Food and Agriculture Organization of the United Nations

GLOBAL RESEARCH ALLIANCE ON AGRICULTURAL GREENHOUSE GASES

GLOBAL DAIRY PLATFORM

The role of animal health in national climate commitments

Required citation:
Özkan, Ş., Teillard, F., Lindsay, B., Montgomery, H., Rota, A., Gerber P., Dhingra M. and Mottet, A. 2022. *The role of animal health in national climate commitments.* Rome, FAO. https://doi.org/10.4060/cc0431en

ISBN 978-92-5-136351-5

The role of animal health in national climate commitments

Şeyda Özkan[1], Félix Teillard[1], Brian Lindsay[2], Hayden Montgomery[3], Antonio Rota[4], Pierre Gerber[5], Madhur Dhingra[1] and Anne Mottet[1]

[1] Food and Agriculture Organization of the United Nations
[2] Global Dairy Platform
[3] Global Research Alliance on Agricultural Greenhouse Gases
[4] International Fund for Agricultural Development
[5] The World Bank Group

Food and Agriculture Organization
of the United Nations
Rome, 2022

Contents

Figures

Tables

Boxes

Acknowledgements

We acknowledge those who reviewed the brief and provided useful comments: Ilias Kyriazakis (Queen's University, United Kingdom of Great Britain and Northern Ireland), Michael MacLeod (Scotland's Rural College, United Kingdom of Great Britain and Northern Ireland), Eric Morgan (Queen's University, United Kingdom of Great Britain and Northern Ireland), Steven Morrison (Agri-Food and Biosciences Institute, United Kingdom of Great Britain and Northern Ireland), Philip Skuce (Moredun Research Institute, United Kingdom of Great Britain and Northern Ireland), Nick Wheelhouse (Napier University, United Kingdom of Great Britain and Northern Ireland), Keith Sumption (FAO, Italy), Ugo Pica Ciamarra (FAO, Italy), Aimable Uwizeye (FAO, Italy), Weining Zhao (FAO, Italy) and Sabrina Rose (Alliance of Bioversity International and CIAT, the United States of America). We also thank Giulia Maria Galbiati (FAO, Italy) for providing the data used in Figure 1, Jean Baptiste Dollé (IDELE, France) and Emmanuel Coste (CNE Interbev, France) for their inputs on the Life Carbon Dairy case study, Caroline Plante (World Bank, the United States of America) for her feedback on the case study in Sahel, Andrew Morris for editing and proofreading the brief and finally Claudia Ciarlantini (FAO, Italy) and Cristiana Giovannini (FAO, Italy) for preparing the brief for publication and the design.

About this brief

This brief has been produced by the Food and Agriculture Organization (FAO) of the United Nations, in collaboration with the Global Dairy Platform (GDP) and the Global Research Alliance on Agricultural Greenhouse Gases (GRA) and with the financial support of the New Zealand Government. The FAO was approached by GDP and GRA to develop guidance following previous research on dairy cattle in order to support policy makers and livestock sector actors in implementing a process that captures the co-benefits of cattle health initiatives in their climate commitments. It provides examples in specific countries in collaboration with the World Bank and the International Fund for Agricultural Development (IFAD). This brief provides methodological guidance on the quantification of animal health interventions and their impact on greenhouse gas (GHG) emissions, on the basis that they deliver multiple benefits to individual farmers and society which could outweigh the costs of the intervention, particularly when considering reduced GHG emissions.

Abbreviations and acronyms

AHN	Animal Health and Greenhouse Gas Emissions Intensity Network of GRA
BVD	bovine viral diarrhea
CAP'2ER®	calcul automatisé des performances environnementales pour des exploitations responsables
CH_4	methane
CITEPA	Interprofessional Technical Centre for Studies on Air Pollution
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalents
CSA	Climate-smart agriculture
DM	dry matter
GDP	Global Dairy Platform
GHG	greenhouse gas
GLEAM	global livestock environmental assessment model
GLEAM-*i*	global livestock environmental assessment model-*interactive*
GRA	Global Research Alliance on Agricultural Greenhouse Gases
FAO	Food and Agriculture Organization of the United Nations
IDELE	The French Livestock Institute
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
LCA	life cycle assessment
MRV	measurement, reporting and verification
NAMA	nationally appropriate mitigation actions
NDC	nationally determined contributions
N_2O	nitrous oxide
NZAGRC	New Zealand Agricultural GHG Research Centre
PPR	peste des petits ruminants
CBPP	contagious bovine pleuropneumonia
PRAPS-2	Regional Sahel Pastoralism Support Project phase 2
RRPCP	Regional Resilient Pastoral Communities Project
UNFCCC	United Nations Framework Convention on Climate Change

Executive summary

Globally, the impacts of animal health conditions on GHG emissions are significant as they affect mortality, morbidity and productivity. Mitigation packages that include animal health interventions can significantly reduce emissions, and yet there are challenges in terms of measurement, reporting and verification (MRV) systems. There is currently no standardized way of including improved animal health in the commonly used approaches for developing (GHG) national inventories or nationally determined contributions (NDCs). It also transpires that the mitigation co-benefits of using animal health as an adaptation measure are not always explicit in the NDC commitments. This paper demonstrates how countries can develop an MRV system at national level to be able to include animal health improvements in national climate commitments.

A pre-condition of any attempt to account for the mitigation impact of improving animal health is the use of an Intergovernmental Panel on Climate Change (IPCC) Tier 2 or 3 methodology. Only such methodologies make it possible to consider how changes in parameters related to animal health affect emissions, as opposed to the Tier 1 approach that relies on default emission factors, that is, GHG emissions per animal.

Tier 2 activity data are specific to animal categories and local production systems and therefore have a direct link to animal health interventions. They include animal numbers per category (or herd parameters to estimate these numbers such as mortality, fertility, age at first calving, calving interval, weaning age, replacement rate) as well as production data such as milk yield, body weight at different life stages and waste and losses of products. Data on feed rations such as digestibility, feed basket composition and protein content also need to be collected for different categories of animals, as these have a strong influence on emission factors. Finally, data regarding the type of manure management system are needed. Secondary parameters such as energy requirements, methane (CH_4) conversion factor, feed production practices and energy use are usually calculated using the parameters above. It is, however, important to note that the CH_4 conversion factor used for estimating enteric CH_4 in Tier 2 methodology does not usually include potential changes resulting from animal health improvements. This may require using Tier 3 approaches with more complex modelling and associated data.

Although required, animal numbers per category are usually not available from national statistics, nor are the herd parameters used to estimate these numbers, such as mortality rate and fertility rate. Information about the quantity of milk or meat discarded as a result of a disease should also be gathered, as it is usually not accounted for in the total production reported in national statistics and therefore not included in the GHG inventory. To ensure the quality of these parameters, dedicated and systematic surveys or monitoring systems at farm or other relevant administrative unit levels should be implemented when feasible. However, secondary data and modelling can also be used. It is critically important that **the different actors of the sector are included in the establishment and maintenance of data collection systems.** Processors (e.g. dairy cooperative) and feed suppliers may already have, for example, data collection systems that are relevant to Tier 2 based calculations.

One outstanding challenge concerns how the emissions from the livestock sector are reported in national GHG inventories and included in NDCs. In their inventories, countries report direct emissions at sector level. These emissions in the livestock sector include CH_4 emissions from enteric fermentation, and CH_4 and nitrous oxide (N_2O) emissions from manure management. Emissions from feed production, processing and transport and energy use are reported under "agricultural soils" or the energy sector. Animal health interventions cannot be considered in isolation at animal level as affecting only direct emissions. For example, supply-chain emissions may diminish due to reduced needs for replacement animals or changes in the feed ration. Therefore, it is important to **adopt a systems perspective and understand the drivers of supply-chain emissions.** Investments to improve research capacity to include forecasting and modelling complex dynamics between climate change and disease/vector distribution will be needed. It will be important to promote and implement research to ensure that the options addressing animal health are linked to other dimensions such as feeding, genetic resources, production systems, food safety and value chains, reflecting the need for a systems perspective.

Enhanced awareness and capacity at national government level and for institutional arrangements are essential. This includes tools tailored to specific country contexts, and stakeholder consultations in formulation of the NDC targets and the development of implementation plans. Inclusive collaboration with the ministry in charge of livestock, and regular communication among different ministries and agencies are, therefore, essential to identify the individuals with knowledge on livestock and emissions. Large investments in livestock by international financial institutions or initiatives led at national supply-chain levels have great potential to be of relevance for reporting in national inventories. For example, a national vaccination campaign, as part of broad livestock development projects, can be identified as contributing to the mitigation ambition of the country, as the case studies included in this brief illustrate. Likewise, countries engaging in projects that aim to boost efficiency in the sector, including through improvements in animal health are likely to have better access to capacity development and tools.

IN BRIEF

- In general, the impact of improvements in animal health are not currently included in national GHG inventories and NDCs
- Tier 2 and higher methodologies are necessary to estimate GHG emissions reductions from improved animal health
- A data collection and maintenance system needs to be established that includes stakeholders right across the sector
- A life cycle assessment (LCA) perspective needs to be considered to account for the reduction in indirect emissions due to improved animal health (e.g. changes in feed consumption, use of pastures, use of energy) applying a systems approach
- The capacity of governments and partners needs to be enhanced in calculating emissions with Tier 2 methodology and accounting for impact throughout the value chain
- Institutional arrangements need to be inclusive of all actors in the sector, including research and academia as well as the private sector (industry).

1 The livestock sector in the context of climate action

Livestock has an important role to play in climate change mitigation and adaptation. Livestock supply chains are responsible for 14.5 percent of all anthropogenic GHG emissions (Gerber *et al.*, 2013) and livestock keepers, especially those in marginal areas and those who keep animals outdoors, are among the populations most vulnerable to climate change. Efforts are being made by nations to reduce emissions, which materialized in the Paris Agreement – a legally binding international treaty on climate change, adopted in 2015 to limit global warming to below 2, preferably to 1.5 degrees Celsius compared to pre-industrial times (United Nations, 2015).

NDCs are the backbone of achieving the goals of the Paris Agreement. A recent synthesis in 2021 of the information from 164 latest NDCs, shows that 30 percent of Parties (or countries) refer to grazing and livestock production as a specific priority area for domestic mitigation measure while 21 percent refer to improved management of manure and herds as a mitigation option (UNFCCC, 2021). The Koronivia Joint Work on Agriculture discussions on different climate-related topics refer to animal health as one of the "no-regret" options (i.e. technical and/or financial priorities which, by reducing diseases, will maximize benefits such as reduced environmental impacts, improved food security and enhanced community resilience) (Drieux *et al.*, 2021). Improved animal health (Box 1) should, therefore, be one of the key action points to reduce GHG emissions from livestock (FAO and GDP, 2018; Statham *et al.*, 2020). For example, the increases in GHG emissions resulting from certain diseases including foot lesions, clinical mastitis and subclinical ketosis can amount to 0.4 million t/year, equivalent to 15 percent of the total emission reduction target for the agricultural sector in the Netherlands in 2030 (Mostert, 2018).

In spite of this apparent "no-regret", the extent to which the role of improved animal health features in NDCs as an option for mitigation of and adaptation to climate change is limited. Of the 148 countries submitting new or updated NDCs in November 2021, 74 referred to livestock. Of these, a total of 14 specifically included animal health, and only four of these (Albania, Burundi, the Gambia and Sri Lanka) in the context of mitigation and/or adaptation with mitigation co-benefits (Rose *et al.*, 2021a, 2021b).

BOX 1: DEFINITION OF ANIMAL HEALTH CONDITIONS IN THE CONTEXT OF THIS BRIEF

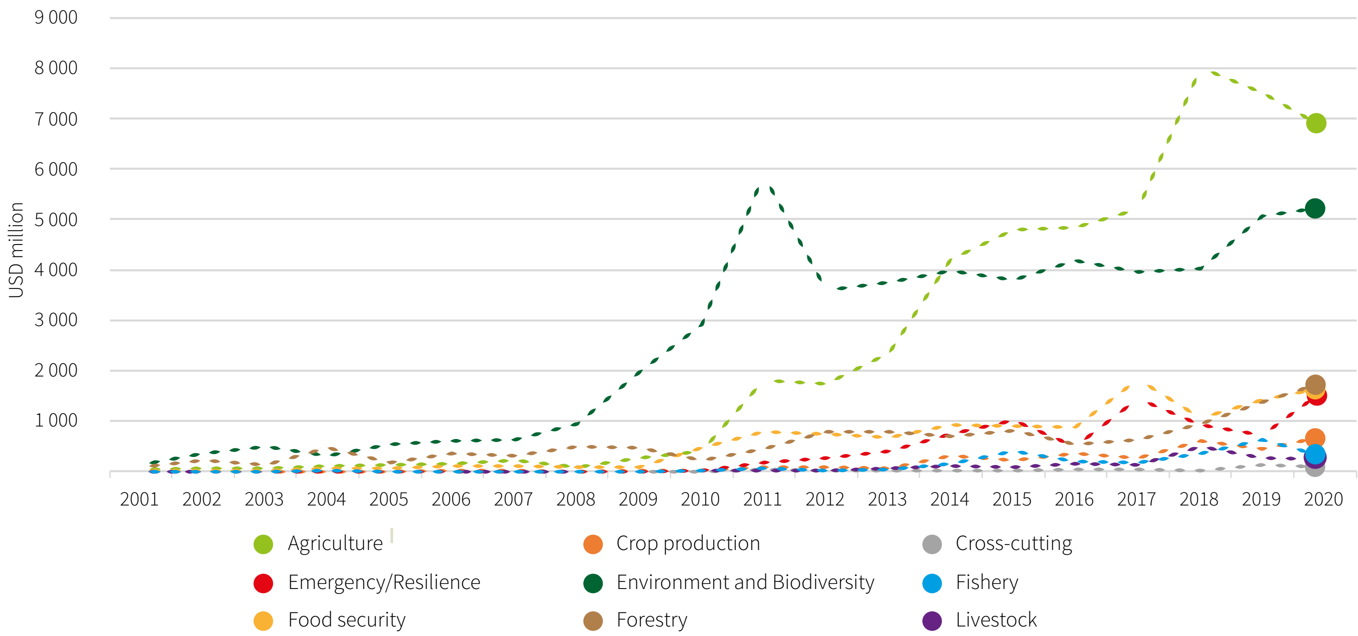
Animal health conditions are defined to cover both infectious and non-infectious causes. While infectious diseases are caused by pathogens including bacteria, viruses, fungi, protozoans and parasites (e.g. mastitis, foot lesion), the non-infectious diseases originate from sources other than pathogens such as environment, genetics and malnutrition. Metabolic and nutritional problems, such as gastrointestinal obstruction, mucosal injury, dietary indiscretion or enzyme deficiencies, as well as climate-led conditions such as heat and cold stress are examples of non-infectious conditions. Infectious and non-infectious diseases can interact to affect outcomes, for example nutrition-parasite interactions.

© FAO/Giulio Napolitano

It should be noted that Annex I countries[1] do not typically include explicit references to actions in any specific sector within their NDCs due to the fact that these countries typically have economy-wide emissions reduction targets. Nevertheless, at a national level the same limitations in capturing the mitigation benefits of animal health measures apply when the GHG reporting methodology used is insufficient, and the benefits of their inclusion could have a significant enough impact on economy-wide emissions to be interesting from a public and/or private perspective.

We observe that most countries do not currently utilize GHG emissions reporting methods that can adequately capture the benefits of improving animal health in GHG inventories or NDCs. In most cases, depending on the methodology of the inventory, emissions would be excluded entirely, or included but not explicitly referenced, thereby limiting the possibility of verifying proactive interventions and the subsequent impact on GHGs. In addition, given that many countries that have included livestock in their NDCs have targets conditional on international support (e.g. climate finance), the extent to which climate and other finance can be mobilized to support animal health interventions is limited, further compounding underinvestment in the sector. Of the total climate-related USD 122 billion invested within the agriculture and land use sector during the period 2000–2019, livestock, with only 2 percent of climate finance received, has been one of the least financed sub-sectors (Figure 1) (Buto *et al.*, 2021; World Bank, 2020).

Figure 1. Climate finance to the agriculture and land use sub-sectors



Source: Buto, O., Galbiati, G., Alekseeva, N. & Bernoux, M. 2021. *Climate finance in the agriculture and land use sector – global and regional trends between 2000 and 2018*. Rome, Italy.

[1] Annex I countries are industrialized countries that were members of the Organization for Economic Co-operation and Development in 1992, in addition to the countries with economies in transition, including the Russian Federation, the Baltic states and several Central and Eastern European States.

2 How does animal health affect greenhouse gas emissions?

The way by which animal health affects emissions intensity is through reduced production efficiency and what is referred to as "unproductive emissions" related to mortality and morbidity. Morbidity causing the reduction in production efficiency, diminishes the growth rate and live weight of animals and leads to lower efficiency in feed utilization, as well as lower reproductive performance and milk yields (FAO and NZAGRC, 2017a).

The extent to which animal health conditions interrelate with feeding, breeding, immune response and the consequential impacts on GHG emissions is an ongoing research arena (Özkan *et al.*, 2016), which is addressed in particular in the Animal Health and Greenhouse Gas Emissions Intensity Network (AHN) of the GRA. Looking specifically at dairy cattle, the increases in GHG emissions from the increases in GHG emissions from diseases (e.g. clinical or sub-clinical mastitis, foot lesion, foot and mouth disease) can originate from removal of discarded milk, reduced milk production, prolonged calving interval and culling (Mostert *et al.*, 2019, 2018, Özkan Gülzari, Vosough Ahmadi and Stott, 2018). Though some diseases are more tractable than others (Skuce *et al.*, 2016) and some health issues result in greater GHG emissions than others.

One of the immediate impacts of disease in an animal's body is the reduction in voluntary feed intake. In addition, digestion, absorption and utilization of nutrients can be significantly compromised, especially in the case of gastrointestinal parasitism. Maintenance requirements, especially those of protein, may increase, and the availability of nutrients for maintenance may diminish, which may make the animal more vulnerable to challenges that were otherwise easier to control (Mackenzie and Kyriazakis, 2021).

BOX 2: EXAMPLE OF THE EVIDENCE AVAILABLE TO QUANTIFY THE IMPACT OF DISEASES ON GHG EMISSIONS

Parasites challenging livestock health and productivity of grazing livestock may affect feed efficiency, nutrient use and production traits, and can increase the CH_4 yield per kg dry matter (DM) intake by 33 percent (Fox *et al.*, 2018). If the increased feed intake due to delayed weaning and compensation for maternal body loss was accounted for, parasitism can increase the emissions per kg lamb weight gain by 11 percent for enteric CH_4, by 32 percent for manure CH_4 and by 30 percent for manure N_2O (Houdijk *et al.*, 2017). Removing parasitic diseases such as *Trypanosomiasis* in East Africa can lead to a reduction of emissions intensity between 0 percent and 8 percent driven mainly by increases in milk yield and fertility rates (MacLeod *et al.*, 2018).

While some diseases like *Johne's* and *Salmonellosis* may have greater impact on GHG emissions per animal per year than bovine viral diarrhea (BVD), the impact of BVD on GHG emissions per 1000 L of milk can be similar to that of *Salmonellosis* due to the losses in productive outputs. The main cause of the increase in GHG emissions was the increased mortality in BVD (immunosuppression opening the way for other diseases) and *Salmonellosis*, and the increased culling rate in *Johne's* disease. The diseases can cause an increase in both CH_4 and N_2O emissions per kg digestible organic matter intake (ADAS, 2015; Mackenzie and Kyriazakis, 2021).

It is important to note that antibiotic treatment can alter the gut microbiome and increase CH4 fluxes because methanogens compete with bacteria for hydrogen (Hammer et al., 2016).

The body of research on specific diseases and their impacts on GHG emissions is growing (see Box 2). However, this evidence, while available, is still underused in estimating GHG emissions reduction in national commitments. It is summarized in Figure 2.

Figure 2. Impact of animal health conditions at animal and herd levels and possible environmental, economic and social impacts. Source: Authors' elaboration based on studies in section 2

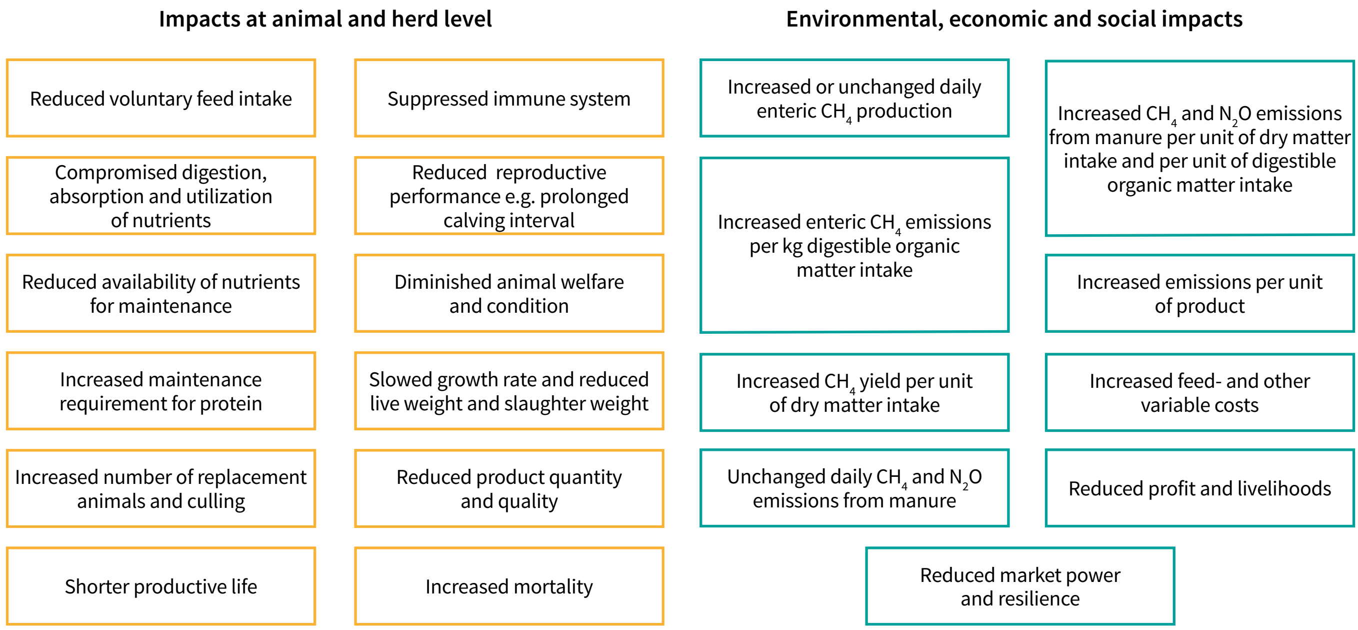
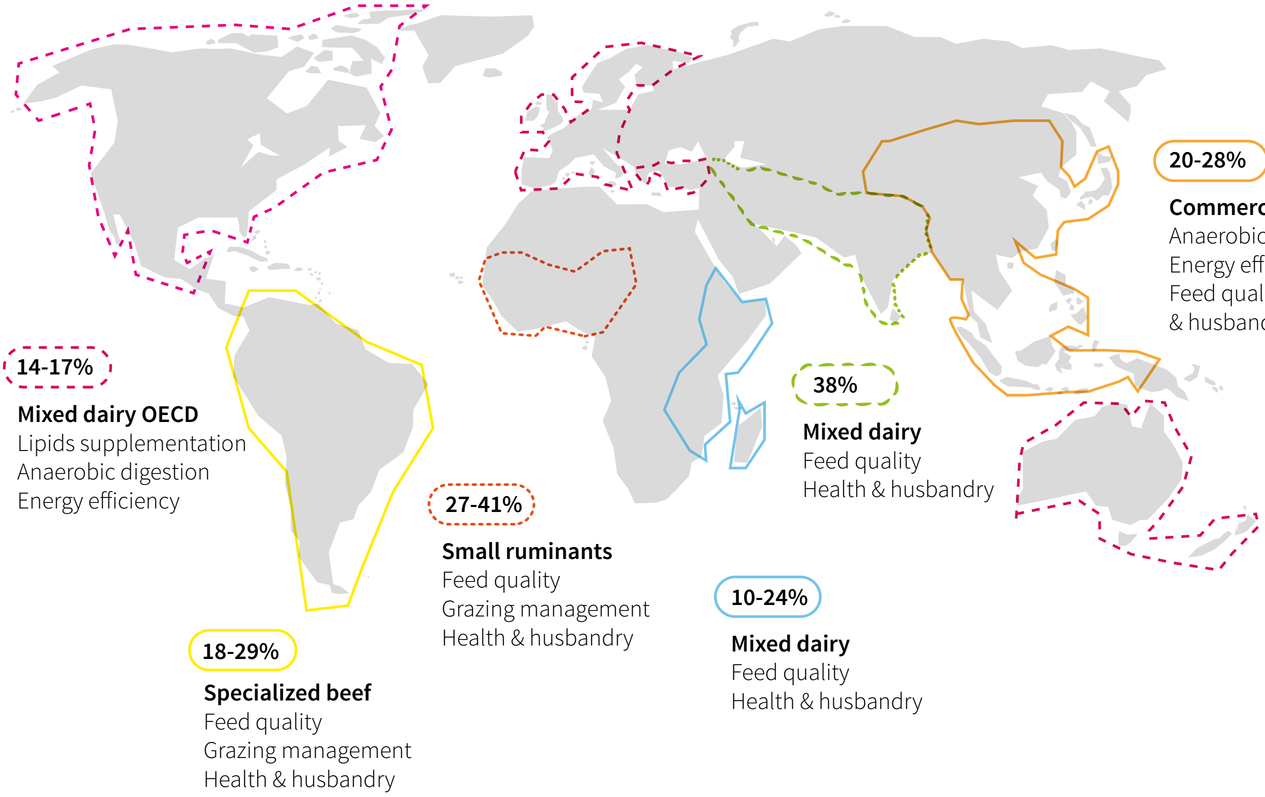


Figure 3. Mitigation packages including animal health and potential for GHG emission reduction in percent of baseline emissions in six regional case studies



Source: Mottet, A., Henderson, B., Opio, C., Falcucci, A., Tempio, G., Silvestri, S., Chesterman, S. & Gerber, P.J. 2017. Climate change mitigation and productivity gains in livestock supply chains: insights from regional case studies. Reg. Environ. Chang. 17, 129–141.

In a constant production scenario where cattle numbers are reduced as a response to productivity gains, improved animal health may also eventually prevent emissions from land-use change due to the grassland area that is no longer needed for livestock production (ADAS, 2015). Even though a constant production level is a useful baseline, consequences for GHG emissions, when changes in production are superimposed, are unlikely to be linear because changes in the number of animals in either direction impact on stocking rates and management systems, as well as land use. This would also mean that the trade-offs between improved production/reproduction efficiency and national level/absolute emissions need to be monitored in case of increased animal numbers.

Good animal health is a prerequisite for other mitigation options to perform to their potential (e.g. introducing exotic breeds or emerging feed additives). Good animal health also facilitates trade and exchange (FAO, 2020) and can decrease risks associated with importing exotic diseases. Productivity gains are generally achieved by improving herd management, animal health and husbandry practices that use the resources for productive animals instead of maintaining them, leading to, for example in the case of dairy cattle, reduced standing biomass for both lactating and replacement animals per unit of milk produced (Gerber *et al.*, 2013). It is, therefore, important to look at animal health as part of a package of interventions.

For example, FAO developed six regional mitigation case studies where animal health was included in packages (ibid; Mottet *et al.* 2017). These mitigation packages based on existing best practices were estimated to have significant emission reduction potentials from 10 percent in mixed dairy systems up to 41 percent in small ruminants (Figure 3).

In other assessments carried out at country level, FAO, in collaboration with the New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) and the Climate and Clean Air Coalition, showed that animal health had a significant mitigation potential when considered as part of packages of interventions in 13 countries. The estimated mitigation potential ranges from 5 percent to 65 percent when considered as part of a package (Table 1).

Table 1. Productivity and mitigation potential benefits of animal health and other interventions

REGION AND COUNTRY	ANIMAL HEALTH INTERVENTIONS	BENEFITS OF ANIMAL HEALTH INTERVENTIONS IN ISOLATION		BENEFITS OF ANIMAL HEALTH INTERVENTIONS WITHIN PACKAGES OF INTERVENTIONS	
		Productivity gain	Emission intensity reduction	Productivity gain	Emission intensity reduction
Latin America[1]					
Argentina	Trichomoniasis control	21–31%	15–22%	24–70%	19–60%
East Africa					
Ethiopia	Trypanosomiasis control	>50%	30–36%	62–225%	36–65%
Kenya	East Coast fever vaccination	25%	14–19%	31–35%	21–36%
	Deworming	12-27%	8-20%		
Uganda	East Coast fever vaccination	4–27%	8–40%	8–120%	5–52%
United Republic of Tanzania	East Coast fever vaccination	12–23%	20–29%	27–43%	29–59%
West Africa					
Benin, Burkina Faso, Mali, Niger, Senegal	Contagious bovine pleuropneumonia (CBPP), Rift Valley fever, Blue Tongue, Peste des petits ruminants (PPR) vaccination	15–21%	13–19%	14–43%	9–29%
South Asia					
Bangladesh	Deworming	6–16%	0–5%	24–27%	17–18%
	Mastitis prevention	5–14%	3–12%		
Sri Lanka	Mastitis prevention	6%	4–6%	15–45%	10–29%
	Heat stress management	6%	3–6%		

Sources: FAO and NZAGRC (2017a, 2017b, 2017c, 2017d, 2017e, 2019a, 2019b, 2019c)

Finally, improved animal health and resulting mitigation benefits can also be economically quantified. For example, using Marginal Abatement Cost Curves, MacLeod and Moran (2017) reported that a 469 kt CO_2e/year emissions could be achieved in the United Kingdom of Great Britain and Northern Ireland by 2035 by improving cattle health, using measures that represent a net benefit to the society. Improving reproductive performance by reducing calving interval by 10 days has the potential to make a ten-fold return on the investment. Prevention of BVD, similarly, can save more than USD 68/cow/year in the herd with preventive vaccination costing about USD 2-3/cow/year (Statham *et al.*, 2020). The change in profits for farmers preventing subclinical mastitis would depend mostly on the change in milk yield and milk and feed market prices (Özkan Gülzari, Vosough Ahmadi and Stott., 2018).

[1] Specific animal health interventions not considered in Uruguay

3 Including animal health in climate commitments

© FAO/Luis Tato

There is no standardized way of including improved animal health in the commonly used approaches for GHG national inventories or NDCs. It appears that the mitigation co-benefits of using animal health as an adaptation measure were not always apparent when countries developed their NDC commitments (Rose *et al.*, 2021b). The inclusion process may vary depending on the coverage in the country (i.e. scale of implementation), the duration (e.g. long- or short-term implementation), the type of the animal health condition or intervention, the institutional roles and responsibilities, as well as the country's science and innovation potential. Therefore, a number of needs exist for the quantification and monitoring of mitigation actions in the context of animal health, including:

- methodological aspects of accounting, data systems and parameters;
- institutional arrangements and capacity building; and
- research and innovation.

It should be noted that the following sub-sections cannot be directed merely at one particular actor of the sector. It is essential that the sector actors collaborate to collect and maintain the quality of data, establish MRV systems and tools, and interpret the results for the climate actions for their relevance for the country. Collaborative efforts are more likely to succeed and attract more climate finance.

The following sections describe the challenges associated with the main points of entry and how to tackle them to ensure inclusion of animal health interventions to climate commitments.

3.1. Measurement, reporting and verification systems, tools, data systems and parameters

GHG emissions from the livestock sector are calculated according to the IPCC guidelines of which a refinement to the 2006 report was prepared in 2019. There are three different levels in IPCC guidelines, representing the complexity in methodologies used, Tier 1 being the most basic, Tier 2 being the intermediate, and Tier 3 being the most advanced and data-demanding (IPCC, 2019). Tier 1 method using fixed values for GHG emissions per head assumes that the GHG emissions of all animals at different ages, health or breeding status are the same and do not change over time or in relation to health status. While Tier 1 methodologies are still widely used because of their relative simplicity and limited data requirements, they are based on default emissions factors which rarely reflect the national specificities and diversity of livestock production systems. These default emission factors, expressed in kg of CH_4 and nitrogen excretion rate per animal, cannot reflect improvements in animal health, for example, feed use efficiency at animal or herd level, which are both important entry points to reduce GHG emissions from livestock. If this method is used, the only way to reduce the livestock emissions is by reducing the number of animals, therefore, it is not a suitable method to support policy makers including animal health in climate commitments (see challenges described in case study 2). The Tier 2 (or Tier 3) method, however, can better account for the impact of management changes such as diet, animal productivity on GHG emissions in different production systems. As emissions varying over time can be captured using Tier 2 method, it is therefore essential to use this method when making climate policies in the sector (Wilkes and van Dijk, 2018; FAO, 2022) even though improvement is also needed for Tier 2 (e.g. modifying fixed equations to better reflect animal health conditions).

As a matter of fact, a more detailed analysis of the four countries that included animal health as a mitigation or adaptation measure in their NDCs (Albania, Burundi, the Gambia and Sri Lanka) showed that none of the countries reported the impact of such measures on GHG emissions, potentially because of applying Tier 1 approaches.

The development of Tier 2 inventories requires a number of steps that have been described and illustrated in an earlier report published by the GRA (Wilkes and van Dijk, 2018). In addition, FAO and the GRA published guidance on activity data for Tier 2 inventories, though not specific to animal health (FAO and GRA, 2020), including how to identify existing data and data gaps, how to fill the gaps, and how to assess the quality of data. For example, activity data collection involves the following steps:

i) define activity data needs;
ii) collect activity data;
iii) assess data availability;
iv) assess data quality;
v) fill data gaps;
vi) compile inventory using adequate quality data;
vii) assess inventory quality; and
viii) continual improvement.

However, further efforts will be required regarding the MRV needs for upscaling data from farm trials; the effect of prevention on individual farms at scale, and the effect on GHG emissions over time. An intermediate step in linking animal health data to Tier 2 GHG inventories should include establishing procedures for data quality assurance and quality control. Processors and feed suppliers may, for example, create data connections where some data are automatically filled and linked to a Tier 2 based calculator. Here, it is of crucial importance to institutionalize data collection to ensure that data availability and quality is maintained over time. This can facilitate mainstreaming climate change mitigation in the delivery of effective animal health service, adapting disease surveillance, and monitoring of disease occurence to climate-related evolutions as well. It is important that the different actors of the sector be included in the establishment of new- and maintenance of existing data collection systems. Platforms such as the AHN of the GRA can also play a role in hosting or facilitating data collection systems. Another approach to capture the impact of health interventions can be revising the baseline by identifying the share of animals that are unhealthy and the implication of the health status on GHG emissions (e.g. Mostert [2018]).

The data necessary to inform the Tier 2 parameters listed in Figure 4 can be obtained from various sources in the country. While dedicated and systematic surveys and farm performance monitoring systems are an ideal way to ensure good quality data on parameters such as weights, yields or number of animals per category, secondary information (or so-called "expert knowledge"), modelling can also be used. MacLeod *et al.* (2018), for example, estimated the effect of *Trypanosomiasis* treatment in East Africa on performance based on a review of longitudinal and cross-sectional studies reporting the productivity of infected and uninfected cattle. The data can also be obtained from animal disease surveillance and information systems (such as EMPRES-*i* and WAHIS) and other One Health Intelligence systems across sectors.

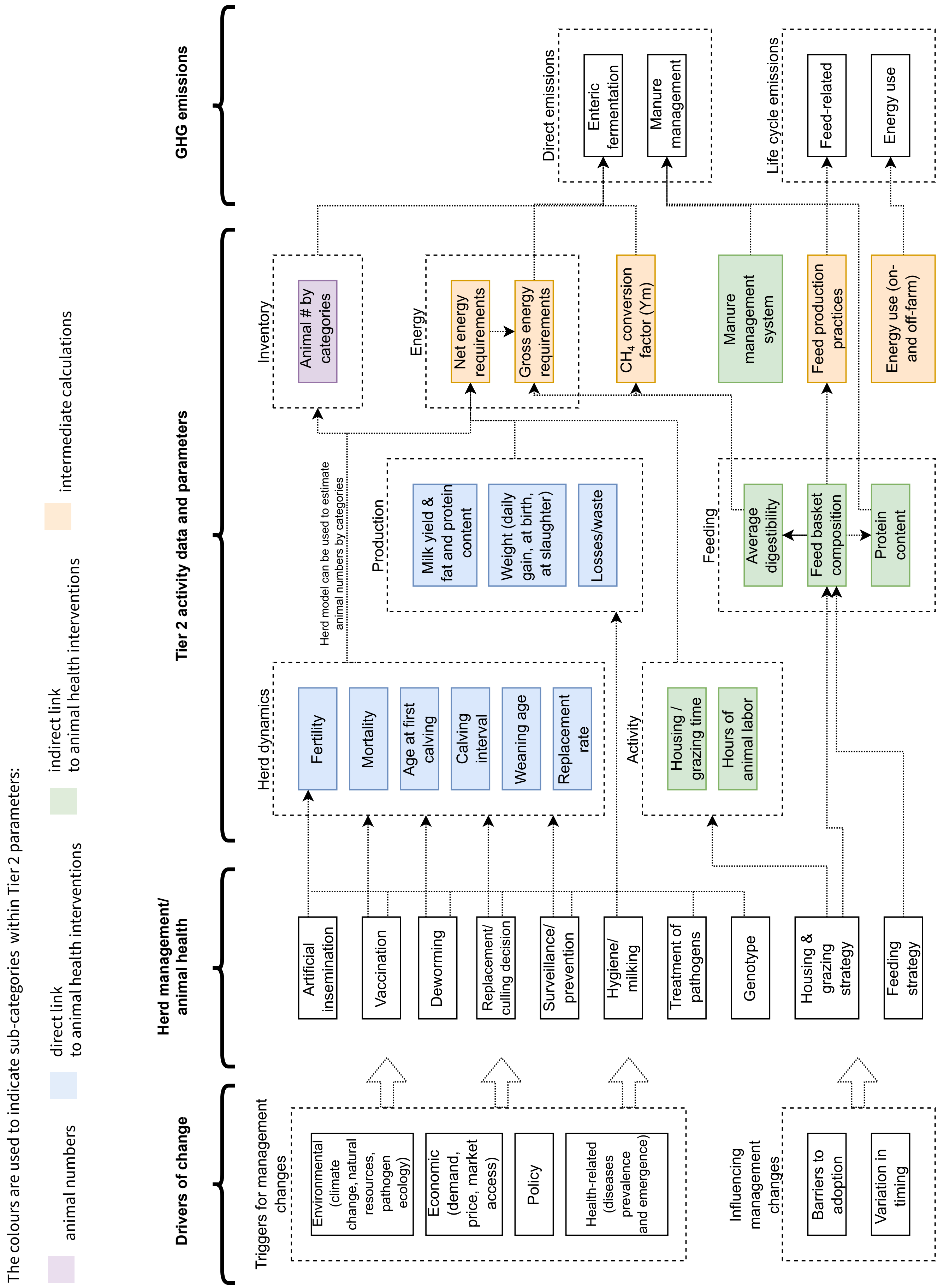
One outstanding challenge lies in how emissions from the livestock sector are reported in national GHG inventories and included in NDCs. The inventory methodology requires countries to report only the direct emissions produced per sector. For the livestock sector, this corresponds to CH_4 emissions from enteric fermentation, and CH_4 and N_2O emissions from manure management. Emissions from feed production, processing and transport and other emissions from energy use are reported under the "agricultural soils" or the energy sector. The impact of animal health interventions may cause trade-offs between direct emissions at animal level and emissions at herd or supply chain level, but the overall herd or supply-chain emissions may decrease due to a reduction in the number of replacement animals needed and therefore in the consumption and production of feed, which are not accounted for in direct emissions. These changes in indirect emissions should also be reflected.

Activity data on the impact of animal diseases and animal health improvements can be found from various sources, including literature reporting trials and measurements and modelling studies (see section 2 of this brief for various examples at different scales). However, the following limitations should be addressed to improve the availability of activity data:

- Mortality and fertility rates are usually not included in animal numbers as reported by national statistics. These numbers are usually not systematic censuses, but estimates based on assumptions on annual growth rates, and they usually do not reflect improvements in animal health. This can be addressed by more regular systematic animal censuses or surveys for better estimates of animal numbers or by the use of herd modelling.
- The methane conversion factor (Ym), percentage of feed energy converted to CH_4, used for estimating enteric CH_4 in Tier 2 methodology does not usually include potential changes resulting from animal health improvements. More studies quantifying this impact could help to generate more references. Tier 3 approaches with more complex models and data requirements may also be needed in certain circumstances.
- Products (i.e. milk or meat) that are discarded, as a result of a disease, for example, may not be accounted for in the total production as reported in the national statistics and therefore not necessarily included in the GHG inventory. This could be addressed with better estimates on waste and losses at various steps in the supply chains, including with data from meat and milk processors.
- Energy requirement of sick animals varies greatly from animal to animal and from disease to disease. Therefore, more research on the impact of diseases on Ym is needed to generate more references for activity data, in various contexts.


© FAO/Maxim Zmeyev

Figure 4. Overview of the linkages between animal health interventions and GHG emissions, as calculated with an IPCC Tier 2 approach. Extra details are provided on the calculation of enteric CH_4 emissions, but other emission categories are considered. Overarching drivers influencing animal health and management decisions are also highlighted. Source: Authors' elaboration based on Kipling *et al*. (2021) for drivers of change, and herd management/animal health interventions, and GLEAM/GLEAM-*i* (based on IPCC) for Tier 2 parameters and GHG emissions.



3.2. Enabling environment

NDCs are usually led in each country by the ministry of environment, where knowledge of livestock systems is not always sufficient for including productivity and efficiency as entry points for mitigation. As a result, reducing herd sizes is sometimes considered as the only option. Technical options specific to livestock are also sometimes included but may not be relevant or feasible for a large part of the national herd (e.g. fat supplementation in extensive grazing systems). This challenge highlights the need to increase awareness and capacity at national government level on the options available. It also emphasizes the need for institutional arrangements, tools tailored to country's contexts, and wide-ranging stakeholder consultations in formulation of the NDC targets and associated development of the implementation plan.

Inclusive collaboration with the ministry in charge of livestock, and regular communication among different ministries and agencies is, therefore, essential to identify individuals with knowledge on livestock and emissions (see case study 3). Capacity development and partnership building are key elements to sustain practice change and integrate climate-smart agriculture (CSA) into policies. Capacity development is needed at all levels: in information management, research, stakeholder processes and evidence-based decision-making (Arslan, 2017).

Institutional mapping aims to identify the role of all institutions with a mandate to support CSA objectives, and the gaps and obstacles addressed to ensure a supporting enabling environment for CSA (ibid. 2017). Governments' roles can also include strengthening veterinary services at national level with priorities at countries projected to be more vulnerable to or at risk of the impacts of climate change (FAO, 2020). Here, it is important for governments to realize that the endemic- and production-limiting diseases are a national problem to overcome, and therefore require capacity development (e.g. training, awareness raising), reporting and action plans specifically targeting them, involving all relevant stakeholders. The delivery of primary animal health services, most of which area is outside the public sector, is also key.

It is of crucial importance to identify the overarching policies and legislations related to linking animal health to national climate commitments. Screening of existing national agricultural development and investment plans, national climate change strategies, sustainable development plans, and/or key agriculture and climate change-related programs will be instrumental to identify any gaps and priority areas, for example national agriculture investment plans , nationally appropriate mitigation actions (NAMAs), national adaptation programmes of action, national communications to the United Nations Framework Convention on Climate Change (UNFCCC), programmes in developing countries to reduce emissions from deforestation and forest degradation, and the NDCs submitted to the UNFCCC in advance of the Paris Agreement (Arslan, 2017). For example, increased coordination among those supporting NDCs and national adaptation plans could also support the design of animal health interventions to meet both mitigation and adaptation goals and turn them into action.

Another key element is for countries to engage in projects that aim to improve efficiency in the sector, such as improvements in animal health (FAO, 2022). Such projects can be carried out at various scales, but large investments in livestock-focused actions are potentially more relevant for reporting in national inventories: a national vaccination campaign, as part of a project also aiming at improving feed quality and supply chains, can be identified as contributing to the mitigation ambition of the country (see case study 1 covering six countries). To this end, it is recommended that large livestock projects, as funded by governments or international finance institutions, also support the development of GHG emissions accounting systems (before or after the project) of which the results can then contribute to the national inventories.

For example, the World Bank's livestock portfolio has increased over the past 10 years, from an average of USD 150 million of new engagement per annum in 2010 to approximately USD 700 million per annum in 2019, 2020 and 2021. Using a joint multilateral development banks method, the World Bank estimates that the average climate co-benefits generated by its livestock portfolio was 61 percent in 2019-2021. This is higher than for the agriculture portfolio (57 percent) and represents an improvement compared to the average in the three previous years (55 percent) (van Niewkoop, 2021). Case study 1 presents an example of a national scale project operating across six countries in West Africa.

IFAD, as another International Finance Institute, has invested a total of USD 1.5 billion in livestock development projects which represent 7 percent of the total investment, over the last 40 years. There has been a significant increase in demand from Member States of IFAD for investments in the livestock sector with an average of USD 63.2 million per year during the period 2010-2020, targeting the poorest and marginalized livestock producers in low-to-middle income countries (LMIC). Investment in strengthening the availability and accessibility of animal health services represented 12.3 percent of the total (A. Rota, personal communication, 2022). Case study 2 presents an example from such project in Kyrgyzstan.

3.3. Research needs and evidence building

While the data and references listed in the previous section exist in countries that have established farm monitoring systems, they are still missing in most LMICs. A priority area of investment here is on linking up with various national statistics offices since these offices gather a wide range and significant amount of data, which could be used to assess the impact of diseases on GHG emissions. Next, research infrastructure needs further focus. For example, Merbold *et al.* (2021) developed a blueprint for establishing an environmental research infrastructure in Africa which would support the generation of such data and references. The blueprint comprises various components: an inventory of already existing observation sites; the spatial disaggregation of locations that helps reduce the uncertainty in forecasting of climate events; and an overall estimated cost for such a project for the whole continent over the next 30 years (estimated at USD 550 million). They also highlighted the necessity for the development of e-infrastructure, capacity and stakeholder inclusion to ensure ownership.

Investments to improve capacity of research to include forecasting and modelling complex dynamics between climate change and disease/vector distribution will be needed. Earlier studies on key parameters (Kipling *et al.*, 2021) and key performance indicators (Statham *et al.*, 2020) can shed some light on the approaches. It will be of importance to improve data on ongoing impacts and to promote research that can help forecast future animal health threats; promoting innovation and technology in animal health and improved surveillance for managing the threat of emerging diseases; and ensuring that the options addressing animal health are linked to other dimensions such as feeding, genetic resources, production systems, food safety and value chains (FAO, 2020). The effects of health conditions on feed intake, growth rate or production are relatively easier to quantify than measuring the impact on enteric CH_4 or the quantity of volatile solids contained in manure. Similarly, the limitations of the Tier 2 IPCC protocol using fixed equations based on DM and energy intake of animals do not sufficiently reflect changes in animal health conditions (Mackenzie and Kyriazakis, 2021) even though emissions intensity is highly sensitive to changes in digestibility and Ym factor (MacLeod *et al.* 2018). Further attempts can be made to improve the tools for inventory (e.g. IPCC equations) and tools for research and development (e.g. models). Experimental studies linking the feed and nutrition aspect to the animal health in the context of its impacts on GHG emissions are needed, especially to identify the attribution of animal health intervention to GHG emissions when there is more than one measure given different measures interact. It could be useful to first prioritise the diseases that have the highest impact and to generate data on the impact of priority animal diseases on Tier 2 parameters listed earlier e.g. fertility rate, mortality rate. Given that the herd parameters are potentially correlated, a stochastic analysis can better capture the impact of interventions.

LCA studies can assess the consequences of management changes on GHG emissions via the changes in mortality rates, fertility rates, the utilization of feed and quality characteristics of products from the farming system, but the epidemiological data may be available only at animal or herd level, making it difficult to scale-up to national level modelling (Mackenzie and Kyriazakis, 2021). Current standard methods use metrics on edible meat or carcass weight with no distinction to nutritional quality. Fat and protein corrected milk (FPCM), for example, uses a standard fat and protein content. Similarly, allocating emissions in LCA studies not only to edible products, but also to other products, for example manure, and other functions such as social value and resilience is likely to affect the results (MacLeod *et al.* 2018). While nutritional functional units can be more helpful in tackling this, the data on the chemical properties of livestock tissue during disease are not readily available (Mackenzie and Kyriazakis, 2021). The unit in which the results are reported is also important. For example, parasitism can reduce the daily enteric CH_4 production while not affecting (Houdijk *et al.*, 2017) or increasing (Fox *et al.*, 2018) the CH_4 yield per unit of DM intake, but increase the CH_4 yield per unit of digestible organic matter intake. Similarly, daily CH_4 and N_2O emissions from manure may not change but CH_4 and N_2O from manure may increase per unit of DM intake and per unit of digestible organic matter intake (Houdijk *et al.*, 2017).

Current models are usually limited to quantifying GHG emissions only, however, in the future, it will be important to consider the incorporation of other environmental externalities, for example eutrophication, acidification, water use and abiotic resource use to capture the trade-offs (Mackenzie and Kyriazakis, 2021). Even though the experimental studies focus mostly on the impact on enteric CH_4 emissions, the impact on manure CH_4 and N_2O can also have a significant importance (Houdijk *et al.*, 2017). Even though the majority of the focus is on ruminants (and mostly extensive systems for being prone to production limitations from endemic diseases such as pasture-borne parasites), it will be necessary to expand the focus to pig and poultry systems as they take up an increasing proportion of livestock products consumed globally, and consider the accompanying side effects, such as land use and feed-food competition. Integrating economic aspects into environmental modelling in order to identify most cost-effective mitigation measures will also be important. This can also facilitate the distribution of funding and subsidies for certain health interventions.

3.4. Measurement, reporting and verification proposition

Based on the impacts identified in section 2 of this brief and the challenges listed in section 3, an MRV for including animal health in national climate commitments was drafted, using the example of vaccination (Figure 5).

Figure 5. Proposition of an MRV to include the impact of vaccination in national GHG inventory or NDC

PROPOSITION OF AN MRV FOR VACCINATION AND HOW IT CAN CONTRIBUTE TO NATIONAL CLIMATE COMMITMENTS

Pre-conditions to support integration of MRV results into GHG inventory/NDC

- Awareness raising with government lead agency/ministry (and producers and industry associations) from first step of the process
- Capacity building on methods and tools, targeting lead agency/ministry and other stakeholders e.g. industry and academia
- Coordination with other sub-sectors (e.g. for emissions on feed, soil carbon sequestration)
- If vaccination provided through large scale project, involve management unit (e.g. World Bank, IFAD) in MRV process

Enabling environment: Process

- Responsibility of MRV system and institutional arrangement decided by government with stakeholders
- Data collected via regular and systematic animal censuses, farm monitoring systems, surveillance/animal health information systems and/or stakeholder consultations (workshops, surveys)
- Data system maintained by an institution designated by the government to ensure coherence and transparency, in collaboration with all stakeholders

1. Establish the required baseline of emissions using IPCC Tier 2 (or 3) methodology

ACTIVITY DATA NEEDED:

- Number of beneficiary animals per cohort (e.g. adult females, heifers) or herd parameters for modeling (e.g. fertility/mortality rates, age at first calving)
- Production data (weights and milk yields)
- Losses/waste
- Animal feed rations (composition and quality)
- Manure management system

2. Assess the expected impact of vaccination on activity data

EXPECTED IMPACT NEEDED ON:

- Animal numbers or herd parameters such as mortality (morbidity, disease prevalence) and fertility rates
- Feed consumption (via energy requirements)
- CH_4 conversion factor (Ym)

3. Calculate the change in emissions and monitor regularly

- Choose tool to calculate baseline and w/vaccination (e.g. GLEAM-*i*, Cool Farm Tool)
- Consider LCA to also capture impact on indirect emissions (e.g. reduced emissions from feed crops, pastures, energy used)

Enabling environment: Who provides what

For step 1:

- Veterinary and animal health services
- Farm monitoring and disease surveillance systems (public or private)
- Industry
- National project management units (e.g. World Bank, IFAD, FAO)

For step 2:

- Research and extension (studies on animal health and livestock performance)
- Industry data

For step 3:

- Agency responsible for MRV system

CASE STUDY 1

Technical assistance to better account for climate co-benefits of animal health in six countries: the Regional Sahel Pastoralism Support Project (PRAPS-2) (World Bank)

A USD 375-million project funded by the World Bank in six countries of West Africa includes a large animal health component that has significant climate co-benefits, though not accounted for yet in the national inventories and climate commitments. The second phase of PRAPS is expected to benefit an estimated 13 million people in Burkina Faso, Chad, Mali, Mauritania, Niger and Senegal. The project will invest in more robust animal health systems – from harmonized animal disease control and eradication strategies, scale-up of vaccination for PPR and CBPP, and disease surveillance programs to stronger veterinary services and controls on veterinary medicines. In particular, there will be a significant incentive to build, rehabilitate or upgrade critical infrastructure such as veterinary units, border inspection posts, vaccination pens, livestock markets and rest areas along transhumance and trade routes. The impact of PRAPS-2 interventions on GHG emissions was calculated by FAO using the tool GLEAM-*i* as part of the environmental and social safeguard mechanism of the World Bank. The primary data necessary for this analysis were collected together with the PRAPS-2 preparation team in each country. Impact of improving animal health was reflected by increased fertility rate, live weight and reduced mortality rate. Droughts, on the other hand, were expected to reduce fertility, increase mortality, reduce live weights and milk yield. Offtake rates were expected to increase due to an improved access to markets and enhanced livestock commercialization. Increased offtake rates (but also droughts) compensate partly or entirely the impact of improvements on the number of reproductive animals. In addition, feed quality was marginally improved to reflect the development of fodder crops and improved rangelands management, which are also part of PRAPS-2.

The project was estimated to have a net negative balance of 399 828 t CO_2e/year on average for the six countries. In particular, it was estimated that the project would not result in an increase of emissions from livestock despite large improvements in animal health, and an increase of total protein production (meat + milk) of 20 percent. Emissions per kg of protein are expected to reduce by 17 percent.

FAO will continue to work with the governments of the six countries and with the World Bank to better account of the climate co-benefits of PRAPS-2 in national climate commitments. This requires in particular ongoing technical assistance and training on tools, data and methods in order to develop the capacity of the project teams in the governments of the six countries to estimate and monitor emissions as they are affected by PRAPS-2 activities. Inventory and NDC teams in each country are also included in this technical assistance (Figure 6).

West Africa

Figure 6. MRV system for the assessment of animal health interventions from PRAPS-2 project in six countries in the Sahel

PRAPS-2 CASE STUDY

Status of integration of MRV results into GHG inventory/NDC	Enabling environment: Who provides what
▸ No inclusion yet ▸ Awareness raising and capacity building have started ▸ Connection between project and national-level MRV systems to be established ▸ Direct emissions extracted from GLEAM-*i*, LCA emissions and global warming potential adapted to inventory/NDC requirements	▸ Conducted by FAO for the World Bank, and targeting government and World Bank staff at country level
1. Establish the required baseline of emissions using IPCC Tier 2 (or 3) methodology	
ACTIVITY DATA NEEDED: ▸ Number of beneficiary animals (by species and type of vaccination) ▸ Herd parameters for modeling animal numbers: fertility and mortality rates, age at first calving ▸ Production data: weights and milk yields ▸ Animal feed rations (composition and quality) ▸ Manure management system	▸ World Bank project management units provided most data, based on consultations with veterinary services and government livestock services
2. Expected impact of vaccination on activity data	
▸ Reduced mortality and increased fertility rates ▸ Increased weights and milk yields and increased feed consumption ▸ Feed ration: decrease in crop residues and increase in grazing	▸ Literature review and consultation at regional and country level
3. Calculate the change in emissions and monitor regularly	
▸ Tool: GHG emissions calculator GLEAM-*i*, coupled with the Livestock Sector Policy and Investments Toolkit	▸ FAO carried out the ex-ante GHG emissions assessment for the World Bank

CASE STUDY 2

An approach to include animal health improvements in the NDC revision process: the Regional Resilient Pastoral Communities Project (RRPCP) in Kyrgyzstan (IFAD)

FAO and IFAD collaborated to estimate the impact of a large-scale livestock project in Kyrgyzstan and to pave the way for its inclusion in the national inventory and in future NDC revisions. The RRPCP aims to reduce poverty in rural areas by improving productivity of pastures and animals and enhancing climate-resilience of pastoral communities. The project has specific targets to improve animal health and productivity. The approach taken and the data used to calculate the GHG emissions associated with project activities were reported in IFAD and FAO (2021). FAO estimated the impact of the project interventions on GHG emissions using the tool GLEAM-*i*. Sources of emissions covered by GLEAM-*i* are LCA emissions from the production of inputs up to the farm gate (FAO, 2021). The collection and validation of data were made possible through stakeholder consultations including animal production scientists, private sector, government officials and veterinary services, in addition to reviewing project documents and literature for complementing information.

The steps taken during this assessment were: i) identify measure: Vaccination (*Brucellosis*, Food and Mouth Disease and sheep/goat pox), improved breeding = improved health and improved reproduction; ii) define parameters and how they relate to one another based on project objectives: mortality rate, replacement rate, age at first parturition, live weight, in addition to feed and manure management; iii) search for project targets and specific changes to parameters to reflect the improvements through literature and expert opinions; iv) select an approach and a tool: Approach: Data validation workshops, expert opinions, literature review, LCA emissions, direct emissions (for NDC input). Tool: GLEAM-*i*; and v) report the impact: Absolute emissions, emissions intensity, feed intake, protein production. Animal numbers in scenario with project were assumed to remain same as in the baseline while in scenario without project increased based on projected GDP agriculture (for NDC figures) and by 20 percent (for LCA figures).

Results from the overall assessment of the project, implementing a combination of measures including vaccination, showed a 17 percent reduction in total emissions, 20 percent reduction in emissions intensity, 4 percent increase in protein production and 15 percent reduction in feed intake. The calculations made as an input to the NDC update comparing 2022 to 2025 and 2030 showed that total emissions were reduced by 11 percent in 2025 and 24 percent in 2030 while emissions intensity was reduced by 21 percent in both years (Figure 7).

Kyrgyzstan

Figure 7. MRV system for the assessment of animal health interventions in Kyrgyzstan. GIZ is the German Agency for International Cooperation and UNIQUE is a consultancy firm specialized in climate change

KYRGYZSTAN CASE STUDY

Status of integration of MRV results into GHG inventory/NDC

- Results published (IFAD & FAO, 2021) and included in the analysis of livestock and pasture sub-sectors by the Kyrgyz Ministry of Economy (Abdurasulova *et al.*, 2021)
- Results presented and discussed with government and all agencies involved in NDC revision, in series of meetings including a side event at COP26

Results not included in 2021 NDC revision, which focused on reducing herd size and biogas production. Further recommendations were formulated for future revision:

- Development of technical capacity in lead agency and government on Tier 2 and how livestock interventions can be quantified and included in NDC
- Better inclusion of relevant livestock actors in NDC process, including for collection and maintenance of quality activity data
- Better alignment of funding sources (Green Climate Fund , Adaptation Fund, NAMA facility) with NDC
- MRV system should include i) policies, plans & measures, ii) measurement; and iii) review to meet obligations under the Enhanced Transparency Framework

Enabling environment: Who provides what

- United Nations Development Program led the NDC update
- FAO + partners (UNIQUE and GIZ) provided results to include in the NDC update and to support Kyrgyzstan in mobilizing external climate finance for conditional targets

- Public and private sector investment to improve animal productivity, develop farmers' capacity and increase pasture productivity
- Inter-agency coordination

1. Establish the required baseline of emissions using IPCC Tier 2 (or 3) methodology

ACTIVITY DATA NEEDED:
- Number of beneficiary animals (by species)
- Herd parameters to estimate the number of animals in each cohort
- Animal feed rations (composition and quality)
- Manure management system

Who provides what:
- IFAD project management unit provided data based on economic & financial analysis
- Multistakeholder workshops to verify or revise default data

2. Expected impact of vaccination on activity data

- Reduced mortality, increased cattle fertility, increased weights and milk yield
- Improved feed ration for cattle (increased share of sugar beet and crop residues from maize, silage from maize, decreased share of crop residues from wheat and other grains, grazing)

Who provides what:
- Literature review, consultations with national experts/stakeholders

3. Calculate the change in emissions and monitor regularly

- Tools: GHG emissions calculator (GLEAM-*i*), Political, Economic (and Financial), Social, Technological, Legal (and Institutional), and Environmental multicriteria framework for adaptation

Who provides what:
- FAO carried out GHG emissions assessment
- UNIQUE consolidate results between project and government interventions

CASE STUDY 3

An initiative mobilizing all actors in the sector: low-carbon dairy in France

The low-carbon dairy initiative (https://www.low-carbon-dairy-farm.com/) aiming to reduce GHG emissions from dairy farms offers dairy farmers individual advice and solutions, specifically adapted to their farm and ambitions. Among the main cost-effective mitigation measures identified are herd and manure management (including herd health and milk yield and genetic improvement, heifers and replacement rate and better use of manure) with a potential of 10-15 percent reduction (Dollé, 2019). Improving animal health is one of the main action points proposed to farmers to build their mitigation action plans. Participating dairy farms commit to reducing the carbon footprint of their milk by 20 percent between 2013 and 2023 (from all measures implemented, including animal health). The emissions are estimated by *calcul automatisé des performances environnementales pour des exploitations responsables* (CAP'2ER®), a diagnostic tool developed by the French Livestock Institute (IDELE). CAP'2ER® follows a combination of Tier 2 and 3 of IPCC methodology to calculate the environmental impacts of interventions. There are two levels of assessment in the CAP'2ER®: Level 1 is a simplified analysis and aims to develop an observatory and highlight the links between practices and the environment. Level 2 is a more comprehensive analysis aiming to simulate mitigation practices and build individual carbon action plans and access carbon markets. The support for Level 2 assessment in the field is made possible with the assistance of advisors from chambers of agriculture, French milk recording umbrella companies and dairy companies. Funding from both state and private sector has supported the implementation of the project on a large scale.

According to the analysis carried out with CAP'2ER®, an average French farm emits 611 635 kg CO_2e/year; maintains 90 ha of biodiversity, stores 60 900 kg CO_2e/year, corresponding to 16 600 kg carbon, offsetting 11 percent of GHG emissions through photosynthesis, grassland and hedges; and feeds 1 840 people based on the protein content of its production (Danilo *et al.*, 2017).

The main barriers to adopting low-carbon practices were identified as: uncertainty in yield benefit, lack of approved carbon accounting methodologies, monitoring tools to certify carbon reductions, and the lack of awareness on the financial support of low-carbon strategies (Dollé, 2019). Facing these barriers, a monitoring protocol has been developed.

The low-carbon dairy project works at farm level. Inventories, on the other hand, may not be sensitive to mitigation measures applied at individual farms, since the scale of activity data that characterize farm efficiency and environmental impacts is farm-specific. However, in order to make sure that inventory methodologies are improved and the mitigation achieved by low-carbon dairy is reflected in the GHG inventory in the future, the initiative is collaborating with the Interprofessional Technical Centre for Studies on Air Pollution (CITEPA) (https://www.citepa.org/fr/presentation/), a non-profit organization that calculates, verifies and disseminates information on GHG emissions and atmospheric pollutants. CITEPA produces emissions inventories operating on behalf of the French Ministry of Ecological and Solidarity Transition. The members of CITEPA include industry, trade bodies, energy production and distribution companies, consultancy companies, research institutes, measuring laboratories and approved associations for monitoring air quality (Figure 8).

Figure 8. MRV system for the assessment of mitigation packages at farm level in France, including animal health interventions

FRANCE CASE STUDY	
Status of integration of MRV results into GHG inventory/NDC	**Enabling environment: Who provides what**
► Need a process to move from farm level monitoring (including activity data and emissions) to national level inventory and NDC ► Collaboration established with the organization operating on behalf of the government to verify and disseminate information on GHG emissions inventories (multistakeholder membership)	► Research institute and extension services ► Ministry of Agriculture ► Ministry of Environment ► CITEPA
1. Establish the required baseline of emissions using IPCC Tier 2 (or 3) methodology	
► Beneficiaries: 12 800 dairy farmers and their animal numbers and herd composition ► Activity data (total of 29 or 150 depending on the level of analysis) collected during farm interviews and feeding into a national farm database	► Research institute and farmers, in collaboration with extension services and private sector
2. Expected impact of vaccination on activity data	
► Package of animal health, reproduction, manure and genetic improvement results 10–15% reduction in emissions	► Research institute and farmers, in collaboration with extension services and private sector
3. Calculate the change in emissions and monitor regularly	
► Tool: CAP'2ER® diagnostic tool ► 1 200 farm advisors trained for method and tool for diagnostic ► Initial farm diagnostic and follow-up appraisal after five years to assess improvement and collect new activity data ► A certification scheme for GHG emissions reduction in agriculture: CARBON AGRI	► Research institute and extension services ► Ministry of Agriculture for the certification

Some common lessons learnt from the case studies

The three case studies included in this brief showed that many animal health interventions focus on capacity and broad application of general animal health supports rather than focusing on specific diseases. This is because policy and development actions generally aim to target multiple entry points at once. It also makes it more challenging to quantify and disaggregate the impacts of animal health interventions on GHG emissions.

This quantification relies mostly on monitoring and data availability/quality not only at production level but also in value chains, which requires substantial financial resources. While such resources may be limited in LMICs, it is also in these countries that the biggest potential lies to achieve the benefits of improved animal health on GHG emissions.

All three case studies also show that this quantification is possible in various countries and contexts, whether animal health interventions are implemented through large development projects at national (case study 1) or sub-national level (case study 2) or through the engagement of farmers with the support of the whole supply chain (case study 3). Coordination with the different government agencies/ministries involved as well as capacity building and adequate tools is key in all three cases.

References

Abdurasulova, G., Wassie, S., Özkan, Ş., Mundy, O., Mottet, A., Eralieva, M., Ibraimova, A., Tenningkeit, T. & Wilkes, A. 2021. *Analysis of livestock and pasture sub-sectors for the NDC revision in Kyrgyzstan*. link

ADAS. 2015. *Study to model the impact of controlling endemic cattle diseases and conditions on national cattle productivity, agricultural performance and greenhouse gas emissions.* link

Arslan, A. 2017. The Theory of Change for the CSA Approach: A Guide to Evidence-Based Implementation at the Country Level. Available SSRN 3300001. link

Buto, O., Galbiati, G., Alekseeva, N. & Bernoux, M. 2021. *Climate finance in the agriculture and land use sector – global and regional trends between 2000 and 2018*. Rome, Italy. link

Danilo, S., Brocas, C., Dollé, J.-B., Lejard, A., Blondel, A., Morin, C., Prigent, A. & Sicot, I. 2017. *Overall results of life carbon dairy.* link

Dollé, J.-B. 2019. *Partnerships for dairy and beef low carbon initiatives in France.* 7th Greenhouse Gas and Animal Agriculture Conference, Iguassu, Brazil. link

Drieux, E., Van Uffelen, A., Bottigliero, F., Kaugure, L. & Bernoux, M. 2021. *Understanding the future of Koronivia Joint Work on Agriculture.* Boosting Koronivia. Rome, Italy. link

FAO. 2020. *Animal health and climate change*. Rome, Italy. link

FAO. 2021. *Global Livestock Environmental Assessment Model – Interactive* (GLEAM-i). Guidelines, Version 1.9. link

FAO. 2022. *Prioritizing the reduction of methane in livestock climate actions in the Eastern Africa Region* – Policy brief

FAO & GDP. 2018. *Climate change and the global dairy cattle sector: The role of the dairy sector in a low-carbon future*. link

FAO & GRA. 2020. *Livestock activity data guidance (L-ADG): methods and guidance on compilation of activity data for Tier 2 livestock GHG inventories.* link

FAO & NZAGRC. 2017a. *Options for low emission development in the Kenya dairy sector - reducing enteric methane for food security and livelihoods.* Rome, Italy. link

FAO & NZAGRC. 2017b. *Low-emissions development of the beef cattle sector in Argentina*. link

FAO & NZAGRC. 2017c. *Supporting low emissions development in the Ethiopian dairy cattle sector – reducing enteric methane for food security and livelihoo*ds. link

FAO & NZAGRC. 2017d. *Options for low emission development in the Bangladesh dairy sector – reducing enteric methane for food security and livelihood*s. link

FAO & NZAGRC. 2017e. *Options for low-emission development in the Sri Lanka dairy sector – reducing enteric methane for food security and livelihoods*. link

FAO & NZAGRC. 2019a. O*ptions for low emission development in the Uganda dairy sector - reducing enteric methane for food security and livelihoods*. link

FAO & NZAGRC. 2019b. *Options for low emission development in the Tanzania dairy sector - reducing enteric methane for food security and livelihoods*. link

FAO & NZAGRC. 2019c. *Soutenir un développement à basses émissions des secteurs laitiers pastoraux et agropastoraux en Afrique de l'Ouest* (Bénin, Burkina-Faso, Mali, Niger & Sénégal). link

Fox, N.J., Smith, L.A., Houdijk, J.G.M., Athanasiadou, S. & Hutchings, M.R. 2018. Ubiquitous parasites drive a 33 percent increase in methane yield from livestock. *Int. J. Parasitol*. 48, 1017–1021. link

Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A. & Tempio, G. 2013. Tackling climate change through livestock: a global assessment of emissions and mitigation opportunities. Food and Agriculture Organization of the United Nations (FAO). link

Hammer, T.J., Fierer, N., Hardwick, B., Simojoki, A., Slade, E., Taponen, J., Viljanen, H. and Roslin, T., 2016. Treating cattle with antibiotics affects greenhouse gas emissions, and microbiota in dung and dung beetles. Proceedings of the Royal Society B: Biological Sciences, 283(1831), p.20160150. link

Houdijk, J.G.M., Tolkamp, B.J., Rooke, J.A. & Hutchings, M.R. 2017. Animal health and greenhouse gas intensity: The paradox of periparturient parasitism. *Int. J. Parasitol*. 47, 633–641. link

IFAD & FAO. 2021. *Low-carbon livestock development in Kyrgyzstan: Quantifying the future impact of the Regional Resilient Pastoral Communities Project on greenhouse gas emissions* (by Özkan Ş, Mottet A, Mundy O). link

IPCC. 2019. *2019 refinement to the 2006 IPCC guideliness for national greenhouse gas inventories*. link

Kipling, R.P., Bannink, A., Bartley, D.J., Blanco-Penedo, I., Faverdin, P., Graux, A.-I., Hutchings, N.J., Kyriazakis, I., Macleod, M., Østergaard, S., Robinson, T.P., Vitali, A., Ahmadi, B.V. & Özkan, Ş. 2021. Short communication: Identifying key parameters for modelling the impacts of livestock health conditions on GHG emissions. *Animal* 15. link

Mackenzie, S. Kyriazakis, I. 2021. Quantifying the contribution of livestock health issues to the environmental impact of their production systems, in: R, B. (Ed.), *Reducing GHG Emissions from Livestock Production*. link

MacLeod, M., Eory, V., Wint, W., Shaw, A., Gerber, P.J., Cecchi, G., Mattioli, R., Sykes, A. & Robinson, T. 2018. Assessing the Greenhouse Gas Mitigation Effect of Removing Bovine Trypanosomiasis in Eastern Africa. *Sustainability*. link

MacLeod, M. & Moran, D. 2017. Integrating livestock health measures into marginal abatement cost curves. Rev. Sci. Tech. Off. Int. Epiz 36, 0. link

Merbold, L., Scholes, R.J., Acosta, M., Beck, J., Bombelli, A., Fiedler, B., Grieco, E., Helmschrot, J., Hugo, W. & Kasurinen, V. 2021. Opportunities for an African GHG observation system. *Reg. Environ. Chang*. 21, 1–12. link

Mostert, P. 2018. *The impact of diseases in dairy cows on greenhouse gas emissions and economic performance*. Wageningen University. link

Mostert, P.F., Bokkers, E.A.M., De Boer, I.J.M. & Van Middelaar, C.E., 2019. Estimating the impact of clinical mastitis in dairy cows on GHG emissions using a dynamic stochastic simulation model: a case study. *Animal* 13, 2913–2921. link

Mostert, P.F., Van Middelaar, C.E., De Boer, I.J.M. & Bokkers, E.A.M. 2018. The impact of foot lesions in dairy cows on greenhouse gas emissions of milk production. *Agric. Syst*. 167, 206–212. link

Mottet, A., Henderson, B., Opio, C., Falcucci, A., Tempio, G., Silvestri, S., Chesterman, S. & Gerber, P.J. 2017. Climate change mitigation and productivity gains in livestock supply chains: insights from regional case studies. *Reg. Environ. Chang*. 17, 129–141. link

Özkan Gülzari, Ş., Vosough Ahmadi, B. & Stott, A.W. 2018. Impact of subclinical mastitis on greenhouse gas emissions intensity and profitability of dairy cows in Norway. *Prev. Vet. Med*. 150, 19–29. link

Özkan, Ş., Vitali, A., Lacetera, N., Amon, B., Bannink, A., Bartley, D.J., Blanco-Penedo, I., De Haas, Y., Dufrasne, I., Elliott, J., Eory, V., Fox, N.J., Garnsworthy, P.C., Gengler, N., Hammami, H., Kyriazakis, I., Leclère, D., Lessire, F., Macleod, M., Robinson, T.P., Ruete, A., Sandars, D.L., Shrestha, S., Stott, A.W., Twardy, S., Vanrobays, M.-L., Vosough Ahmadi, B., Weindl, I., Wheelhouse, N., Williams, A.G., Williams, H.W., Wilson, A.J., Østergaard, S. & Kipling, R.P. 2016. Challenges and priorities for modelling livestock health and pathogens in the context of climate change. *Environ. Res*. 151, 130–144. link

Rose, S., Khatri-Chhetri, A., Stier, M., Vu Hong, T. & Nelson, K. 2021a. *Agricultural sub-sectors in new and updated NDCs: 2020-2021.* CCAFS dataset version 2.0. Wageningen. link

Rose, S., Khatri-Chhetri, A., Stier, M., Wilkes, A., Shelton, S., Arndt, C. & Wollenberg, E. 2021b. *Livestock management ambition in the new and updated NDC: 2020-2021: Analysis of agricultural sub-sectors in national climate change strategies*. CGIAR Research Program on Climate Change, Agriculture and Food Security. link

Skuce, P.J., Bartley, D.J., Zadoks, R.N. & Macleod, M. 2016. *Livestock health and greenhouse gas emissions*. Edinburgh, UK. link

Statham, J., Scott, H., Statham, S., Acton, J., Williams, A. &Sandars, D. 2020. *Dairy cattle health and greenhouse gas emissions pilot study: Chile, Kenya and the UK*. link

UNFCCC. 2021. *Conference of the Parties serving as the meeting of the Parties to the Paris Agreement.* link

United Nations, 2015. Paris agreement, in: *Report of the Conference of the Parties to the UNFCCC* (21st Session, 2015: Paris). link

van Niewkoop, M. 2021. *State of World Bank investment in Sustainable Livestock*. link

Wilkes, A. & van Dijk, S. 2018. *Tier 2 inventory approaches in the livestock sector: a collection of agricultural greenhouse gas inventory practices*. link

World Bank. 2020. *Opportunities for climate finance in the livestock sector*. link

CC0431EN/1/07.22