Foreword

It is easy to draw a dramatic picture of today's world. Climate change, the most serious environmental challenge humanity has to face, is threatening the well-being of the next generation. Globalization has led to rapid economic, social and technological changes that have left too many behind. Hunger is still a persistent problem, affecting over 900 million human beings worldwide. Faced with these issues, we sometimes feel overwhelmed by their magnitude and powerless.

But we need not despair. Difficult problems can be tackled for the benefit of many if we apply the right policies that support the required innovation and investment.

We have known for several years that livestock supply chains are an important contributor to climate change. This new report shows that the potential to significantly reduce emissions exists and is within reach. Options are available for all species, systems and regions. But we need political will and better policies.

The report provides much-needed data that will allow us to move forward. It presents an evidence-based picture of emissions with data broken down by species, agro-ecological zones, regions and production systems. The breadth of information provided by this report and the two complementary technical reports[1] reflect the vast diversity of the livestock sector.

A detailed understanding of the magnitude, sources and pathways of emissions is essential to inform policy dialogue and avoid oversimplifications. It will help us to make more informed choices about livestock policies in support of sustainable food production, economic growth and poverty alleviation.

This report identifies ways of reducing emissions by assessing the mitigation potential of sets of technologies. Such analysis provides guidance for local and system-specific solutions, as sector actors seek to improve sustainability and viability, but also for more targeted pro-poor livestock development.

The work of the Food and Agricultural Organization of the United Nations (FAO) in assessing the environmental impact of livestock production (of which this report forms part) has triggered the interest and support of multiple partners engaging with FAO to improve data and analysis. The Livestock Environmental Assessment and Performance (LEAP) Partnership focuses on the development of broadly recognized sector-specific guidelines and metrics for assessing and monitoring the environmental performance of the sector.

Increasingly, sector actors realize that the growing scarcity of natural resources may well shape the sector's future and they have started to address its environmental impact. Reflecting these concerns, a wide range of partners have engaged in a global policy dialogue with FAO. The Global Agenda of Action in support of Sustainable Livestock Sector Development aims to catalyse and guide stakeholder action towards the improvement of practices for a more efficient use of natural resources.

[1] FAO, 2013a. *Greenhouse gas emissions from ruminant supply chains – A global life cycle assessment.*
FAO, 2013b. *Greenhouse gas emissions from pig and chicken supply chains – A global life cycle assessment.*

Better knowledge and growing willingness to act create a momentum to tackle climate change with livestock. We should not miss it. As the effect of climate has started to be felt in everyone's life, collective action is now urgently needed.

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Overview

Climate change is transforming the planet's ecosystems and threatening the well-being of current and future generations. To "hold the increase in global temperature below 2 degrees Celsius" and avoid "dangerous" climate change,[2] deep cuts in global emissions are urgently required.

The global livestock sector contributes a significant share to anthropogenic GHG emissions, but it can also deliver a significant share of the necessary mitigation effort.

Concerted and collective action from all sector stakeholders is urgently required to ensure that existing and promising mitigation strategies are implemented. The need to reduce the sector's emissions and its environmental footprint has indeed become ever more pressing in view of its continuing expansion to ensure food security and feed a growing, richer and more urbanized world population.

LIVESTOCK: A SIGNIFICANT CONTRIBUTOR TO CLIMATE CHANGE

With emissions estimated at 7.1 gigatonnes CO_2-eq per annum, representing 14.5 percent of human-induced GHG emissions, the livestock sector plays an important role in climate change.

Beef and cattle milk production account for the majority of emissions, respectively contributing 41 and 20 percent of the sector's emissions. While pig meat and poultry meat and eggs contribute respectively 9 percent and 8 percent to the sector's emissions. The strong projected growth of this production will result in higher emission shares and volumes over time.

Feed production and processing, and enteric fermentation from ruminants are the two main sources of emissions, representing 45 and 39 percent of sector emissions, respectively. Manure storage and processing represent 10 percent. The remainder is attributable to the processing and transportation of animal products.

Included in feed production, the expansion of pasture and feed crops into forests accounts for about 9 percent of the sector's emissions.

Cutting across categories, the consumption of fossil fuel along the sector supply chains accounts for about 20 percent of sector emissions.

IMPORTANT REDUCTIONS IN EMISSIONS WITHIN REACH

Technologies and practices that help reduce emissions exist but are not widely used. Their adoption and use by the bulk of the world's producers can result in significant reductions in emissions.

Emission intensities (emissions per unit of animal product) vary greatly between production units, even within similar production systems. Different farming practices and supply chain management explain this variability. Within the gap between the produc-

[2] Copenhagen Accord, 2009. COP 15.

tion units with the lowest emission intensities and those with the highest emission intensities, lies an important potential for mitigation.

A 30 percent reduction of GHG emissions would be possible, for example, if producers in a given system, region and climate adopted the technologies and practice currently used by the 10 percent of producers with the lowest emission intensity.

EFFICIENT PRACTICES KEY TO REDUCING EMISSIONS

There is a direct link between GHG emission intensities and the efficiency with which producers use natural resources. For livestock production systems, nitrous oxide (N_2O), methane (CH_4) and carbon dioxide (CO_2) emissions, the three main GHG emitted by the sector, are losses of nitrogen (N), energy and organic matter that undermine efficiency and productivity.

Possible interventions to reduce emissions are thus, to a large extent, based on technologies and practices that improve production efficiency at animal and herd levels. They include the use of better quality feed and feed balancing to lower enteric and manure emissions. Improved breeding and animal health help to shrink the herd overhead (i.e. unproductive part of the herd) and related emissions.

Manure management practices that ensure the recovery and recycling of nutrients and energy contained in manure and improvements in energy use efficiency along supply chains can further contribute to mitigation. Sourcing low emission intensity inputs (feed and energy in particular) is a further option.

ADDITIONAL PRACTICES WITH PROMISING MITIGATION POTENTIAL

Grassland carbon sequestration could significantly offset emissions, with global estimates of about 0.6 gigatonnes CO_2-eq per year. However, affordable methods for quantifying sequestration, as well as a better understanding of institutional needs and economic viability of this option, are required before it can be implemented at scale.

A range of promising technologies such as feeding additives, vaccines and genetic selection methods have a strong potential to reduce emissions but require further development and/or longer time frames to be viable mitigation options.

MITIGATION INTERVENTIONS TO CONTRIBUTE TO DEVELOPMENT

Most mitigation interventions can provide both environmental and economic benefits. Practices and technologies that reduce emissions can often simultaneously increase productivity, thereby contributing to food security and economic development.

MITIGATION POTENTIAL ACROSS THE BOARD

Substantial emission reductions can be achieved across all species, systems and regions. Mitigation solutions will vary across the sector as emission sources, intensities and levels vary amongst species, production systems and regions, but the mitigation potential can be achieved within existing systems; this means that the potential can be achieved as a result of improving practices rather than changing production systems (i.e. shifting from grazing to mixed or from backyard to industrial).

The major mitigation potential lies in ruminant systems operating at low productivity (e.g. in South Asia, Latin America and the Caribbean, and Africa). Part of the mitigation potential can be achieved through practices related to better feeding, animal health and herd management.

In the most affluent regions, where emission intensities of ruminant production are relatively low but the volume of production and emissions remain high, small reductions in emission intensity can nonetheless result in large emission reductions (e.g. dairy production in Europe and North America). In these areas where animal and herd efficiency is already high, mitigation can be achieved by improvements in other farm operations such as manure management, energy use and the sourcing of feed with lower emission intensity.

Sizeable reductions could also be achieved in intermediate pork and poultry production systems, in particular, in East and Southeast Asia which rely on purchased, high emission intensity inputs, but do not operate at high efficiency levels.

ENABLING ENVIRONMENTS CRUCIAL FOR UNLEASHING MITIGATION POTENTIAL

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

Awareness-raising and extension are important first steps towards the adoption of better technologies and practices. These require investments in communication activities, demonstration farms, farmer field schools, farmer networks and training programmes. Sector organizations can play an important role in raising awareness among producers and disseminating best practices and mitigation success stories.

While many of the mitigation practices are likely to be profitable in the mid-term, public policies should ensure that farmers can face initial investment and possible risks. This is particularly important in least affluent countries, where limited access to credit and risk adverse strategies will prevent the uptake of novel options requiring upfront investment. The provision of microfinance schemes can be effective to support the adoption of new technologies and practices by small-scale farmers. Where the adoption of technologies and practices are costly for farmers in the short or medium term, but provide large public mitigation benefits, abatement subsidies should be envisaged.

Public and private sector policies also have a crucial role to play in supporting research and development to improve the applicability and affordability of existing technologies and practices, and to provide new solutions for mitigation. Significant additional research is also needed to assess the costs and benefits of mitigation options in practice.

Efficiency-based mitigation strategies will not always result in a reduction of emissions, especially where production grows rapidly. While keeping rural development and food security issues in consideration, complementary measures may be needed to ensure that overall emissions are curbed. Further, safeguards should be in place to avoid the potential negative side-effects of efficiency gains, such as animal diseases, poor welfare, and soil and water pollution.

International efforts should be pursued to ensure that mitigation commitments, both within and outside the United Nations Framework Convention on Climate Change (UNFCCC), are strengthened to provide stronger incentives to mitigate livestock sec-

tor emissions and ensure that efforts are balanced through the different sectors of the economy.

In least affluent countries where the mitigation potential is important, it is crucial to set up sector development strategies that serve both mitigation and development objectives. Such strategies may well condition the wider adoption of mitigation practices.

NEED FOR COLLECTIVE, CONCERTED AND GLOBAL ACTION

Recent years have seen interesting and promising initiatives by both the public and private sectors to address sustainability issues. Complementary multistakeholder action is required to design and implement cost-effective and equitable mitigation strategies, and to set up the necessary supporting policy and institutional frameworks.

It is only by involving all sector stakeholders (private and public sector, civil society, research and academia, and international organizations) that solutions can be developed that address the sector's diversity and complexity. Climate change is a global issue and livestock supply chains are increasingly internationally connected. To be effective and fair, mitigation actions also need to be global.

Abbreviations and acronyms

AEZ	Agro-ecological zone
ABC	Low Carbon Agriculture programme, of the Government of Brazil
AGA	Animal Production and Health Division (FAO)
AGGP	Agricultural Greenhouse Gases Program
APS	Alternative policy scenario
BAU	Business as usual
CCX	Chicago Climate Exchange
CDM	Clean Development Mechanism
CFI	Carbon Farming Initiative (Australia)
CGIAR	Consultative Group on International Agricultural Research
CW	Carcass weight
DE	Digestible energy
DM	Dry Matter
ETS	Emission Trading Scheme (European Union)
FCPF	Forest Carbon Partnership Facility
FIP	Forest Investment Program
FPCM	Fat and protein corrected milk
GAEZ	Global Agro-Ecological Zone
GHG	Greenhouse gas
GIS	Geographic Information System
GLEAM	Global Livestock Environmental Assessment Model
GMI	Global Methane Initiative
GRA	Global Research Alliance (on Agricultural Greenhouse Gases)
GWP	Global warming potential
HFCs	Hydrofluorocarbons
IDF	International Dairy Federation
IEA	International Energy Agency
IFPRI	International Food Policy Research Institute
IIASA	International Institute for Applied Systems Analysis
IPCC	Intergovernmental Panel on Climate Change
LAC	Latin America and the Caribbean
LCA	Life cycle assessment
LEAP	Livestock Environmental Assessment and Performance Partnership
LUC	Land-use change
MICCA	Mitigation of Climate Change in Agriculture
NAMA	Nationally Appropriate Mitigation Action
NASA	National Aeronautics and Space Administration
NENA	Near East & North Africa
NZAGRC	New Zealand Agricultural Greenhouse Gas Research Centre

OECD	Organisation for Economic Co-operation and Development
OTC	Over-the-counter
REDD+	Reducing Emissions from Deforestation and Forest Degradation Programme
SAI	Sustainable Agriculture Initiative
SIK	Swedish Institute for Food and Biotechnology
SSA	Sub-Saharan Africa
TNC	The Nature Conservancy
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USEPA	United States Environmental Protection Agency
VCS	Verified Carbon Standard
VS	Volatile solids
WRI	World Resources Institute

Glossary

Age at first calving (farrowing)	The time spent between birth and first calving (farrowing); i.e. the age at which a heifer (gilt) becomes a cow (sow).
Anaerobic	In the absence of oxygen, i.e. conditions conducive to the conversion of organic carbon into methane (CH_4) rather than carbon dioxide (CO_2).
Anaerobic digesters	Equipment where anaerobic digestion is operated; i.e. the process of degradation of organic materials by microorganisms in the absence of oxygen, producing CH_4, CO_2 and other gases as by-products.
Backyard production system	Production that is mainly subsistence-driven or for local markets, displaying animal performance lower than in commercial systems and mostly relying on swill and locally-sourced materials to feed animals (less than 20 percent of purchased concentrate).
Breeding overhead	Animals dedicated to reproduction, rather than to production; i.e. animals necessary to maintain herd/flock size.
Broiler	Chicken reared for meat.
By-product	Material produced during the processing (including slaughtering) of a livestock or crop product that is not the primary objective of the production activity (e.g. oil cakes, brans, offal or skins).
Carbon footprint	The total amount of GHG emissions associated with a product along its supply chain; usually expressed in kg or t of carbon dioxide equivalent (CO_2-eq) per unit of output.
CO_2-eq emission	The amount of CO_2 emissions that would cause the same time-integrated radiative forcing, over a given time horizon, as an emitted amount of a mixture of GHGs. It is obtained by multiplying the emission of a GHG by its global warming potential (GWP) for the given time horizon. The CO_2 equivalent emission is a standard metric for comparing emissions of different GHGs (IPCC, 2007).

Cohort	Class of animals within a herd/flock defined by their age, sex and function (e.g. adult females, replacement females, males for fattening).
Co-product	Output from a production activity that generates more than one output (e.g. milk, meat, manure and skins are among the co-products of dairy production). The term does not include services that may also be provided (e.g. draught power).
Crop residue	Plant materials left in an agricultural field after harvesting (e.g. straw or stover).
Dairy herd	For the purposes of this assessment, includes all animals in a milk-producing herd: milked animals, replacement stock and surplus calves that are fattened for meat production.
Direct energy	Energy used on-farm for livestock production activities (e.g. for lighting, heating, milking and cooling).
Emission intensity (Ei)	Emissions per unit of output, expressed in kg CO_2-eq per unit of output (e.g. kg CO_2-eq per kg of egg).
Fat and protein corrected milk (FPCM)	A standard used for comparing milk with different fat and protein contents. It is a means of evaluating milk production of different dairy animals and breeds on a common basis. Cow's milk is corrected for its fat and protein content to a standard of 4 percent fat and 3.3 percent protein.
Feed balancing	The action of selecting and mixing feed materials (e.g. forages, concentrates, minerals, vitamins, etc.) that are free from deleterious components, to produce an animal diet that matches animal's nutrient requirements as per their physiological stage and production potential (FAO, 2013d).
Feed conversion ratio	Measure of the efficiency with which an animal converts feed into tissue, usually expressed in terms of kg of feed per kg of output (e.g. live weight, eggs or protein).
Feed digestibility	Determines the relative amount of ingested feed that is actually absorbed by an animal and therefore the availability of feed energy or nutrients for growth, reproduction, etc.
Feed processing	Processes that alter the physical (and sometimes chemical) nature of feed commodities to optimize utilization by animals (e.g. through drying, grinding, cooking and pelleting).

Forage off-take rate	The proportion of above-ground grassland vegetation that is consumed by livestock (grazed or harvested).
Geographic Information System (GIS)	A computerized system organizing data sets through the geographical referencing of all data included in its collections.
Global warming potential (GWP)	Defined by the Intergovernmental Panel on Climate Change (IPCC) as an indicator that reflects the relative effect of a GHG in terms of climate change considering a fixed time period, such as 100 years, compared with the same mass of carbon dioxide.
Grazing production systems	Livestock production systems in which more than 10 percent of the dry matter fed to animals is farm-produced and in which annual average stocking rates are less than ten livestock units per hectare (ha) of agricultural land (Seré and Steinfeld, 1996).
Greenhouse gas	A greenhouse gas (GHG) is a gas that absorbs and emits radiation within the thermal infrared range; this process is the fundamental cause of the greenhouse effect. The primary greenhouse gases in the earth's atmosphere are water vapour (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and ozone (O_3).
Indirect (or embedded) energy	Energy or emissions arising during the manufacture of farm inputs such as fertilizer or steel.
Industrial production systems	Large-scale and market-oriented livestock production systems that rely on fully enclosed housing, high capital input requirements (including infrastructure, buildings and equipment) and purchased non-local feed or on-farm intensively-produced feed. Industrial systems have high overall herd performances.
Intermediate production systems	Market-oriented livestock production systems that rely on partially enclosed housing, a medium level of capital input requirements and locally-sourced feed materials for 30 to 50 percent of the ration. Intermediate systems have reduced levels of performances compared with industrial systems.
Layer	Chicken reared to produce eggs for human consumption.
Methane conversion factor	The percentage of manure's maximum CH_4-producing capacity that is actually achieved during manure management; i.e. part of organic matter actually converted into CH_4.

Mixed production systems	Livestock production systems in which more than 10 percent of the dry matter fed to livestock comes from crop by-products and/or stubble or more than 10 percent of the value of production comes from non-livestock farming activities (Seré and Steinfeld, 1996).
Natural resource use efficiency	Measured by the ratio between the use of natural resources as input to the production activities and the output from production (e.g. kg of phosphorus used per unit of meat produced, or ha of land mobilized per unit of milk produced).
Productivity	Amount of output obtained per unit of production factor. In this report, it is used to express amount of product generated per unit of livestock and time (e.g. kg milk per cow per year).
Replacement rate	The percentage of adult animals in the herd replaced by younger adult animals.
Scavenging	Backyard animals roaming freely in search of feed sources (e.g. food scraps, insects).
Soil liming	The application of lime and other calcium fertilizers to the soil to eliminate excess acidity.
Urea treatment	The application of urea to forages under airtight conditions. Ammonia is formed from the urea and the alkaline conditions which compromise cell wall conformation and improve intake and digestibility of low quality roughages or crop residues.