherdo?id=1331047113009&lang=eng>

⁵¹ <http://www.daff.gov.au/climatechange/carbonfarmingfutures>

⁵² <http://www.climatexchange.org.uk>

⁵³ <http://www.agresearch.co.nz/our-science/land-environment/greenhouse-gas/Pages/default.aspx>

⁵⁴ <http://www.animalchange.eu>

Reducing Emissions from Deforestation and Forest Degradation (REDD+)

Since its 16th meeting, the Conference of the Parties of the UNFCCC has adopted the Reducing Emissions from Deforestation and Forest Degradation (REDD+)⁵⁵ programme in developing countries as an important mitigation strategy in the forestry sector. Global and national REDD+ mitigation efforts are supported by multilateral initiatives such as the UN-REDD programme, Forest Carbon Partnership Facility (FCPF) and Forest Investment Program (FIP), hosted by the World Bank.⁵⁶ These initiatives rely on the provision of financial incentives and technical support for developing country adoption of REDD+ practices. Up to US\$30 billion per year in financial flows are expected to become available for REDD+⁵⁷ because the conversion of forest to grazing land for livestock production is one of the drivers of deforestation, the REDD+ strategy has an important role in abating emissions from the livestock sector. The role of agriculture as a driver of deforestation has gained recognition in UNFCCC REDD+ negotiations since 2012 (Wilkes *et al.*, 2012).

Private sector initiatives

The livestock industry is playing an increasing role in the development of mitigation strategies. The last ten years have seen a rise in private sector initiatives involved in developing targeted responses to sustainability challenges.

Voluntary mitigation programmes

In some cases, the livestock sector has taken a leadership role in better identifying the environmental impacts of production and the potential mitigation options to reduce environmental impact. The International Dairy Federation's (IDF's) Common Carbon Footprint Approach for Dairy is one such example (IDF, 2010). Based on life-cycle assess-

ment, the methodology developed is the result of an intensive process involving international experts and dairy companies to develop common guidelines to calculate the carbon footprint of the dairy sector. Such initiatives not only identify GHG emission hotspots and reduction opportunities, but can also enhance efficiency across the supply chain. In relation to this international effort, an increasing number of national dairy associations are engaging in voluntary mitigation programmes. The meat industry is also progressively engaging in this way, as illustrated by several national initiatives, for example by the US Cattleman Association and a number of key pork producing countries (IMS, 2012). Additional efforts also include the tools recently released by the US National Pork Board and Teagasc-Bord Bia Partnership to assess and better understand the industry's carbon footprint.⁵⁸

Sustainability platforms

Sustainability platforms, bringing together a number of sectors to work collectively on developing and adopting more sustainable practices, are also active. For example, the Sustainable Agriculture Initiative (SAI), originally set up in 2002, now draws on an international membership of over 50 members, including some of the world's biggest agricultural production companies.⁵⁹ Sustainability programmes have progressed across a number of product areas, including beef and dairy and with a focus on climate and water.

Growing involvement of retailers

Retailers have also taken important strides in driving improved environmental performance. Walmart's Global Sustainable Agriculture Goals is one such retailer programme that is investing substantially in more efficient and sustainable livestock supply chains. The recent announcement in April 2013 of the partnership between The Nature Conservancy (TNC), a leading conservation or-

⁵⁵ The 'plus' refers to conservation actions, sustainable forest management, and the enhancement of forest carbon stocks, in addition to actions for preventing deforestation and forest degradation.

⁵⁶ <http://www.un-redd.org/AboutREDD/tabid/102614/Default.aspx>

⁵⁷ www.un-redd.org

⁵⁸ <http://www.pork.org/Resources/1220/>

CarbonFootprintCalculatorHomepage.aspx and The 'Beef Carbon Navigator' <http://www.teagasc.ie/news/2012/201209-25.asp>

⁵⁹ www.saiplatform.org

ganization, Marfrig Group, one of the world's largest food producers, and Walmart Brazil to invest in a targeted sustainability programme with beef operations in southeastern Pará, Brazil, demonstrates the more active role retailers are taking in the livestock sector towards driving sustainable practice.

Need for further interaction across supply chains actors

These developments are mostly motivated by changing consumer preferences and the increasing awareness of stakeholders along the livestock supply chain. The challenge for the private sector will be to ensure that policies and initiatives are implemented by producers and sustained over the long term, through a process of continuous improvement. In addition, the connection between producers and consumers needs attention to ensure that the livestock sector is meeting consumer needs in an appropriate and relevant manner. This drives an ongoing need to better understand the life cycle of livestock products and encourage further interaction between decision-makers across the supply chain.

7.5 CONCLUSIONS

Strategies for concomitant development and mitigation objectives

To have traction among policy-makers, livestock mitigation policies need to be consistent with the overall development goals of the country, and they must be part of a vision of how the sector should and could develop. A key requirement for developing country participation, where most of the mitigation potential in the livestock sector is found, is the creation of strategies that can serve both development and mitigation objectives.

It is estimated that up to one-third of the livestock sector's emissions could be reduced in the short to medium term by the greater use of more efficient, readily available practices and technologies that can serve both of these objectives. While much of the livestock sector's mitigation potential could be achieved profitably or at minimal cost (USEPA, 2006; Moran *et al.*, 2010; Schulte *et al.*,

2012), further assessments are needed to improve our understanding of how and where among the range of available mitigation practices, regions and production systems, development and mitigation goals can converge.

Investments and policies for enabling environments

Additional investments and partnerships are, however, required to encourage technological innovation and build institutional capacity to support and make use of these innovations. Extension and other knowledge exchange along with network activities are the principal policy instruments for closing the efficiency gap between more efficient farmers and their peers. At the same time, stronger policy frameworks are needed to better align private and public economic objectives, and to facilitate further uptake of all mitigation strategies. However, without strong internationally binding emission targets that are inclusive of agriculture and the world's most important emitting countries, the introduction of effective mitigation policies will remain a political and economic challenge. Trade-offs between mitigation and other environmental and socio-economic objectives must also be considered and managed. While efficiency-based GHG mitigation strategies can also improve efficiency in the use of other natural resources, policy safeguards are still needed to avoid unintended environmental, disease and socio-economic risks. For instance, a single-minded commodity-based focus on production efficiency can come at the expense of some ancillary services of livestock that are important for poor rural households, including their role as a store of wealth.

Additional research and development

There is a role for additional research and development in all mitigation strategies to improve existing technologies, develop new ones, but also to develop interventions that are based on packages of mitigation technologies suited for specific production conditions. There is also a need for more accurate and affordable methods for measuring

emissions, to guide practice change and support more accurate national inventories. These challenges vary among livestock emission sources, by sector and region. For example, validated methodologies exist for measuring the recovery and use of CH₄ from stored manure as a clean energy source. The predominance of livestock biogas projects in the CDM offset scheme provides evidence of this.

Conversely, carbon sequestration in grasslands has tremendous potential, but more research and development is required to develop measurement methodologies. Furthermore, pilot studies and supporting institutional mechanisms are needed before the strategy can be incentivized on a meaningful scale. This will also improve the prospects for the greater inclusion of this strategy in national mitigation targets. Further, given the paucity of cost-benefit analyses for mitigation options, research and development to redress this neglect is vital. As discussed, knowledge about the economic attractiveness of these options is fundamental for the design of cost-effective mitigation policies.

Investing in mitigation in the context of weak incentive policies

On the whole, the mitigation incentives for livestock provided by existing international and national mitigation policies and programmes are very limited. Much of this weakness stems from the small proportion of countries and emissions that are covered by the Kyoto Protocol, and its related market-based instruments. Further incentives are provided by NAMAs; however, these pledges only involve voluntary mitigation ambitions which, with the notable exception of Brazil, so far exclude specific mitigation targets for livestock. In the absence of a stronger and more inclusive international agreement to reduce emissions, action will largely depend on identifying profitable opportunities for investing in mitigation. These will be driven by reduced production costs or market premiums for low emission intensity products. The design of financial instruments that allow the public sector to underwrite the risks of mitigation projects, which

the private sector is unwilling to take on board, could play an important catalytic role in attracting private sector co-investment into these projects.

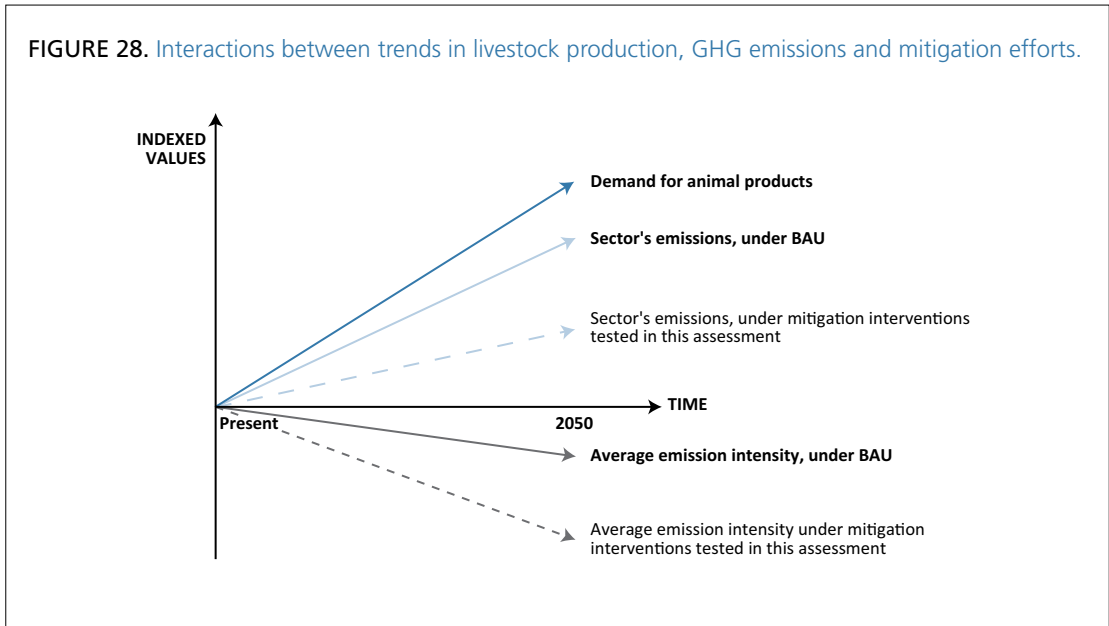
Emission intensities versus absolute emissions

The future overall emissions of the sector will depend on the combined effect of emission intensity reductions and growth in production, which is projected to increase by about 70 percent between 2010 and 2050 (FAO, 2011c).

Under the BAU outlook, the global average emission intensity of livestock supply chains is expected to decrease slightly, as more efficient practices are adopted and as most of the sector's growth takes place in commodities with relatively low emission intensities. This assessment has shown that narrowing the emission intensity gap within production systems could reduce of emission intensities by about one-third of current levels. On a global scale, it is unlikely that the emission intensity gains, based on the deployment of current technology, will entirely offset the inflation of emissions related to the sector's growth (Figure 28). However, the full technical mitigation potential of the sector, i.e. the effect of applying all available mitigation techniques, irrespective of their cost, is greater than a third of current emissions and it is possible that technological breakthroughs will allow mitigation above and beyond current estimates. Furthermore, in regions where expected production growth is low, reductions in emission intensity may be able to fully offset sector trends.

These considerations, which were not included in the scope of this assessment, require further research. This would involve economic and social analyses to better understand regional specificities, differences between systems and interactions between rural development, food security and mitigation. It would also require to assess the effect that efficiency gains may have on consumers' price and consumption levels. This research is required to better understand the overall mitigation potential in the sector and to identify livestock's role in global and multisector efforts for addressing climate change.

FIGURE 28. Interactions between trends in livestock production, GHG emissions and mitigation efforts.



The need for international, multisector, multistakeholder action

Due to the size and complexity of the livestock sector, the design and implementation of cost-effective and equitable mitigation strategies and policies can only be achieved through concerted action by all stakeholder groups (including producers, industry associations, academia, the public sector and intergovernmental organizations). Moreover, given the nature of climate change as a global public good and the sector's socio-economic challenges, collective global action is both welcome and needed. And because of the increasing global economic integration of livestock sector supply chains, unilateral actions to mitigate GHG emissions will be much less effective than more internationally coordinated actions. For example, where strong mitigation policies are limited to one country, there are risks that a large share of that country's emission reductions will be offset or "leaked" into unregulated sectors abroad (Golub *et al.*, 2012). In addition, unilateral policies invariably raise issues about competitiveness and fairness for sectors that are exposed to international trade.

While the main official mechanism for international and multisectoral action on GHG miti-

gation is provided by the UNFCCC, important mitigation efforts are also being carried out on local industry scales, often led by the private sector. There is, however, a need for more support from global initiatives that are focused on livestock-specific issues, and that can effectively integrate and mainstream the mitigation and development objectives pursued by sector stakeholders.

An example is LEAP, which gathers partners from the private sector, governments, civil society organizations, research and international organizations that have agreed to develop common metrics to define and measure environmental performance of livestock supply chains.⁶⁰ The Global Agenda of Action in support of Sustainable Livestock Sector Development is a closely related initiative by a similar group of stakeholders from all parts of the livestock sector, which tackles the issue at the level of implementation, by focusing on practice change and continuous improvement.⁶¹ It draws on the differing strengths of each stakeholder group to build the trust and cohesion that are essential for concerted international action along the sector's entire supply chain.

⁶⁰ www.fao.org/partnerships/leap

⁶¹ www.livestockdialogue.org