Food and Agriculture Organization of the United Nations

OPTIONS FOR LOW-EMISSION DEVELOPMENT IN THE SRI LANKA DAIRY SECTOR

Reducing enteric methane for food security and livelihoods

NEW ZEALAND
AGRICULTURAL GREENHOUSE GAS
Research Centre

CLIMATE & CLEAN AIR COALITION
TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

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Contents

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Executive summary

This study evaluates the potential for improving milk production while reducing enteric methane emission intensity from dairy production in Sri Lanka. The overall objective of this study is to support Sri Lanka in identifying low-cost strategies to reduce enteric CH_4 emissions while contributing to the countries' short- to long-term social and economic development and increasing resilience to climate change.

The dairy sector has been identified as one of the key sectors to contribute to the projected annual national economic growth. The sector is envisaged to ensure food security, provision of raw materials for agro-industries, creation of employment opportunities, generation of income and foreign exchange earnings. The sector is however the most vulnerable to the impacts of climate change and extreme weather events. Due to these challenges, the government recognizes the need to develop interventions that make agriculture more resilient to climate change and extreme weather events while minimizing its contribution to greenhouse gas emissions.

Benefits of moving towards a climate-resilient dairy sector

With this in mind, Sri Lanka in its Intended Nationally Determined Contributions (INDC) has put forth adaptation actions to reduce its vulnerability to climate change. These actions will also play a key role in realizing the transition to a low-carbon, climate-resilient economy.

Adopting a low-carbon and climate resilient growth pathway for the dairy sector could benefit Sri Lanka in several ways:

- The dairy industry is the most important livestock sub-sector. It contributes 7.5 percent to agricultural Gross Domestic Product (GDP) and 0.8 percent of total GDP. The dairy sector currently provides income and employment to about 400,000 farmers. Milk production in Sri Lanka is predominantly managed by small-scale farmers, who own one to three dairy animals, and produce about 70 percent of the milk in the country. Milk production is primarily a small farmer enterprise; 72 percent of the milking herd is found on holdings of less than one hectare and another 20 percent on holdings that are in the 1-2 hectare. Amongst these dairy farmers are some of the poorest and most marginalized such as women. Considering the importance of the dairy sector to rural livelihoods and its potential role in poverty reduction, implementing a low-emissions development strategy for the dairy sector through the adoption of performance-enhancing technologies and use of incentives is expected to significantly increase milk yields with net benefits in the short-to-medium term.
- Milk is one of the most complete foods; it is rich in high quality protein providing all ten essential amino acids and is an excellent source of calcium and vitamin B2, vitamin A, and a fair source of vitamin D. Milk is therefore a crucial source of nutrition in a country which has one of the highest rates of under-nutrition in the world; 30 percent of the children under 5-years of age are undernourished. Current per capita consumption of milk and milk products in Sri Lanka is on average 35 litres of milk per day - very low compared with the World Health Organization's recommendation of 200 litres per year.
- Dairying represents one of the fastest returns for dairy farmers in the developing world. It provides milk for home consumption, regular cash flow from milk sales to farmers, especially to women, enhances household nutrition and food security and creates off-farm employment. In Sri Lanka, dairy animals are one of the most valuable assets for rural households playing many functions such as traction, nutrient value and risk management.

- The "National Policy on Agriculture and Livestock" provides a clear statement of the Government's objective to move towards increasing sufficiency. The dairy industry has been earmarked as a priority area for investment and development in the livestock sector. The main policy target is attaining 50 percent self-sufficiency by 2015 and the medium term goal is to reduce the proportion of imported milk from the current level of 70 percent to 35 percent by 2020. This will help reduce the drain on the country's foreign exchange resources, support employment and family incomes in the rural areas.
- The current productivity of dairy animals in general is low, which results in a shortage of supply of dairy products. For example, on average, milk yields range from 6.5 litres per cow per day in the intensive systems (Upland and Mid-country production zone) to 1 litres per cow per day in extensive systems in the Dry Lowland production zone. Seasonal fluctuation of milk production – the yield per cow and by extension the total amount of milk produced fluctuates greatly during the year. Milk yields are low and largely variable mainly because of poor and limited feed resources, disease and poor herd management. Milk yields remain low even in semi-intensive and intensive systems in the Upland and Mid-country production zone that rear high yielding exotic breed and cross-breeds. These animals cannot reach their full genetic potential if factors in their environment are limiting.
- Given the dependence of the country on agriculture and natural resources, Sri Lanka is also highly vulnerable to climate change. Sri Lankan agriculture has already felt the effect of extreme weather events and impacts of a changing climate, including: a slow but steady rise of ambient temperature (0.01–0.03 °C per year); high-intensity rainfall resulting in landslides and soil and coastal erosion; salinity intrusion into soils and aquifers; tornado-type winds; and increasingly extreme droughts and floods. Future climate change will continue to impact the agricultural sector in general, but will be especially acute for Sri Lanka's smallholder farmers. Solutions that both enhance the sector's resilience to climate change while at the same time reduce its contribution to GHG emissions are required.

Emissions and emission intensities from the dairy production

The dairy cattle sector produces about 0.32 million tonnes of milk; of this 43 percent of the milk is produced by the intensive systems in the Upland and Mid-country production zones, while 31 percent, 18 percent and 8 percent is produced in the Dry Lowland, Coconut Triangle and Wet Lowland zones, respectively.

Milk production from the dairy cattle sector in Sri Lanka emits about 2.3 million tonnes CO_2 eq. The emission's profile of milk is dominated by methane (93.2 percent), while the nitrous oxide (N_2O) and carbon dioxide (CO_2) contribute 1.6 percent and 5.2 percent of the total emissions, respectively.

Three sources of emission contribute the bulk of emissions from dairy cattle. Approximately 88 percent of the emissions arise from methane produced by the rumination of cows and 5 percent from the management of stored manure. CO_2 emissions associated with feed production, transport and processing contribute an additional 5 percent to total emissions.

At national level, the emission intensity of milk produced in Sri Lanka is on average 6.9 kg CO_2 eq./kg FPCM; the highest values were estimated for the low input-output dairy systems in the Dry Lowland zone and the lowest in in the intensive systems in the Upland and Mid-country production zone. Emissions were on average, 13.8, 6.8, 4.8 and 2.3 kg CO_2 eq./kg FPCM for the Dry Lowland, Coconut Triangle, Wet Lowland and Upland and Mid-Country systems, respectively

Options for improving productivity and reducing enteric methane per unit of output

Improving animal and herd productivity is one of the key pathways to reduce enteric CH_4 emissions per unit of product. Methane is produced in the process of feed energy utilization by the animal. Changes in the efficiency of feed energy utilization therefore influence enteric methane emissions of animals. The efficiency of feed energy utilization depends on the type of animal, the type or quality and quantity of feed, environmental conditions, etc. The way feed energy is partitioned between the different body functions (maintenance and production) also explains the variation in emission intensity.

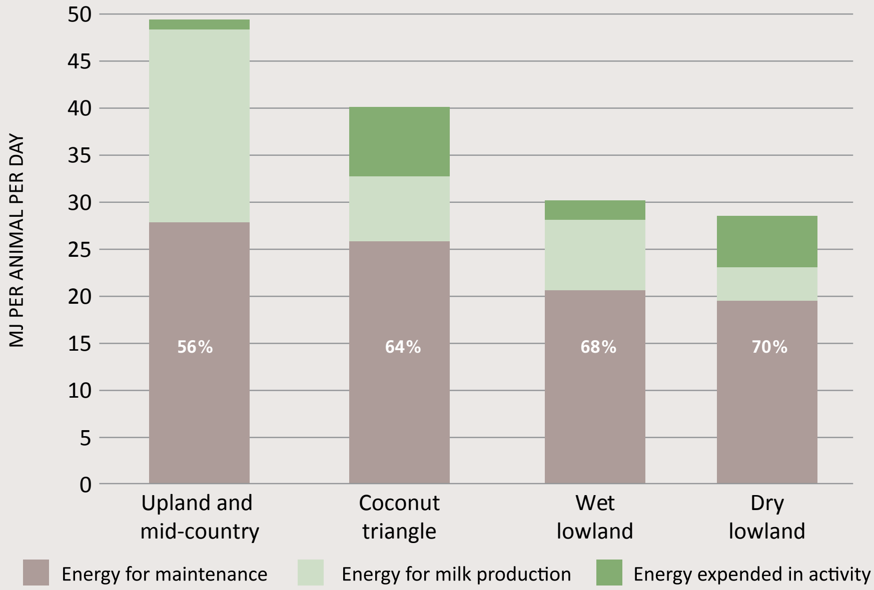
Productive efficiency and dilution of the maintenance requirements

The nutrient requirements of cows come from two components – maintenance and production. Maintenance requirements are the nutrients needed for cows to live every day. They are used to maintain metabolic functions such as walking around, breathing, digesting food and regulating body heat. All animals have a necessary maintenance requirement that must be met and results in no production, yet are still associated with CH_4 losses. Once all maintenance requirements are met then leftover nutrients can be used for milk production and other functions such as reproduction and growth.

The biological processes underlying improved productive efficiency is known as the 'dilution of maintenance' effect (Bauman et al., 1985; VandeHaar and St-Pierre, 2006). A lactating dairy cow requires daily nutrients for maintenance and for milk synthesis. The maintenance requirement does not change with production level and therefore can be thought of as a fixed cost needed to maintain vital functions.

As shown in the Figure below, the average maintenance energy requirement for milking cows in Upland and Mid-country, Coconut triangle, Wet lowland and Dry lowland systems is 27.8, 25.8, 20.5 and 19.9 MJ per day, respectively. Assuming milk composition remains constant, the nutrient requirement per unit of milk production also does not change, but the total energy cost for lactation increases as a function of milk production. It can therefore be thought of as a 'variable cost' of dairy production. A high-producing dairy cow requires more nutrients per day than a low producing animal; the cow with a daily milk output of 6.5 kg per day uses 56 percent of consumed energy for maintenance whereas the low producing cow (1 kg milk/day) uses 70 percent of energy intake for the maintenance (Figure below). Increased production thus dilutes out the fixed cost (maintenance) over more units of milk production, reducing the total energy requirement per kg of milk output. A cow producing an average of 6.5 kg milk/day in Upland and Mid-country systems requires 7.6 MJ/kg milk, whereas a cow yielding 1 kg/day in Dry Lowland dairy systems needs 32 MJ/kg milk.

Energy requirement for milking cows in dairy systems in Sri Lanka



Source: GLEAM, 2017

Bauman, D.E., S.N. McCutcheon, W.D. Steinhour, P.J. Eppard and S.J. Sechen. 1985. Sources of variation and prospects for improvement of productive efficiency in the dairy cow: A review. J. Anim. Sci. 60:583-592; **VandeHaar, M.J. and N. St- Pierre.** 2006. Major advances in nutrition: Relevance to the sustainability of the dairy industry. J. Dairy Sci. 89:1280-1291

Research shows that there are several technologies that if comprehensively applied throughout the sector would make a rapid and important contribution to improving the technical performance and profitability of dairy production while reducing GHG emissions. Improved practices and technologies such as strategic supplementary feeding, and improving the diet quality, adequate animal health control, and improved animal husbandry practices are some of the techniques that can improve dairy productivity and reduce emission intensity.

In the assessment of technical options for the main dairy cattle production systems, the following criteria were used:

- Interventions had to have potential for improving productivity while at the same time reducing enteric CH_4 emissions per unit of output.
- Interventions had to be feasible in the short or medium term. Feasibility was first determined by sectoral experts and selected interventions had to have already been implemented or in use at least at farm level in Sri Lanka.

A team of national experts identified key areas to address low productivity in dairy systems including: (i) improving the quality and availability of feed resources; (ii) strategic feeding and supplementation to address feed seasonality constraints; and (iii) improved herd management and animal health interventions. Within this broad categorization, 6 single interventions and 1 'package' consisting of combination of single interventions were assessed.

Mitigation of enteric methane results in 15 percent - 45 percent increase in milk production

This work shows that significant reductions in methane emission intensity can be realized through the adoption of existing and proven technologies and practices. Overall, the analysis shows that there scope to reduce emission intensities; methane emission intensity (kg CO_2 /kg FPCM) can be reduced by 10 percent to 29 percent, the magnitude of impact will vary depending on the intervention and production system; not all systems have equal opportunity to mitigate emissions.

Many of the biological effects are interrelated and interdependent and, accordingly, the changes in enteric CH_4 emissions per unit of milk (kg CH_4/kg FPCM) are not additive. The reduction in CH_4/FPCM range is modest because the range of alterations was restricted to what might reasonably be implemented or expected occur in dairy production. The implementation of many of the improvements is limited to lactating dairy cattle for practical or economic reasons and, thus, the reductions in enteric CH_4 are modest.

All interventions returned a positive productivity outcome with increases in milk production ranging between 15 percent and 45 percent.

Reduction of enteric methane emissions is profitable for farmers

A key incentive to farmers adoption is increased revenue and/or reduced production costs. To better understand the implications for farmers, a cost benefit analysis was conducted to assess the profitability of adopting mitigation intervention. The benefit-cost ratio (BCR) indicates the overall value for money of the interventions. Generally, if the ratio is greater than 1, benefits of the interventions outweigh the costs. In this study the, the BCR for different mitigation options ranged from 1.6 to 4.3 indicating that benefits exceed economic costs for the different options considered.

The results from the BCR analysis shows the investment returns as a result, those interventions with low investment requirements tend to perform better. Low-input systems with relatively low production costs such as those in the Dry Lowland zone, also returned higher benefits compared to the intensive systems.

A preliminary ranking of interventions per production system to identify interventions with high reduction potential, increased production and high economic return was undertaken to provide an indication of what is workable. Putting the reduction potential, productivity increase and returns to farmers allows for a first-order prioritization of interventions.

Out of the 6 interventions assessed, only one (use of total mixed rations) was considered relevant for the Upland and Mid-country production zone. Only two of the four interventions selected for the Dry and Wet Lowland systems were included in the prioritization process. Three interventions were assessed for Coconut triangle. Interventions excluded from the prioritization process intervention did not meet

the threshold methane reduction target of more than 10 percent.

The use of total mixed ration (TMR) in the Upland and Mid-country production zone ranks high on the productivity criteria and low on the methane reduction and economic criteria.

The interventions (all related to feed) assessed for the 3 other production zones (Coconut triangle, Wet lowland, and Dry lowland) gave similar benefits (ranging from moderate to high) in terms of methane reduction, milk yield increase and financial returns to farmers.

The full summary of interventions analyzed interventions analyzed for each production systems is presented in the figure below. It demonstrates the comparative benefits (in quantitative terms) of each intervention covering increase in milk production, a benefit cost ration (BCR) score for each intervention to indicate the investment performance and the annual emissions reduced/avoided through the adoption of each intervention.

Reducing enteric CH_4 via increasing productivity is economically viable in most situations; several activities that reduce methane emissions have low or negative economic costs when considering the increase in production. This study has identified a range of abatement options with negative net present cost which should be attractive investment opportunities, yet are not implemented. All interventions assessed are cost-beneficial (i.e. measures that not only reduce GHG emissions but also save money in the long term) accounting for an abatement potential of 1.4 million tonnes CO_2 eq., annually. The idea of significant savings opportunities being ignored by the sector does not make economic sense. Clearly, there are barriers preventing these savings-creating measures from being taken up at once.

Summary of quantitative impacts of each interventions

Note: *BCR: benefit-cost ratio; Milk production (Red column=Baseline): additional milk production with the adoption of the intervention (Gray columns=Mitigation); Emission savings: GHG emissions reduced with the intervention*

CHAPTER 1

A climate resilient dairy sector for food security

The dairy industry is earmarked as the priority area for investment and development in the livestock sector. The main policy target is attaining 50 percent self-sufficiency by 2015 and the medium term goal is to double the local milk production to reduce the proportion of imported milk from the current level of 70 to 35 percent by 2020.

Currently, only 35 percent of the national milk requirement is met through local production. The consumption of milk and other dairy products is expected to increase over the next few years, with increasing per-capita income and living standards of people. Sri Lanka spends around US$ 400 million a year on the importation of milk powder. With the aim of reducing the drain on the country's foreign exchange resources and supporting employment generation and family income, the government and the dairy industry has committed to improving productivity. To be self-sufficient in milk a further 482 million liters has to be produced annually. It would be an impossible task to achieve this production target with the present production of the national herd. In a business as usual situation, meeting this target given current levels of production would mean a doubling of the number of milking animals.

Around 28 percent of the country's population depends on livelihoods related to agriculture.

The sector is however the most vulnerable to the impacts of climate change and extreme weather events. Enhanced temperatures and change in precipitation regimes have led to reduced suitability of agro-based enterprises; reducing productivity of crops, livestock and fisheries due to temperature and water stresses; and rising production costs. The increase in frequency and intensity of extreme weather events such as droughts and floods have led to loss of investments, incomes and livelihoods, the destruction of agro-based infrastructure as well as increased frequency of weather related disasters. Due to these challenges, the government recognizes the need to develop interventions that make agriculture more resilient to climate change and extreme weather events while minimizing its contribution to greenhouse gas emissions.

In particular, the National Adaptation Plan for Climate Change Impacts[1] has identified adaptation priority areas for livestock including: development of heat tolerant breeds, promote intensive management of livestock, develop disease resistant breeds, improvement of pasture and fodder management (diversification into other feeds other than pasture, promote feed conservation, silage and hay). Many of these interventions will also have positive impacts on both productivity and emissions from the sector.

This report presents the findings and recommendations from an initial assessment of the dairy cattle sector of Sri Lanka. It is undertaken in collaboration with the Department of Animal Production and Health in Sri Lanka and the National Science Foundation and funded by Climate and Clean Air Coalition (CCAC), the New Zealand Government and the Food and Agriculture Organization of the United Nations (FAO).

The primary focus of this initial assessment is to identify and prioritize interventions to reduce enteric methane emission intensity from ruminant systems that are consistent with other development goals. To that end, this report examines the scale of enteric methane emissions from the dairy sector, and identifies cost-effective interventions through which methane can potentially be reduced. This analysis is meant to inform where reductions can be made and to systematically explore emission reduction opportunities with the objective to translate emission savings into benefits for producers.

[1] Government of Sri Lanka (2015). National adaptation plan for climate change impacts in Sri Lanka, 2016-2025. http://www.climatechange.lk/NAP/NationalAdaptationPlan_RevisedFinal.26.10.2015.pdf

CHAPTER 2
Objectives and approach

This study seeks to identify and evaluate low-cost options that Sri Lanka can implement in the short-to-medium term geared towards improving productivity in dairy cattle production systems, reducing enteric methane emissions and fostering economic development.

Three main methodological steps were employed in this study (Figure 2.1):

1) **Establishment of a baseline scenario**; Including the selection and characterization of production system, estimation of GHG emissions and emission intensity, and identification of key determinants of low productivity and emission intensity.

2) **Assessment of the mitigation potential.** Identification of system specific interventions consistent with development objectives for improving productivity, addressing enteric methane emissions and quantification of the mitigation potential.

3) **Prioritization of interventions.** Prioritization of interventions is undertaken by drawing on modeling results and cost-benefits analysis. It assesses productivity impacts, the potential profitability for farmers in adopting implementing the selected interventions and identifies the implementation barriers.

A key focus of this work is on interventions that reduce emission intensity while maintaining or increasing milk production such that climate change and productivity improvement can be pursued simultaneously (Box 1).

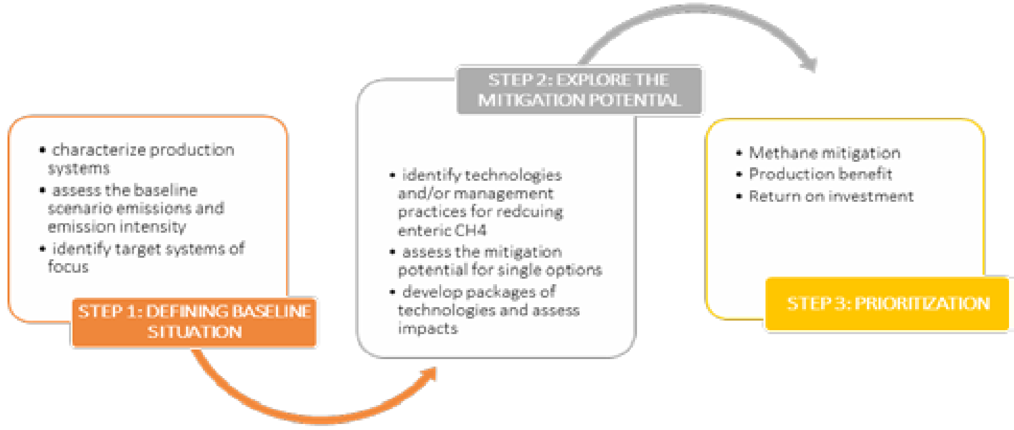
The analysis focuses on the dairy cattle sector, a strategic sector in Sri Lanka that was selected in consultation with front-line government ministries e.g. ministry of livestock, environment, academia institutions, and public and private stakeholders. The huge and diverse livestock population, varied and favorable agro-ecology for dairying, increasing demand for dairy products in urban and peri-urban areas, as well as the long-standing culture of dairy products consumption, are criteria that have supported this choice.

Smallholder dairy development presents a promising option to boost rural incomes, improve food and nutrition security, and create employment along the dairy value chain; thus contributing to the National rural development policy and strategy.

The study undertakes biophysical modeling and scenario analysis using the Global Livestock Environmental Assessment Model[2] (GLEAM) to

[2] FAO – The Global Livestock Environmental Assessment Model – GLEAM http://www.fao.org/gleam/en/

Figure 2.1: Process framework for the identification and prioritization of interventions to address enteric methane



Box 1: Absolute emissions versus emission intensity

The primary determinants of enteric methane emissions are feed intake, and fermentation characteristics of that feed in the rumen. In general, management practices that increase the proportion of feed used to produce meat or milk rather than maintain the animal, reduce the amount of methane per unit of animal product produced (emissions intensity). Higher individual animal productivity generates more animal product and more methane per animal but as a smaller proportion of the feed consumed is used to maintain the animal emissions intensity is reduced.

The same amount of animal product can be produced with fewer methane emissions if producers keep fewer animals. More intensive production provides flexibility to control emissions and generally improves profitability. However, increasing feed intake per animal will always lead to an increase in total farm methane production unless the total number of animals is reduced.

In low and medium-income countries, the concept of emission intensity remains the most attractive mitigation route because it allows for the harnessing of synergies between food security and development objectives and climate change mitigation goal. Emissions intensity reductions will reduce absolute emissions below the business-as-usual.

Box 2: Modelling GHG emissions from dairy production systems in Sri Lanka

In this study, the Global Livestock Environmental Assessment Model (GLEAM; Gerber et al. 2013) is the main analytical tool used to assess the emissions and emission intensities in the baseline scenario and to assess the emission reduction potentials of selected interventions.

GLEAM is a spatially explicit model of livestock production systems that represents the biophysical relationships between livestock populations, production, and feed inputs (including the relative contribution of feed types—forages, crop residues, and concentrates—to animal diets) for each livestock species, country, and production system. The production parameters and data in GLEAM have been drawn from an exhaustive review of the literature and validated through consultation with experts during several joint projects and workshops. The relationships between GHG emissions and production have also been cross validated for ruminants across a range of regions and studies, and published reports on GLEAM have also been through rigorous peer review (Opio et al. 2013; Gerber et al. 2013). GLEAM works at a definition level of 1 km2, the spatially explicit GLEAM model framework allows the incorporation of heterogeneity in emissions, emission reductions and production responses.

The model was further developed to meet the needs of this study. The dairy production systems in GLEAM were further refined to reflect the specificities of the dairy cattle production systems in Sri Lanka and the database of production systems parameters was updated with more recent and system specific information and data on cattle populations, performance parameters, feeding systems, manure management, etc. taken from national databases. The GLEAM framework is used to characterize the baseline production and GHG emission output of dairy production systems. Emissions and emission intensities are reported as CO_2 eq. emissions, based on 100-year global warming potential (GWP100) conversions factors as reported by the IPCC in its 5th Assessment Report (AR5).

The abatement potential for each practice was calculated by estimating the changes from the baseline GHG emissions, following the application of system specific interventions. To specify each abatement practice within GLEAM, it was necessary to incorporate additional data and information on the impacts associated with the application of the interventions. These data were obtained from a range of literature sources and databases.

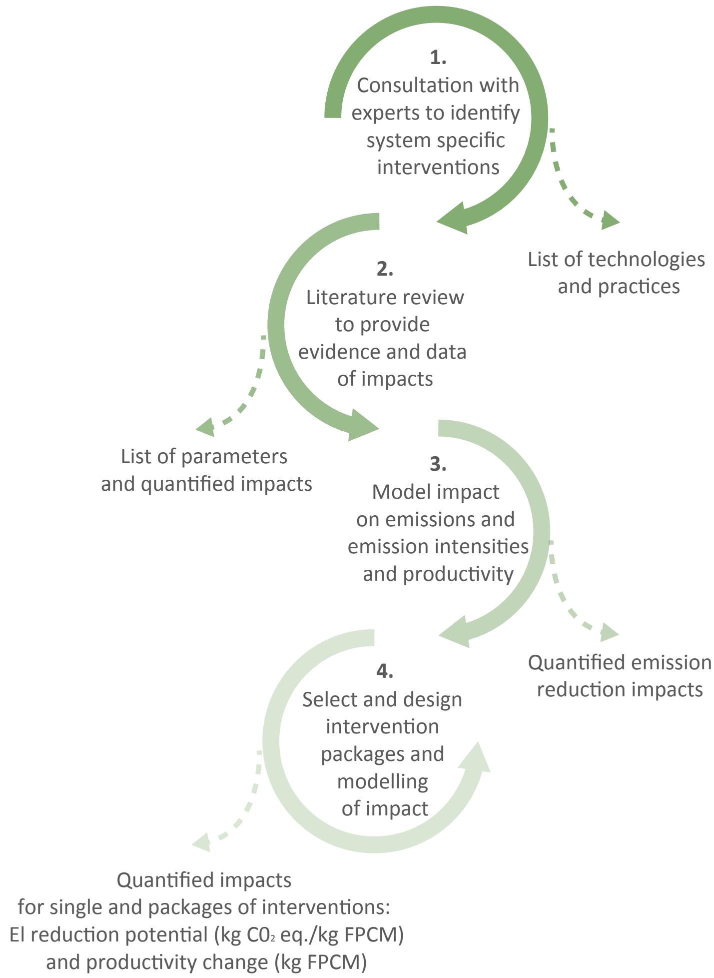
The calculations are performed twice, first for the baseline scenario and then for the mitigation scenario. Emission intensity reductions and changes in productivity can then be compared to those under the baseline scenario.

Source: http://www.fao.org/gleam/en/

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;

FAO. 2013a. Greenhouse gas emissions from ruminant supply chains – A global life cycle assessment, by C. Opio, P. Gerber, A. Mottet, A. Falcucci, G. Tempio, M. MacLeod, T. Vellinga, B. Henderson & H. Steinfeld. Rome.

Figure 2.2: Process for exploring mitigation impacts



provide a broad perspective of opportunities and attainable goals in terms of productivity gains and emission intensity reduction in the dairy sector (Box 2). The scenario analysis uses the outputs of the biophysical analysis combined with information taken from published literature, existing studies and expert knowledge on potential impacts of each intervention on herd performance and production to quantify the emission intensity reduction potential.

The range of options evaluated (referred to as "interventions") were selected by national sector experts based on their potential for methane emission intensity reductions, their impact on milk production and their feasibility in terms of political, social, institutional, and other preconditions. The interventions identified are presented individually and with a subset evaluated as a 'package', in order to demonstrate to stakeholders how a combination of interventions would impact reduction potential and productivity gains. It also gives the ability to assess this flexibly within the framework of political conditions, available resources, and other considerations. Figure 2.2 presents the generic steps undertaken in the identification of interventions and assessment of their impacts on enteric methane emissions and production. ability to assess this flexibly within the framework of political conditions, available resources, and other considerations. Figure 2.2 presents the generic steps undertaken in the identification of interventions and assessment of their impacts on enteric methane emissions and production.

CHAPTER 3

Overview of dairy production

The dairy industry is single largest agricultural sub-sector in Sri Lanka. It contributes 7.5 percent to agricultural Gross Domestic Product (GDP) and 0.8 percent of total GDP. The dairy sector currently provides income and employment to about 400,000 farmers. In terms of nutrition and food security, per capita consumption of milk in 2014 was 35 litres and demand for dairy products is projected to continue to grow rapidly as a consequence of population growth.

Total milk production from dairy cows in 2014 was about 0.32 million tonnes. Milk production is only sufficient to satisfy 25-30 percent of the national demand; the rest is imported. Powdered milk and milk products imports have increased by 3.3 percent compared to 2013[3]. It has been estimated that a further 482 million liters has to be produced annually for the country to be self-sufficient in milk[4]. Thus to fulfill this gap of demand the country heavily depends on milk imports, mainly as powdered milk. Twenty-five years ago, Sri Lanka barely imported 5,000 Mt of milk powder per year, and in 2012, it rose to almost 85,000 tonnes[5]. Sri Lanka spends around US$ 400 million a year on the importation of milk powder[6]. The main policy target of the National Livestock Development Policy is to attain 50 percent self-sufficiency by 2015 and the medium term goal is to double the local milk production to reduce the proportion of imported milk from the current level of 70–35 percent[7].

Milk production in Sri Lanka is predominantly managed by small-scale farmers, who own one to three dairy animals, and produce about 70 percent of the milk in the country.

Many factors influence the distribution of livestock in Sri Lanka dominant among them being the agro-ecological zoning (Box 3) and proximity to markets and feed resources.

Dairy cattle management systems in different parts of the country have largely been infuenced by the climate, type of crops grown and cropping patterns, availability of grazing land, genetic make-up of the animals and the main production objectives. From the point of view of livestock production, the country is divided into four production zones, namely: Upland and Mid-country, Coconut Triangle, Wet Lowland and Dry Lowland (Map 3.1).

- The **Upland and Mid-Country** are characterized by small holdings under intensive/semi-intensive management, with pure-bred or cross bred European breeds of cattle, zero-grazing with high inputs of feed. Primary objective is milk production with meat as a by-product of the dairy industry.
- The **Coconut Triangle**, is a high potential area for dairy development and is characterized by small herds managed under semi-intensive system with either tethered or free grazing on natural pastures/legumes under coconut and other perennial crops. Primary products are milk and draught with surplus animals being sold for meat.
- The **Wet Lowland** covers both the highlands and the southwest region. This is the most intensively exploited zone with 67 percent of its area under permanent agriculture. Cattle comprise of crosses of exotic breeds, Zebu types, Indigenous

[3] Government of Sri Lanka. 2014. Statistical Bulletin, Department of Animal Production and Health. http://www.daph.gov.lk/web/images/content_image/publications/livestock_stat_bulletin_2014.pdf

[4] National Livestock Development Board, (2013). 'Sri lanka Dairy Development Project', http://www.nldb.gov.lk/Doc/Dairy_Development_Project.pdf

[5] Nanayakkara, P. (2013). 'Liquid Milk: On the path to self-sufficiency', Business Today, 2013.05, http://www.businesstoday.lk/cover_page.php?issue=262

[6] Nathaniel, C. (2014). 'Milk Production in a Quandary?'

[7] Marambe B; Silva P; Weerahewa J; Pushpakumara G; Punyawardena R; Pallawala R. 2014. Enabling policies for agricultural adaptations to climate change in Sri Lanka. In: Handbook of Climate Change Adaptation. Leal W. (ed.). Springer-Verlag Berlin Heidelberg. (Available at: http://link.springer.com/ referenceworkentry/10.1007/978-3-642-40455-9_108-2).

animals and their crosses, with limited grazing and mostly cut and carry from roadsides.

- The **Dry Lowland** covers virtually two thirds of the island and encompasses a considerable variety of settings, from sub-humid forest to dry scrub to large irrigated rice-growing areas. The largest number of cattle is found in the dry zone, where herd sizes are also the largest. Characterized by indigenous cattle, zebu cattle and their crosses and buffaloes, generally free grazing.

Milk production takes place in all parts of the country (Map 3.1). While the largest cattle population is found in the dry and intermediate zones, the mid-country and upland zones are the main milk production areas. These zones also reflect the level of production intensity where: intensive stall feeding is practiced in Upland area; semi-intensive production in Mid-country; tethering/semi-extensive in the Coconut Triangle and grazing/extensive production in the Dry Zone. Table 3.1 summarizes the key features of the four systems.

The dairy cattle sector produces about 0.32 million tonnes of milk; of this 43 percent of the milk is from the Upland and Mid-country systems, while

Box 3: Agro-climatic zones of Sri Lanka

Sri Lanka can be divided into three Agro-climatic zones; Dry Zone, Intermediate Zone and Wet Zone (Figure below).

The **Wet Zone** covers both the highlands and the southwest region. This is the most intensively exploited zone with 67 percent of its area under permanent agriculture. This zone receives relatively high mean annual rainfall of 1800-2,500 mm/year without pronounced dry periods.

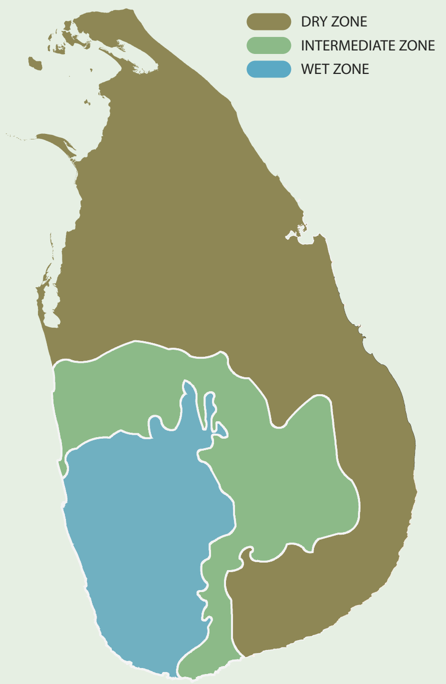
The **Dry Zone** covers virtually two thirds of the island and encompasses a considerable variety of settings, from sub-humid forest to dry scrub to large irrigated rice-growing areas. It covers predominantly the northern and eastern part of the country. The Lowland Dry zone receives a mean annual rainfall of less than 1,750 mm with a distinct dry season from May to September.

The **Intermediate Zone** covers an area of about 1.2 million ha of the country. The intermediate zone receives a mean annual rainfall between 1,750 to 2,500 mm with a short and less prominent dry season. It is dominated by coconuts along the Western Coastal region, where dairy production has a long tradition.

The largest number of cattle is found in the dry zones, where herd sizes are also the largest. The relative distribution of cross-bred dairy cattle is highest in the Upland and mid-country zones as well in the wet lowlands near Colombo. In the former case, this can be attributed to the temperate climatic conducive to the health and performance of improved animals. While in the latter, it may be attributed to the high milk prices available through the informal market close to the urban area, under which circumstances the risks to improved animals of lowland conditions are acceptable.

Within these three climatic zones four major ruminant livestock production zones can be identified, namely *Upland country and Mid-country system, Coconut triangle, Wet lowland and Dry lowland systems.*

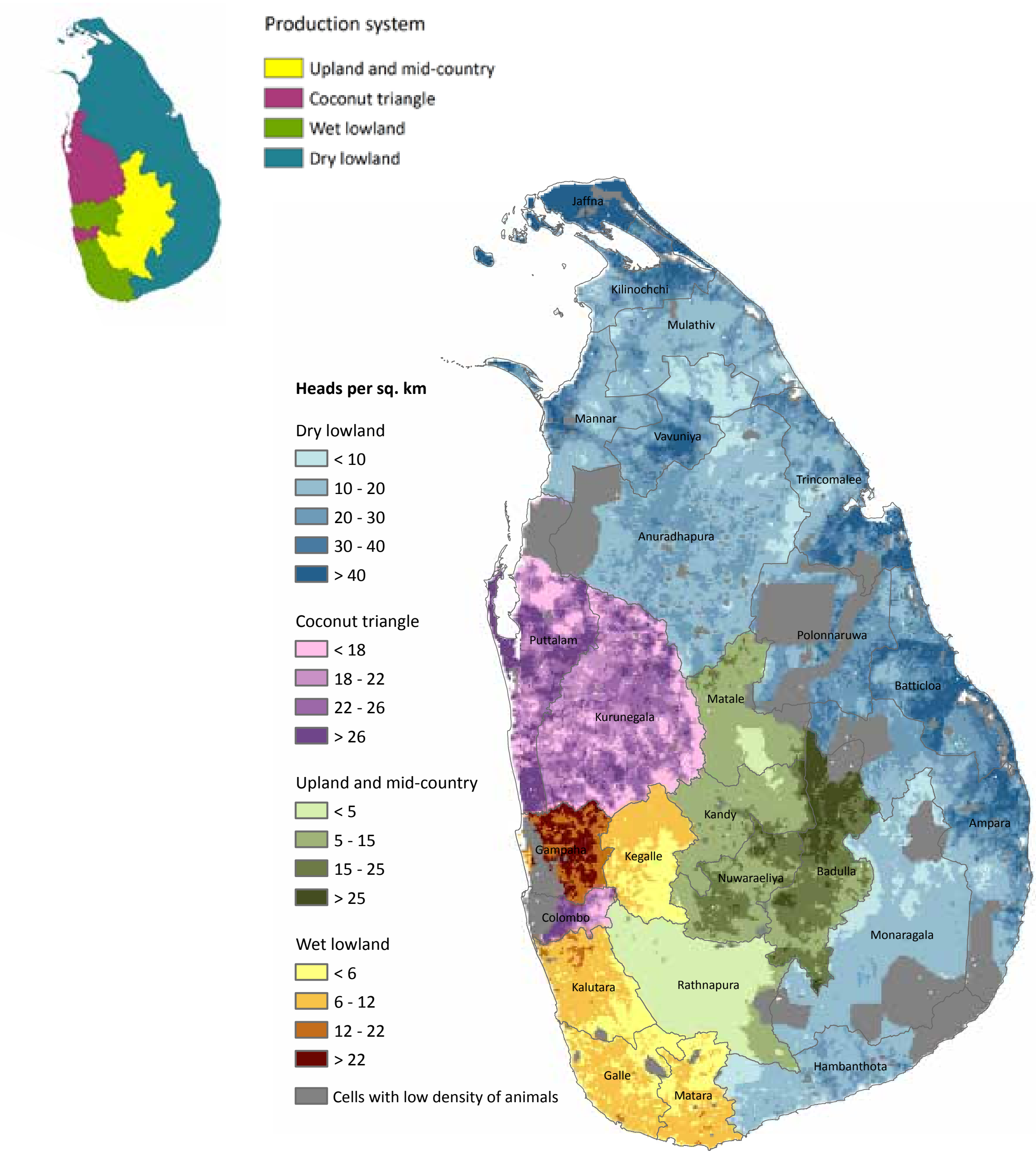
Agro-ecological zones in Sri Lanka



31 percent, 18 percent and 8 percent is produced in the Dry Lowland, Coconut Triangle and Wet Lowland systems, respectively. The productivity of dairy cows in Sri Lanka is highly variable within the same systems but also increases as production intensifies (Map 3.2).

The Upland and Mid-country dairy systems produce the largest share of milk from 13 percent of milking animals. The Dry Lowland, Coconut Triangle and Wet Lowland contribute to total milk production with 65 percent, 16 percent and 6 percent of the milking cows, respectively (Figure 3.1).

Map 3.1: Geographical distribution of dairy cattle herd across production zones

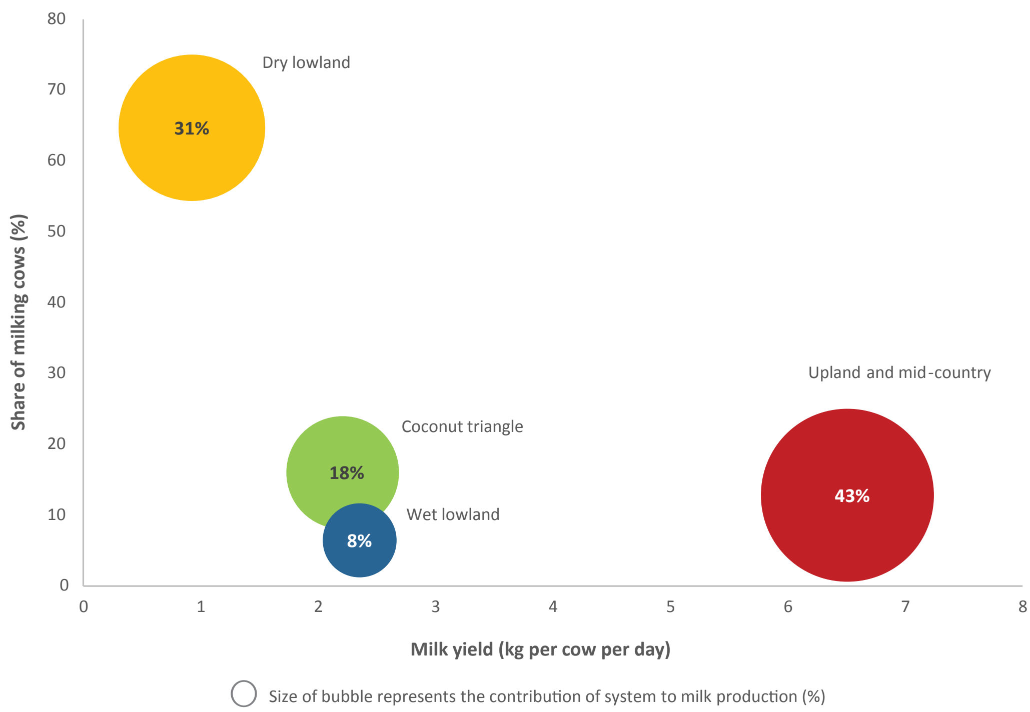


Source: GLEAM, 2017

Table 3.1: Summary description of dairy cattle production systems in Sri Lanka

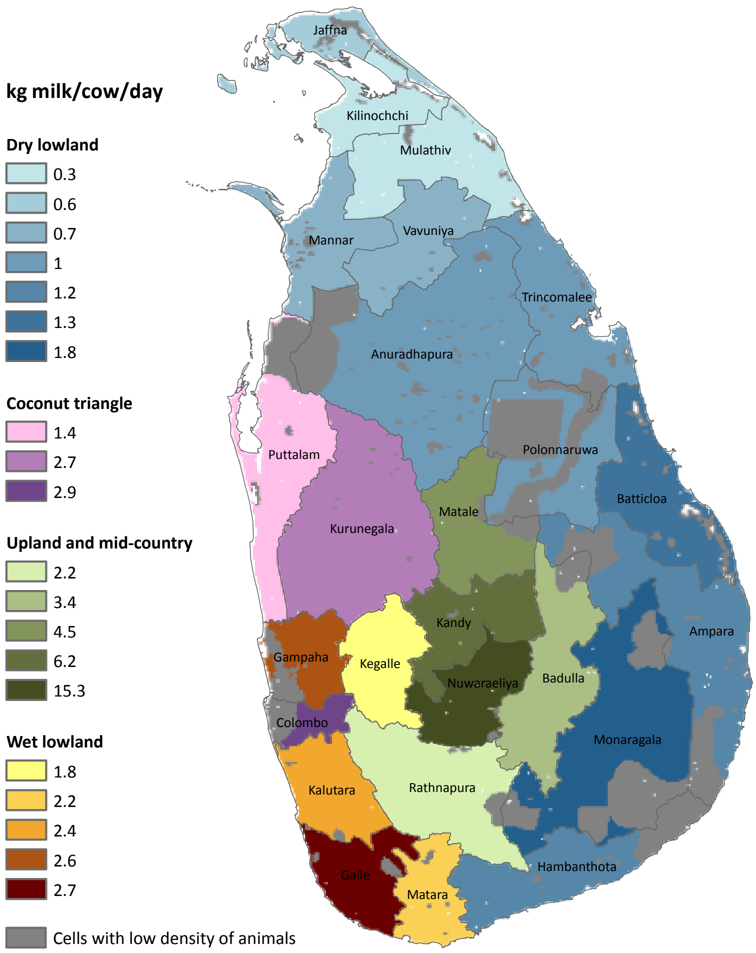
Production system			Characterization
Up-Country and Mid-Country (Wet Zone)	Semi-intensive /stall feeding	Diet	Cut and carry (local fodder) with high inputs of concentrate feed; small herds some tethering
		Genotype	Pure exotic/crossbred, some Zebu crosses
		Productivity	Exotic breeds: 12-18 litres milk/cow per day Crossbred: 5-8 litres/cow per day
		Reproductive Practice	Breeding by artificial insemination, average calving interval 12-18 months
Coconut Triangle	Free grazing on natural pasture/ Tethering	Diet	Mixed grazing on natural pasture/legumes under coconut; tethering on the roadside and fallow land; rice straw freely available along with limited concentrate.
		(Wet Zone & Intermediate Zone)	Crosses of exotic breeds, Zebu types, Indigenous animals and crosses.
		Productivity	Indigenous: 2-3 litres/cow/day Crossbred: 5-8 litres/cow/day Average herd size is two cattle
		Reproductive strategy	Artificial insemination and natural breeding
Lowland dry (Dry Zone)	Grazing/ extensive	Diet	Free grazing with rice straw; sedentary small herds in irrigation schemes
		Genotype	Mainly indigenous, very few crossbreds
		Productivity	Indigenous cattle: 1-2 litres/cow/day Crossbred: 5-8 litres/cow/day
		Reproductive Practice	Free range natural breeding; average age at first calving 30 months
Lowland wet (Wet Zone and Intermediate Zone)	Semi-extensive	Diet	Mainly natural grazing during the day time. Some cut and carry with straw and small amount of concentrate
		Genotype	Crosses of exotic breeds and improved indigenous
		Productivity	Crossbred: 3-5 litres/cow/day Indigenous breed 1-2 litres/cow/day Average herd size of five cattle
		Reproductive Practice	Natural breeding with some artificial insemination

Figure 3.1: Milk yield and contribution to milk production by production zone



Source: GLEAM, 2017

Map 3.2: Milk yield by production system



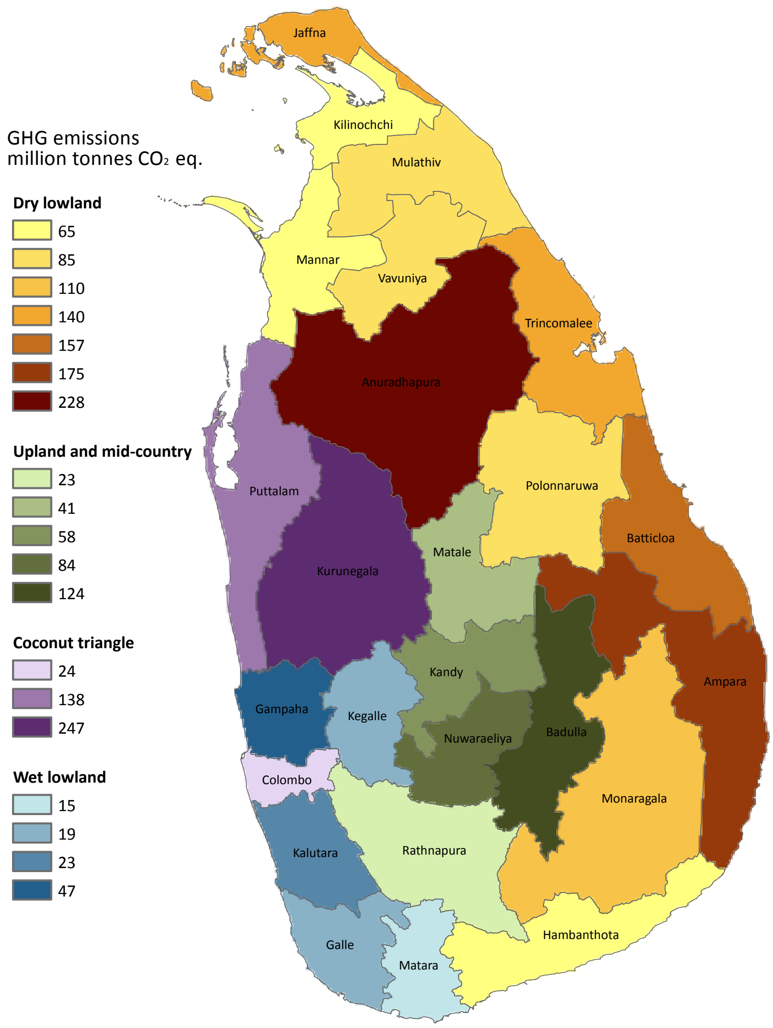
Source: GLEAM, 2017

CHAPTER 4

Emissions and emission intensities

Milk production from the dairy cattle sector in Sri Lanka emits about 2.3 million tonnes CO_2 eq. The Dry Lowland zone with about 66 percent of the dairy cattle herd emits more than 60 percent of the total emissions.

Map 4.1: Regional distribution of total GHG emissions from cattle milk production



Source: GLEAM, 2017

The activities and processes that contribute towards the GHG emissions from dairy cattle sector are shown in Figure 4.1. The GHG profile of milk is dominated by methane (93.2 percent), while the nitrous oxide (N_2O) and carbon dioxide (CO_2) contribute 1.6 percent and 5.2 percent of the total emissions, respectively.

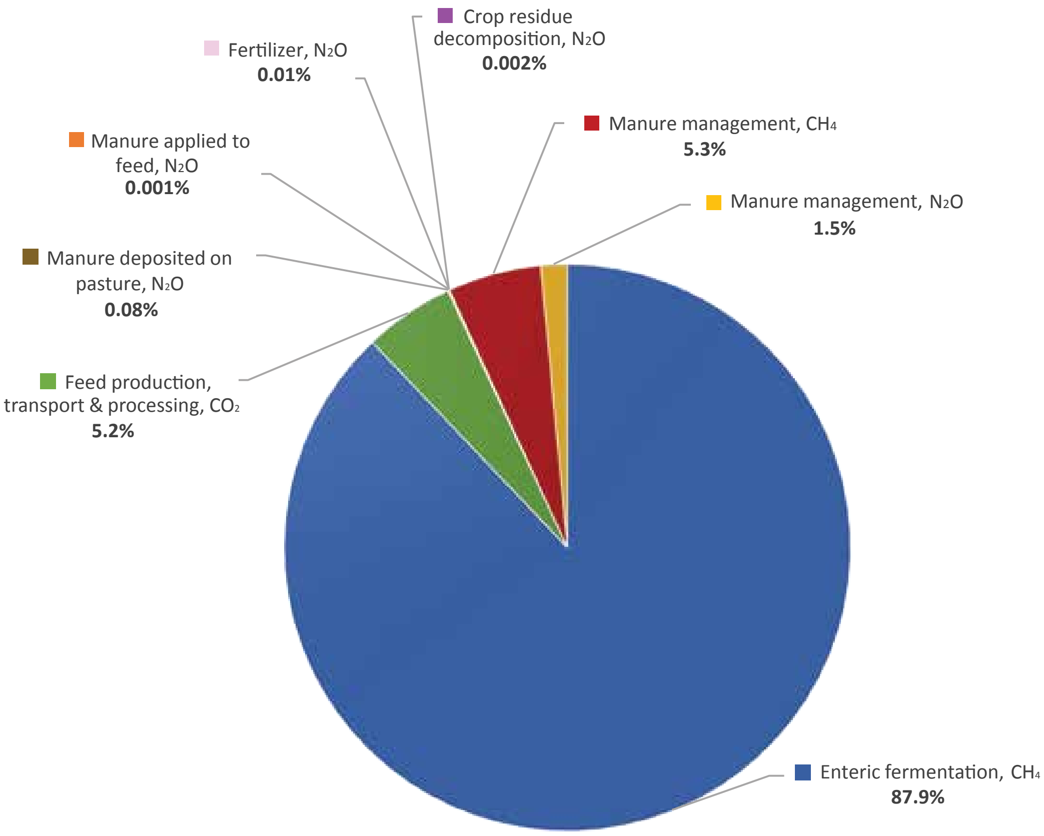
Three sources of emission sources contribute the bulk of emissions from dairy cattle. Approximately 88 percent of the emissions arise from methane produced by the rumination of cows and 5 percent from the management of stored manure. CO_2 emissions associated with feed production, transport and processing contribute an additional 5 percent to total emissions.

Production system contribution to the total GHG emissions

Within the dairy cattle sector, the Dry Lowland dairy production system which produces 31 percent of the national milk, is responsible for 62 percent (1.4 million tonnes CO_2 eq.) of the total GHG emissions. The Coconut Triangle, Upland and Mid-Country, and wet lowland systems contribute 18 percent, 15 percent and 5 percent of the emissions, respectively (Figure 4.2).

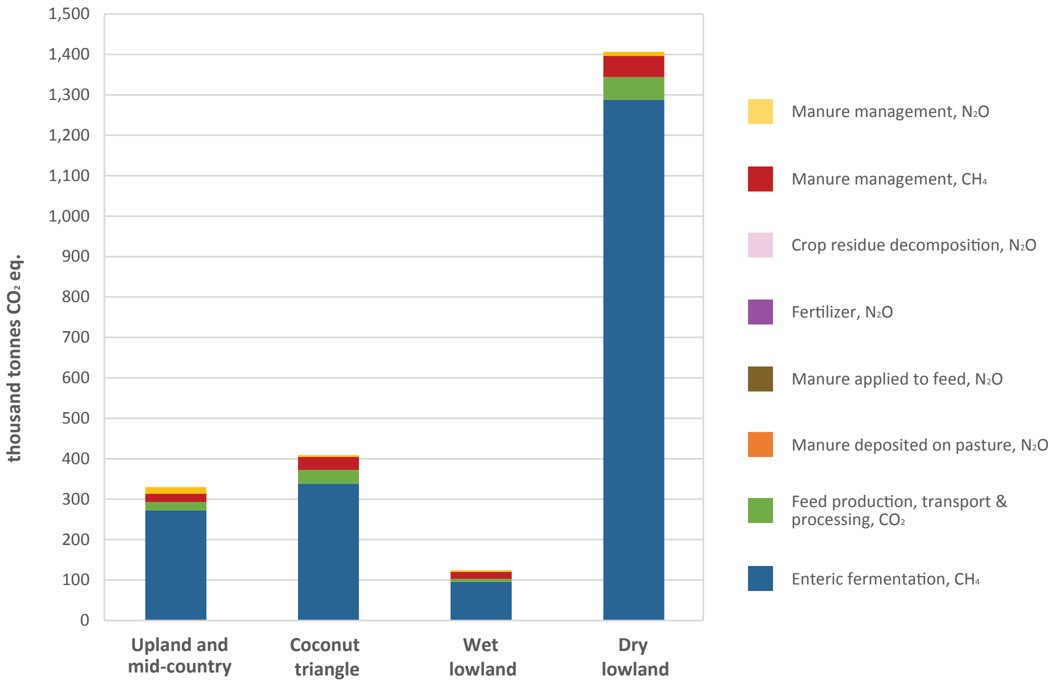
Across all production systems methane emissions from enteric fermentation comprise the bulk of emissions ranging from 77-92 percent of the total emissions. Extensive and semi-intensive systems have very similar emission profiles; enteric methane and

Figure 4.1: Share of total emissions by emission source



Source: GLEAM, 2017

Figure 4.2: Absolute emissions by production system and emission source



Source: GLEAM, 2017

N_2O emissions from manure deposited on pasture dominate both profiles. Emissions from manure management especially methane is important in the Coconut Triangle, upland and mid-country, and wet lowland systems (Figure 4.2).

Greenhouse gas emissions per kg of fat and-protein corrected milk (FPCM)

At national level, the emission intensity of milk produced in Sri Lanka is on average 6.9 kg CO_2 eq./kg FPCM; the highest values were estimated for dairy systems in the Dry Lowland zone and the lowest in Upland and Mid-country systems. Emissions were on average, 13.8, 6.8, 4.8 and 2.3 kg CO_2 eq./kg FPCM for the Dry Lowland, Coconut Triangle, Wet Lowland and Upland and Mid-Country systems, respectively (Figure 4.3).

Variability in emission intensity within dairy production systems

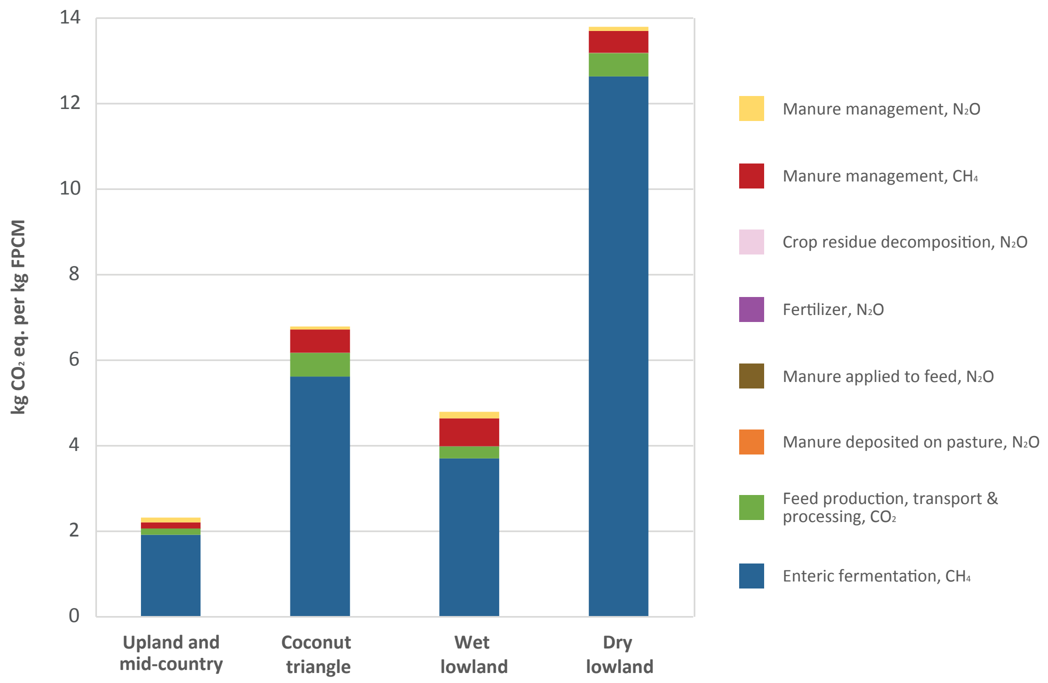
At production system level, there is a wide variation in emission intensity which is closely related to diversity the production and management practices in the dairy production systems. At production system level, the highest variability in emission intensity is observed for the Dry Lowland extensive systems with a range from 8 to 48 kg CO_2 eq./ kg FPCM (Figure 4.4). The existence of a wide variability is strong indication of the potential for reductions in GHG intensity of milk through the adoption of practices associated improvements in efficiency.

Determinants of emissions and emission intensities

A number of factors influence emissions and emission intensities from dairy production in Sri Lanka:

- **Inadequate and poor quality feed.** An inadequate supply of quality feed is the major factor limiting dairy production in Sri Lanka. Feed resources, are either not available in sufficient quantities due to fluctuating weather conditions or even when available are of poor nutritional quality. Generally, the productivity of dairy farmers is relatively low. While the small scale of dairy farm operations

Figure 4.3: Emission intensity per kg FPCM, by production system

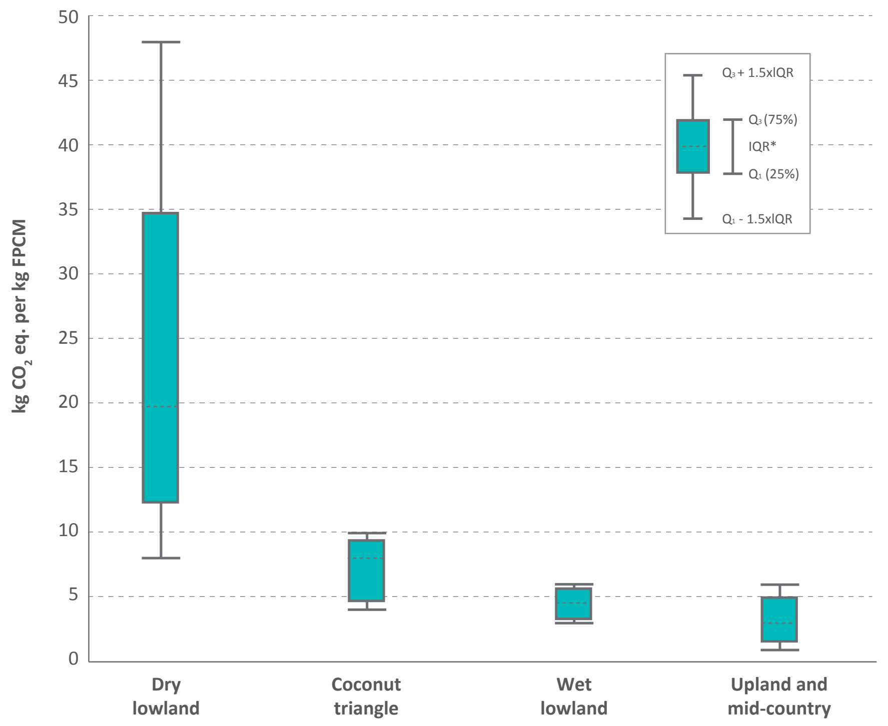


Source: GLEAM, 2017

and the lack of broad-based use of modern farm technologies/practices and improved breeds explain a great deal of the productivity gap, a notable factor is the lack of access to feed. Across all systems, fodder availability is inadequate and prices are too high for smallholder dairy farmers to access. This is constraining their milk output and their ability to expand production. This problem is compounded by seasonal changes in pasture conditions, with poor productivity during dry seasons. High milk fluctuations arise because most farmers depend on rain-fed feed production and rarely make provisions for preserving fodder for the dry-season. In addition to seasonality of feed supply, the diet is largely made up of low quality feed products such as crop residues and native pastures of poor nutritive value. Consequently, the digestibility of feed rations in all systems is low: ranging between 58 percent in extensive systems in Dry Lowlands to 62 percent in intensive systems. These constraints explain the low milk yields and short lactations, high mortality of young stock, longer parturition intervals, low animal weights and high enteric methane emissions per unit of metabolizable energy.

- **Animal health.** The prevalence of various animal diseases, tick-borne diseases, internal and external parasites affects the performance of dairy cattle. Animal health affects emission intensity through the "unproductive emissions" related to mortality and morbidity. Animal mortality rates are high (ranging between 7 percent and 16 percent) regardless of the system. Many of the health problems result from poor animal condition as a result of inadequate nutrition, but also disease. Major animal diseases include brucellosis, mastitis, foot and mouth disease, and other internal parasites. Morbidity has an indirect effect on emission intensities through slow growth rate, reduced mature weight, poor reproductive performance and decreased milk production. This is particularly true for improved exotic dairy cattle breeds which often have higher nutritional demands, poor adaptability,

Figure 4.4: Variability in milk emission intensity



* IQR = Interquartile range (Q_3-Q_1)

Source: GLEAM, 2017

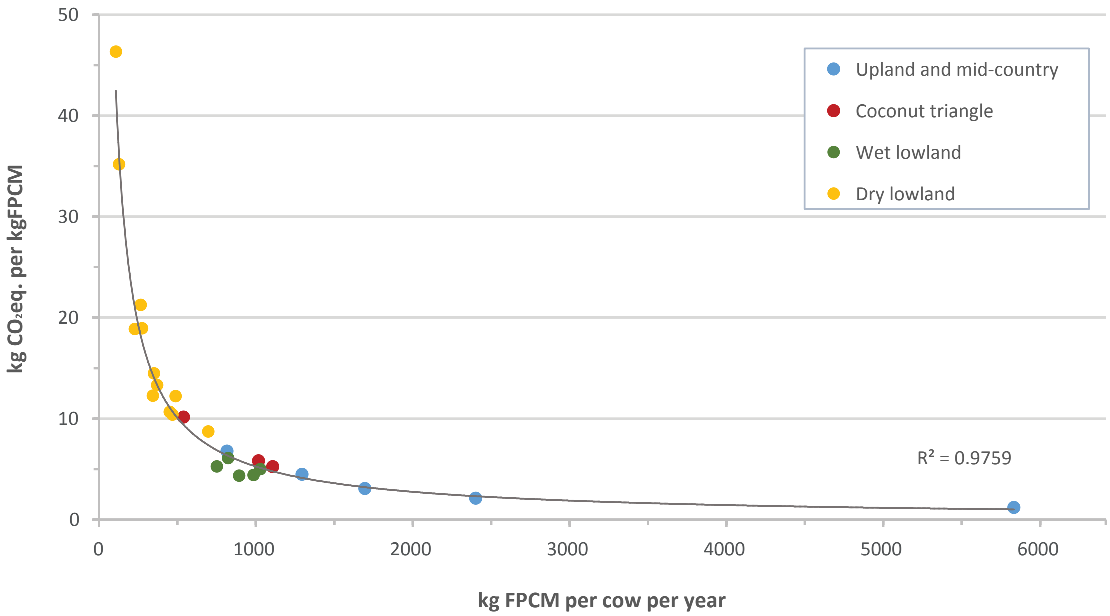
often inherently more susceptible to diseases compared to the indigenous cattle and low production efficiency under smallholder conditions.

- **Reproductive efficiency.** Reproductive efficiency affects emission intensity by influencing the portion of the herd that is in production (e.g. milked cows and young stock fattened for meat). It is also a key parameter to the economic performance of dairy systems. Improvements in reproductive performance is a major efficiency goal of the dairy industry. However, achieving this goal is currently hampered by a number of factors, particularly feed availability and quality. Poor reproductive performance of the dairy herd is manifested in a number of parameters such as low fertility rates (37 percent to 55 percent), delayed time to reach puberty and age at first calving (3.3 and 4 years in intensive/semi-intensive and extensive systems, respectively), long calving intervals, short productive life (due to culling for infertility or sterility) and high calf mortality (8 percent-16 percent).
- **Better management of genetics:** Enhancing the genetic potential of the animal is critically important, but it is equally important not to promote high genetic potential animals into climates and management environments where high-producing animals can never achieve their potential and will, in fact, perform worse than native breeds or crossbreeds due to management, disease, or climatic challenges. In intensive systems, farmers generally rely on exotic breeds such as Friesian and Ayrshire which are high yielding animals which have high feed requirements, have a high demand for clean water, susceptible to disease and other climatic stressors. In the extensive, systems animals have been bred for draft purposes, disease resistance, etc.

All these factors contribute to low milk yield, both at animal and herd levels. As a result, we observe a strong inverse correlation between the emission

intensity and the average annual milk yield per animal in dairy production systems in Sri Lanka (Figure 4.5). For animals with a higher annual milk yield, the overall farm GHG emissions (from all animal cohorts) are distributed over a larger amount of milk. In terms of feed energy utilization, the herd directs a higher percentage of feed energy intake to generate the products, rather than simply maintain body and reproduction functions. The R^2 value describes the proportion of the variation in values that is explained by the trend. In other words, an R^2 value of 0.97 means that 97 percent the variation in emissions intensity is explained by milk production per cow.

Figure 4.5: Variation in greenhouse gas (GHG) emission intensity of milk in relation to milk productivity per cow (kg FPCM, fat and protein corrected milk per cow). Each dot represents a district



Source: GLEAM, 2017

CHAPTER 5

Exploring the mitigation potential in dairy cattle production

The analysis of current production of milk in Sri Lanka shows that improved management practices and technologies that increase milk production per cow can reduce the GHG emissions intensity of milk production. This approach to mitigation is compatible with the national objective of increasing overall milk output for improved nutrition and food security. The abatement technologies and practices assessed in this study were selected for their potential impact on enteric CH_4. This is not a purely technical process but incorporates other factors such as existing political priorities. As such other considerations taken into account during the selection of interventions was the need to integrate mitigation with a number of key developmental goals for the dairy sector, such as their role in promoting food security, rural and overall economic development.

The mitigation options evaluated in this analysis were selected in a consultative process with national experts. These options identified as having the potential for large improvements in productivity were assessed alongside their potential to reduce on-farm greenhouse gas intensity while taking into account the feasibility of implementation and their potential economic benefits at the farm level. Box 3 summarizes the criteria used to identify interventions that were included in the analysis.

Enhancing animal productivity has several dimensions including animal genetics, improved feeding, reproduction, health and overall management of the herd. The interventions evaluated ranged from improved feeding practices to better herd health and management. These comprised: supplementation of basal diets with fodder trees and low cost concentrate, supplementation with rice straw concentrate mixture, use of total mixed ration, supplementation of forage diets with Gliricidia blocks, mastitis prevention and control and reduction of heat stress. Interventions were selected to address the key determinants of low productivity and inefficiencies in dairy production cycle such as seasonality of feed resources, low quality of feed, poor reproductive status of breeding herd, and animal health.

Table 5.1 provides a summary of the pre-selected interventions. The interventions were not applied uniformly, but selected for each production system, animal category, and agro-ecological zone using evidence from modelling and field studies and expert judgement of their specific operating requirements and likely impact on performance. For example, all interventions were applied only to a proportion of lactating, pregnant cows, and replacement heifers.

Quantitative summary of mitigation outcomes from the application of single interventions

The potential outcomes (emission reductions and improvements in productivity) from the application of the single interventions evaluated in this study are presented in Figures 5.1. Overall, the analysis shows that there is a high potential to reduce emission intensities; methane emission intensity (kg CO_2 /kg FPCM) can be reduced by by as low as 3 percent to 50 percent, the magnitude will vary depending on the intervention, adoption rate and production system assessed (Figure 5.1). All interventions returned a positive productivity outcome with increases in milk production ranging between 6 percent and 108 percent.

Multi-purpose fodder tress are a known and cheap source of protein for dairy cattle. They help bridge the gap between supply and demand of protein especially during the dry season. Most small-scale dairy farmers graze their animals on unimproved, natural grass. Natural pastures which commonly form the bulk of roughage for dairy cows, are generally low in crude protein, especially so during the dry season. Although crop residues may be added to grass-based diets, they are not sufficient and balanced to support milk production.

Box 4: Criteria for selection of interventions

Three principal criteria were used to identify interventions for analysis in the study; **the potential for improving production efficiency, technical feasibility of adoption by farmers and the potential to reduce enteric methane emission intensity.**

Improving production efficiency is a strategy that farmers can implement to decrease methane emissions. Enhancing animal productivity has several dimensions including animal genetics, feeding, reproduction, health and overall management of the herd.

Reduction in enteric CH_4 emission intensity. Many measures that have the potential increase productivity are associated with increased individual animal performance and this increased performance is generally associated with a higher level of absolute emissions (unless animal numbers are decreasing) but reduced emissions intensity. The figure below demonstrates some of these impacts. The impacts from the application of 4 diets were evaluated for dairy cattle across the 4 production systems. For three of the feeding strategies, enteric methane emissions increased because feeding better quality feed rations increased dry matter intake as a consequence of improved digestibility and palatability of the diet (Figure below). The total daily methane emissions (g/day) increase with higher levels of milk production. This is logical since more feed is being consumed and processed in the rumen. From an emission intensity perspective, these interventions however translate into a decrease in emission intensity (see Figure 5.1). Some practice changes however can result in a decrease in both absolute enteric emissions and emissions intensity.

Feasibility of implementation. The third criterion is that the interventions had to be feasible in the short or medium term. For the purposes of selecting interventions, "feasibility" was first determined by sectoral experts in terms of their technical potential, production system and territorial applicability, and market development. The study also assumed reliance on existing and proven technologies. The selected interventions were subsequently discussed with a broader group of stakeholder to assess the social and institutional feasibility of adoption and up-scaling of interventions. Ensuring that this criterion was met also required investigation of information on barriers to adoption. Other aspects taken into consideration with regard to feasibility included: location of interventions should be informed by location-specific determinants e.g. soil type, and potential to enhance other benefits, e.g. raising income of target population (poverty reduction).

Impacts of feeding strategies on enteric methane emissions

Source: GLEAM, 2017

In addition, commercial protein sources that could supplement these roughages are too costly for many smallholder dairy farmers to purchase on a regular basis and in adequate quantities. Production and utilization of fodder trees is a low-cost method for improving both the quantity and quality of livestock feeds on smallholder farms. Fodder trees are an ideal solution to supplement dairy animals with high quality feed especially during the dry season. Feeding lactating animals and heifers on fodder trees (*Gliricedia*) and low cost concentrate returned a reduction in enteric CH_4 emission intensity of 39 percent, 36 percent and 37 percent in Coconut Triangle, Wet Lowland and Dry Lowland system, respectively.

Improving feed availability and quality will be a key strategy to realize the largest proportion of the desirable animal productivity levels. Feed seasonality is a major constraint to achieving the targeted milk production because of heavy reliance on rainfed forage and pasture production. However during the dry season, feed availability reduces and animals are forced to survive on scarce, low quality mature grass and crop residues. In addition, there is low adoption of alternative feeding strategies such as use of conserved fodder or use of non-conventional feed resource materials to smoothen seasonal fluctuations in milk production.

Due to feed shortages, dairy farmers tend to compensate for some of the shortages by purchasing concentrate feed, however evidence from a number of studies indicates that the large majority of farmers feed a low, flat rate of concentrate throughout lactation. This often results in under-nutrition in the early part of lactation and can have a negative effect on milk production later in lactation. Supplementation with rice straw concentrate mixture resulted in a reduction in enteric CH_4 intensity by 36 percent in Wet Lowland and Coconut Triangle systems. And a corresponding increase in milk production by 58 percent in both systems. The use of total mixed ration applied in the intensive systems (Upland and Mid-Country systems) resulted in a reduction in enteric CH_4 intensity by 19 percent and a corresponding increase in milk production by 48 percent.

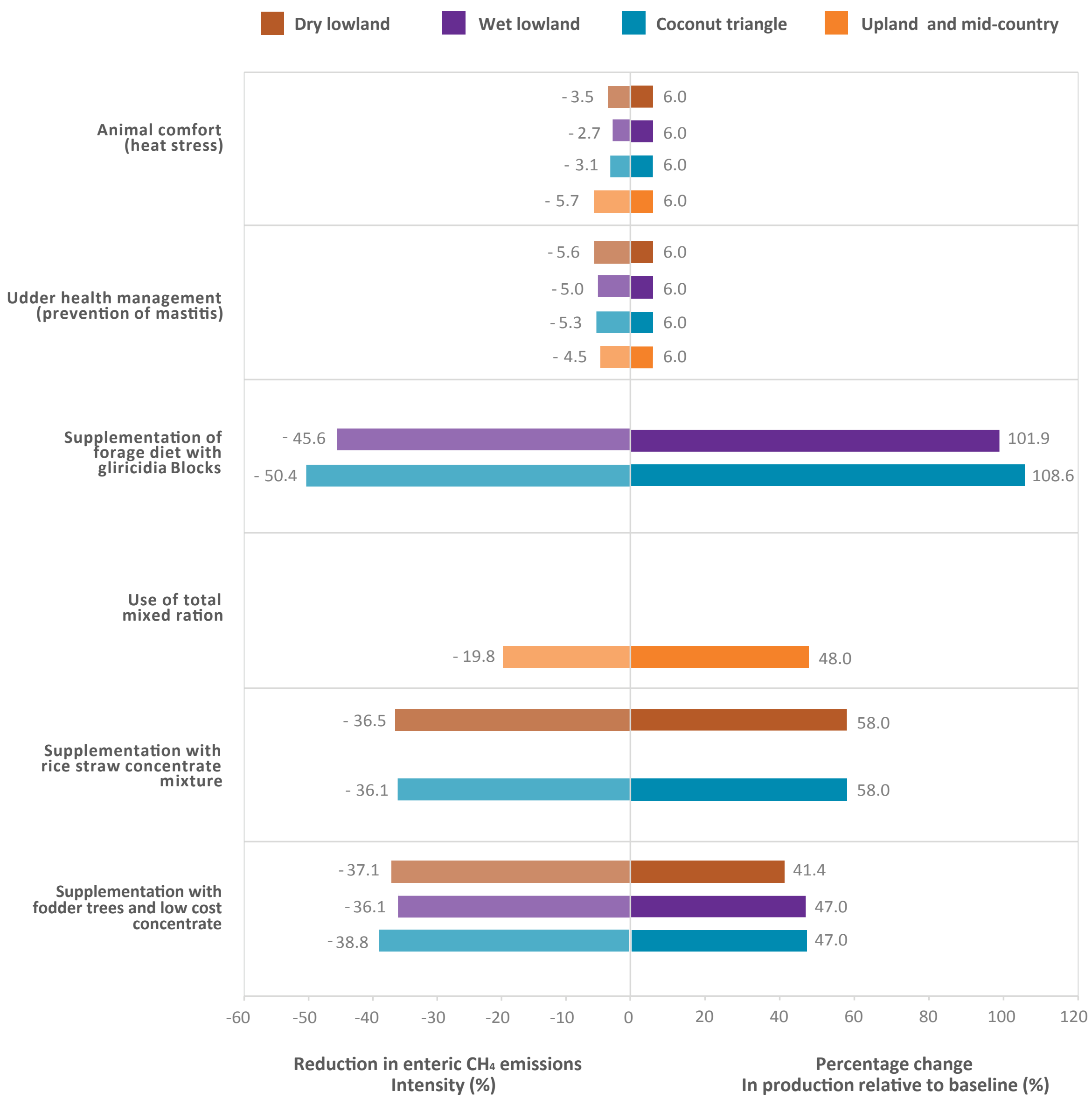
A major constraint faced by the dairy farmers in Sri Lanka is the severe drop in body condition

Table 5.1: Summary of selected interventions for dairy cattle systems in Sri Lanka

Intervention	Objective and constraint addressed	Mitigation mechanism
Supplementation with fodder trees and low cost concentrate	• Minimize quantitative and qualitative deficiency of basal diet to address feed seasonality and quality constraints	• Lower CH_4 observed with legumes is attributed to lower fiber content and faster rate of passage of feed through the rumen and therefore intakes are higher with legume forages
Supplementation with rice straw concentrate mixture	• Supplementation of diet with good-quality concentrates helps overcome problem of palatability and digestibility	• A high proportion of concentrate in diet reduces rumen pH and consequently affects the protozoa population
Use of total mixed ration	• Increase efficiency of dietary nutrient use by providing critical nutrients that are deficient in the diet and therefore balancing nutrient availability with animal requirements	• Alters rumen fermentation towards more production of microbial protein and lower volatile fatty acid production. Improves efficiency of nutrient utilization, improves productivity and reduces methane emissions
Supplementation of forage diet with Gliricidia blocks	• Improve the quality of low basal diets and addresses feed availability during periods of scarcity	• Provides rumen fermentable nitrogen and by-pass protein to fibrous diets. Promotes high dry matter intake and have a faster rate of passage through the rumen and reduction of CH_4/FPCM
Udder health management (prevention of mastitis)	• Improve health status of animals, increase productivity, reduce • Economic losses for farmers and reduce human health risks • High morbidity, reduced milk production and milk wastage	• Enhanced animal productivity and reduced GHG emission intensity
Animal comfort (heat stress management)	• Improve productive and reproductive performance of animals • Addresses reduced milk production, decreased reproductive efficiency	• Enhanced animal productivity and reduced GHG emission intensity

during prolonged droughts due to scarcity of feed. Therefore, forage diets need to be supplemented with an additional energy or protein source (concentrates) and minerals to satisfy the cows' nutritional requirements. In order to ensure a steady supply of quality feeds for livestock even during the dry season, excess forages could be preserved as leaf meal. *Gliricidia* is widely used as a source of nitrogen for ruminants, especially during the dry spell. It could be fed as a fresh diet or in dried form as leaf meals. Gliricidia leaf meal can be formed into blocks to improve the storage quality and these blocks can be improved nutritionally by mixing leaf meal with other feed ingredients such as coconut poonac and rice bran. Supplementation of forage diet with *Gliricidia* blocks reduced enteric CH_4 emission intensity by

Figure 5.1: Impact of single interventions on milk production and enteric CH_4 emission intensity relative to baseline emissions



Source: GLEAM, 2017

51 percent and 47 percent in Coconut Triangle and Wet Lowland system, respectively. With this intervention milk production doubles compared to the baseline (Figure 5.1).

The animal health related intervention (mastitis prevention) results in higher impacts in the subsistence dairy production systems; between 4.5 percent and 5.7 percent reductions, respectively. These impacts are achieved through decreased mortality rates, reduction in the age at first calving, reduction in replacement animals and increased milk yield.

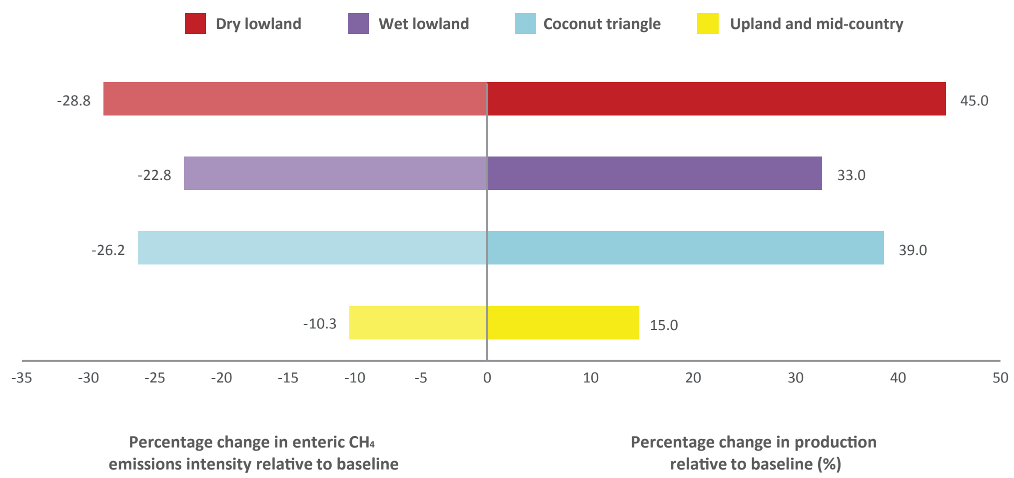
Heat stress is a major factor that reduces milk production in dairy cows. Up to 10 percent of the variability in milk production has been attributed to the effect of climatic factors such as temperature. Animals cannot reach their full genetic potential if factors in their environment are limiting. Currently, a wide range in herd average milk yields exists, which reflects the variation in genetic potential and the variation in environment, which is altered by management practices. Heat stress has adverse effects on the reproductive performances of dairy animals. Animal responses to heat stress include reduced dry matter intake, decreased average daily gain, decreased milk yield, and decreased fertility and poor reproduction. Management strategies are needed to minimize heat stress and attain optimal dairy animal performance. Managing heat stress in lactating animals resulted in methane reduction between 2.8 percent and 5.6 percent.

Quantitative summary of mitigation and productivity outcomes from the application of mitigation packages (combined technologies)

Significant reductions in emissions can be achieved through a combination of herd and health management, nutrition and feeding management strategies, and genetics. The reality is that farmers are likely to combine technologies and will select the combination of technologies that will maximize a number objectives and address multiple constraints to productivity. The joint impacts realized from applying a combination of technologies are better understood as multiplicative rather than additive i.e. they are mutually enhancing and dependent.

Applying combinations of interventions aimed at improving feed availability and quality, herd health, and herd management can potentially result in a reduction potential of between 10 percent and 29 percent in emission intensity relative to the baseline emission intensity. With these combinations of technologies, an increase in milk production between 15 percent and 45 percent can be achieved compared to the baseline (Figure 5.2).

Figure 5.2: Package of mitigation options (supplementation with fodder trees and low-cost concentrate, supplementation with rice straw concentrate mixture, total mixed ration, udder health management and heat stress management)



Source: GLEAM, 2017

CHAPTER 6
Prioritization of interventions to address enteric methane

Having identified and assessed the mitigation of potential, these technologies can be prioritized for wider dissemination and adoption. Prioritization should not only consider enteric methane mitigation potential but also the productivity benefits, income advantages to farmers and other co-benefits that are likely to provide additional incentives for farmers to adopt mitigation interventions. A key incentive to farmers for adoption is increased revenue and/or reduced costs. To better understand the implications for farmers, a cost benefit analysis was conducted to assess the profitability of each intervention. The benefit-cost ratio is the ratio between the present value of the benefit stream and the present value of the cost stream. It provides an indication of how much the benefits of an intervention exceed its costs. The results from the cost-benefit analysis are presented in Box 4.

Box 4: Assessing the costs and benefits of mitigation Interventions

The benefit-cost ratio (BCR), i.e. the ratio of the present value of the benefits to the present value of the costs. Costs were calculated as production costs (baseline scenario) plus costs involving the implementation of the mitigation strategy while benefits were calculated as total revenue from meat output within a year. The benefit-cost ratio indicates the overall value for money of the interventions. Generally, if the ratio is greater than 1, benefits of the interventions outweigh the costs. In this study the, the BCR for different mitigation options ranged from 1.6 to 4.4 (table below) indicating that benefits exceed economic costs for the different options under consideration.

The results also show wide differences in benefits across the production zones. Highest returns per dollar invested are achieved in the Dry Lowlands where costs of productions are lower compared to the other three production zones. On the other hand, the returns in the intensive systems though positive are lower due to higher costs of production and the lower price received for milk in the formal markets.

Benefit-cost ratios of mitigation interventions Benefit-cost ratios of mitigation interventions

Intervention	Upland and mid-country	Coconut triangle	Wet lowland	Dry lowland
Supplementation with fodder trees and low cost concentrate	**	1.88	1.79	3.73
Supplementation with rice straw concentrate mixture	**	2.08	**	4.28
Use of total mixed ration	1.9	**	**	**
Supplementation of forage diet with Gliricidia blocks	**	2.95	2.8	**
Mastitis prevention and control	1.58	1.64	1.56	3.43
Animal comfort (heat stress)	1.58	1.63	1.55	3.38

Note: ** intervention not applied; *Source: Authors own calculations*

The prioritization process

All individual practices were ranked for their ability to reduce enteric methane. Given that there is always uncertainty around any estimation of reduction potential we discarded any practice that would reduce emissions by <10 percent. This reduces the risk of promoting practices that have marginal or no enteric methane reduction benefit. The remaining practices were then assessed against their enteric methane reduction potential and two other criteria; productivity improvement and economic benefits (Figure 6.1).

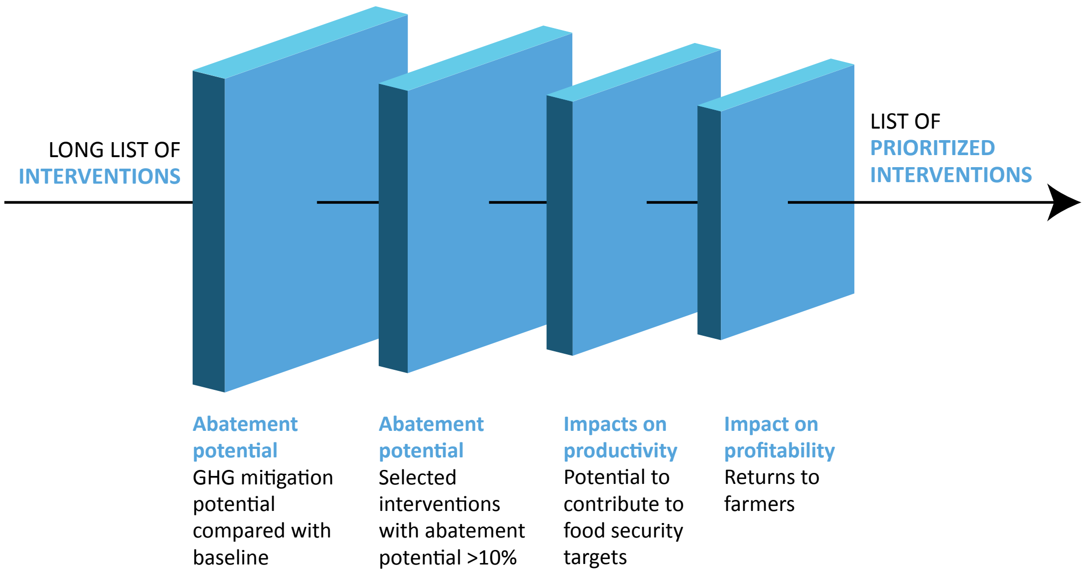
For ease of interpretation a 'coloured light' system was developed for assessing impact where red was 'high', blue 'medium' and yellow 'low'. As the impact of an individual practice varies by system, practices were prioritized separately for each system. The values associated with the high, medium and low classification system are shown at the bottom of Table 6.1. It must be emphasized that this system was developed as an aid to facilitate the identification of those practices with the highest potential both within and between practices and systems. It does not signal potential since even practices ranked 'low' against all three criteria reduced enteric methane emissions, increased output and returned a net financial benefit. The outcomes of the prioritization process are shown in Table 6.1.

Comparison of individual interventions

Across all production zones, two interventions (heat stress management and udder health management) resulted in methane emission reductions of less than 10 percent and hence were excluded from the prioritization. The remaining interventions assessed, in addition to decreasing enteric methane production, resulted in increased milk production and returned a positive benefit-cost ratio. However, the magnitude of the impacts varied considerably with each system. There were large differences in the number of interventions that local experts identified as appropriate for each system. Table 6.1 summarizes the impacts of the individual interventions within each production system.

In the Upland and Mid-country dairy zone, only one interventions was included in the prioritization process. The use of total mixed ration (TMR) ranks high on the productivity criteria and low on the

Figure 6.1: Initial prioritization process of technical interventions



other two criteria. Despite the benefits of feeding TMR it still results in an increase in enteric methane emissions because feeding better quality feed rations increased dry matter intake as a consequence of improved digestibility and palatability of the diet. The financial returns to farmers are low due to the high costs associated with adopting the intervention. In addition, most of the milk output is sold on the formal markets, where milk prices are 50 percent less than the price offered by the informal market.

The interventions (all related to feed) assessed for the 3 other production zones (Coconut triangle, Wet lowland, and Dry lowland) gave similar benefits (ranging from moderate to high) in terms of methane reduction, milk yield increase and financial returns to farmers.

Table 6.1: Results from the prioritization of single interventions for dairy cattle production systems

Intervention	Supplementation with fodder trees and low cost concentrate	Supplementation with rice straw concentrate mixture	Use of Urea Molasses Multi-nutrient Blocks	Supplementation of forage diet with Gliricidia blocks	Mastitis prevention and control	Heat stress management
UPLAND AND MID COUNTRY SYSTEM						
Methane reduction			● Low		**	**
Production increase			● Low			
Economic benefit			● Low			
COCONUT TRIANGLE SYSTEM						
Methane reduction	● Medium	● Medium		● High	**	**
Production increase	● Low	● Low		● Low		
Economic benefit	● Low	● Medium		● Medium		
WET LOWLAND SYSTEM						
Methane reduction	● Medium			● Medium	**	**
Production increase	● Low			● Low		
Economic benefit	● Low			● Medium		
DRY LOWLAND SYSTEM						
Methane reduction	● Medium	● Medium				
Production increase	● Low	● Low				
Economic benefit	● High	● High				

Note: ** Impact on methane emissions less than 10 percent

Assessment criteria:

Methane mitigation:	● Low: >10 <25	● Medium: >25 <50	● High: >50
Production increase:	● Low: >10	● Medium: >10 <15	● High: >15
Economic benefit:	● Low: <2	● Medium: >2 <3	● High: >3

Intervention packages

The large number of possible intervention 'packages' ruled out a comprehensive comparison and prioritization of alternative 'packages'. Expert judgment was therefore used to define what was deemed an appropriate common intervention 'package' to compare across the three dairy systems. Results of an assessment of this package, which comprised interventions aimed at improving herd health and nutritional status of the dairy herd, are shown in Table 6.2.

With the exception of the intensive systems in the Upland and Mid-country production zone, the results show that there is a clear benefit from introducing a package of interventions. In the Dry lowland the package of intervention has moderate impacts on methane emissions and milk production production and high benefits with regard to profitability.

Table 6.2: Prioritization results for a "package" intervention for dairy production systems

Common intervention 'package'	Methane reduction	Production increase	Economic benefit
Upland and mid country system	● (Low)	● (Low)	● (Low)
Coconut triangle system	● (Medium)	● (Low)	● (Low)
Wet lowland system	● (Low)	● (Low)	● (Low)
Dry lowland system	**	● (Low)	● (High)

Assessment criteria:

Methane mitigation:	● Low: >10 <25	● Medium: >25 <50	● High: >50
Production increase:	● Low: >10	● Medium: >10 <15	● High: >15
Economic benefit:	● Low: <2	● Medium: >2 <3	● High: >3

CHAPTER 7

Un-locking the potential of 'no regrets' opportunities

Smallholder dairy systems will continue to be a dominant agricultural production system in Sri Lanka. Dairy farming is a part and parcel of many such systems, and is an important livelihood option to increase household income of dairy farmers. This study reveals that pathways for enhancing productivity and achieving emission reductions exist in all the three systems.

This study didn't consider changes in systems i.e. from smallholder to commercial-oriented production, however, it is also possible to meet the increasing demand for dairy products by expanding milk production in the existing market-oriented systems however such choices will have to be made taking into account the implications for livelihoods and poverty reduction.

The results presented in the preceding sections indicate that there are significant opportunities for growth on a low carbon path for the dairy sector and that economically viable opportunities exist (in varying degree) within all production systems. The study also indicates that while there are many interventions to reduce emissions and improve productivity, the same intervention can also have contrasting impacts on emissions, production and farmer revenues as Table 6.1 illustrates. This reinforces the need to tailor interventions to local realities.

Increasing individual animal productivity arising from the adoption of better feeding practices, improved health and herd management, also results in a reduction of the herd. Reduction in animal numbers, particularly in subsistence production systems, allows for the provision of adequate feed, better health management leading to improvements at both animal and herd levels. Methane emissions will be reduced at both the total herd and per liter of milk. However, these mitigation options might be in conflict with the interests of smallholders who generally tend to keep animals for other functions such as traction, nutrient value and risk management. Particularly in extensive systems, appreciation of these roles is necessary if any policy geared towards change in the structure of the systems is to succeed.

The idea of significant opportunities being ignored by the sector does not make economic sense. Clearly, there are a number of challenges that must be addressed if a radical transformation of the sector is to occur. To achieve the policy objective of self-sufficiency as a strategic approach for promoting dairy development for food security, the following should be considered:

- upgrade the native herd as a fundamental necessity for dairy development, while encouraging the active involvement of the private sector;
- transform the current subsistence-level dairy production systems into a viable commercially oriented activity;
- provide a conducive environment for investment in the domestic dairy industry, with market forces governing the pricing of domestic milk;
- development of a viable, medium-to-large scale, commercially oriented private sector engaged in dairy production, which is crucial for the long-term sustenance of the domestic dairy industry;
- empowerment of dairy farmers and facilitate their participation and that of the processors in the dairy value chain.

Addressing these issues requires innovations and investments by dairy value chain actors and input and service providers, if this potential is to be unlocked. Development of the entire milk value chain will be important if dairy producers and supply chain actors are to benefit from increased productivity.

CHAPTER 8

Key messages and policy conclusions

This chapter sets out to present key highlights and messages from the analyses. It is not the intention of the chapter to repeat the detailed analysis of previous chapters but rather to draw out some key overarching messages and policy conclusions, both from the perspective of the results process and what is actually required to implement on the ground.

1. The potential for low-cost abatement is sizable

This study helps illustrate how, the dairy sector in Sri Lanka could make substantial reductions in emissions with interventions and investments that in many cases will pay for themselves. The analysis on the dairy sector demonstrates how milk productivity can grow significantly (between 15 percent and 45 percent) while reducing emissions by 10 percent and 29 percent.

More importantly, from the study low emissions development of the dairy sector can support a range of other national policy goals, including achieving it targets on self-sufficiency, economic growth and development, improved livelihoods, and environmental protection. It is this combination of reasons that explains the strong interest of Sri Lanka in low emissions growth and justifies investment in the sector.

However, achieving these reductions will require ambitious action. Translating the actions outlined in this document into food security and developmental gals will require bolder efforts to support the transfer and uptake of technology, reduce costs of technologies, scale-up private sector investment, and support development of the dairy value chain and removing disincentives to growth.

2. Many interventions are already planned under the National Adaptation Plan for Climate Change and should be prioritized.

In particular priority areas for livestock include: improvement of pasture and fodder management, diversification of feed resources (promoting feed conservation and other alternative feeds), promoting intensive management of livestock, promoting use of heat tolerant and disease resistant breeds.This Analysis suggest that these planned interventions should continue to be a priority for the government. There are also significant triple wins for the farmers, society (jobs), the economy (reduced foreign expenditure on imports, sector growth, GDP) and the environment (GHG savings).

3. Many interventions will pay for themselves

A significant percentage of the emission savings come at a negative cost, meaning they will actually contribute not only to reducing GHG emissions, but also save money in the long-term. Figure 8.1 shows that all the total potential for emissions reduction have positive net benefits (or "negative costs"). This visual presentation provides a wealth of information to policymakers and transforms the high-level objective of emissions abatement into detailed and specific choices. The curve can be used to compare the size and cost of opportunities, as well as estimate the overall size of the emissions reduction opportunity.

All interventions assessed are cost-beneficial (i.e. measures that not only reduce GHG emissions but also save money in the long term) accounting for an abatement potential of 1.4 million tonnes CO_2 eq. The intervention with the highest benefit per ton of CO_2 eq. abated (use of total mixed rations), shown on the left-hand side of the marginal abatement cost curve also provides the lowest abatement potential (0.05 million tonnes CO_2 eq.). On the other hand, supplementation (with rice straw and low cost concentrate and fodder trees) account for about 80 percent percent of the overall emissions reduction potential of the interventions analyzed.

This doesn't signify that this potential will be realized in the absence of incentives. It is clear that even win-win interventions still face barriers that require

holistic policy action. The reasons for low adoption lie in the numerous barriers that that prevent the uptake of these opportunities. Technology alone is insufficient to achieve the multiple objectives that have been charted out for the Sri Lankan dairy sector. Polices and incentives are required to minimize risks faced by various stakeholders and attract investment capital to the sector.

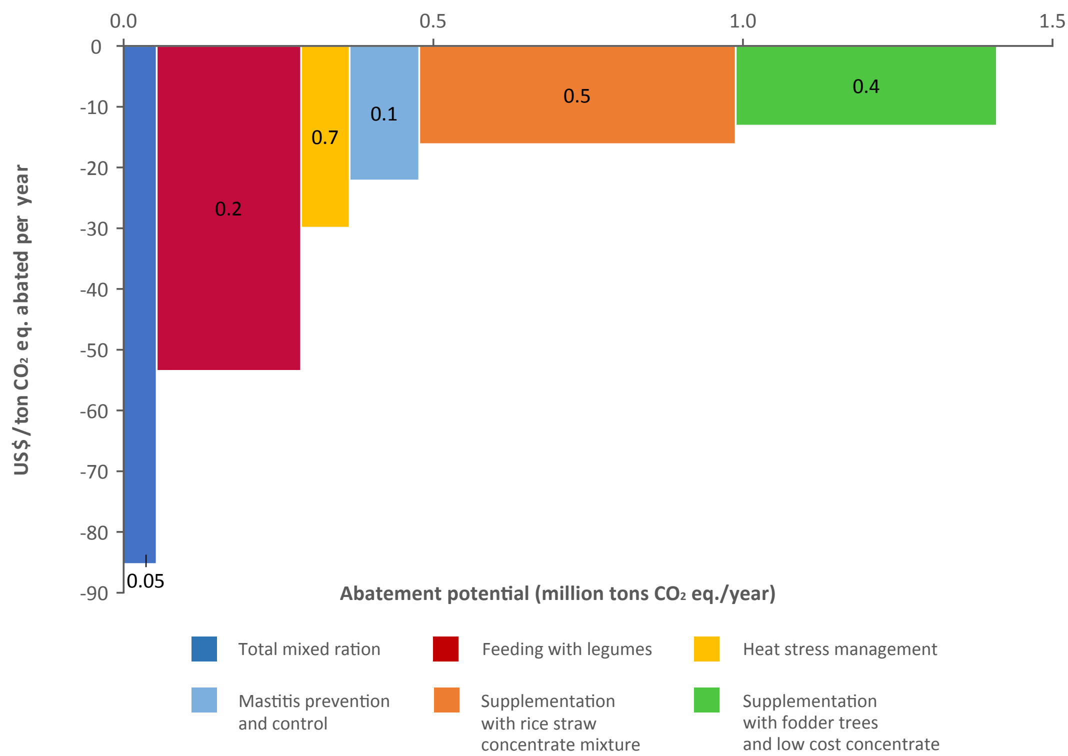
4. Action to address methane must continue to support food security goals, economic growth and other sustainable development goals

Over time, the need to integrate climate change policies into national sustainable development strategies has become more evident as these policies can only be effective when embedded within broader strategies designed to make national development paths more sustainable. There is general agreement is that policies pursuing climate change and sustainable development can be mutually reinforcing.

The numbers of smallholders engaged in dairy production is so large that any climate change strategy targeted at the sector needs to prioritize food security and livelihoods. Milk production in Sri Lanka is predominantly managed by small scale farmers; about 70 percent of the milk is produced on smallholder farms, and milk sales contribute significantly to farmer's incomes.

Actions to reduce enteric methane is thus important as it provides vulnerable countries like Sri Lanka, a critical opportunity to adapt to the challenges of our changing climate. At the same time, reducing enteric methane can reap food and nutritional benefits including other development benefits (Box 6). This will provide incentive to countries to act responsibly in global climate mitigation, while simultaneously ensuring continued domestic growth.

Figure 8.1: Abatement cost curve for the dairy sector in Sri Lanka



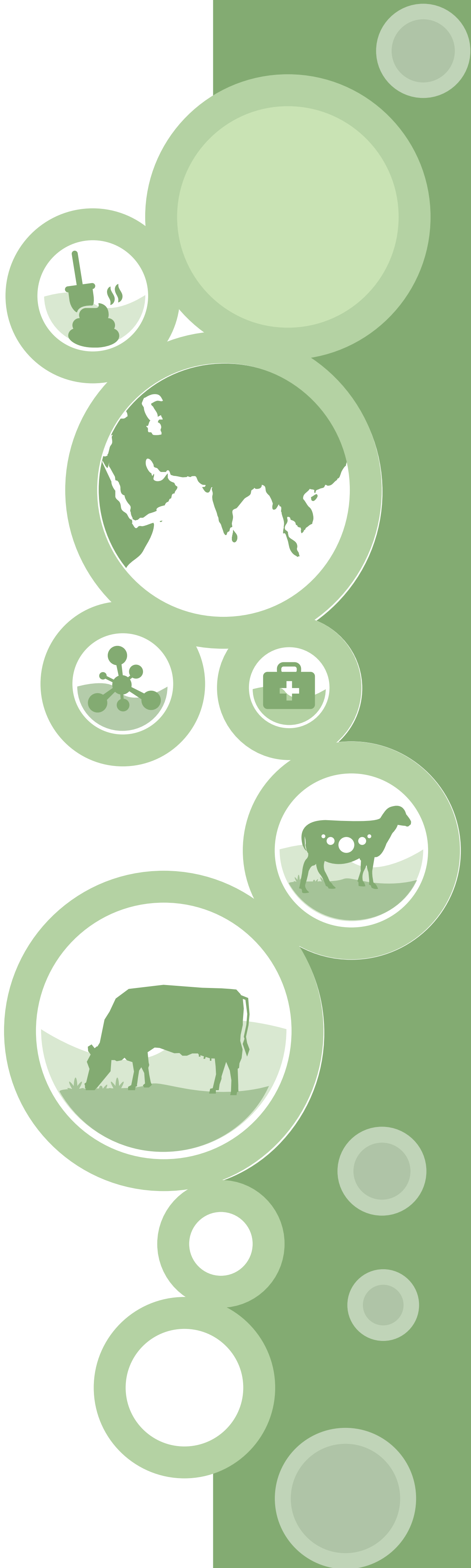
Note: *The width of the bar represents the potential GHG emissions reductions from each specific intervention. The height of each bar represents the average annual cost for each abatement opportunity of avoiding one metric ton of* CO_2

Source: GLEAM, 2017

Box 6: Reducing enteric methane for development and climate goals simultaneously

The exclusive focus on methane in the climate debate is short-sighted, if the analysis is confined only to emissions. The opportunity to mitigate methane is only one reason to reduce emissions; reducing emissions of methane can provide significant development benefits, including improved productivity, food security and livelihoods. This study confirms the often cited multiple synergies that can be achieved by combining measures that address enteric methane with efforts to improve food and nutrition security.

Methane production through enteric fermentation is not only of global concern for its contribution to global warming, but also for its wastage of feed energy, an inefficiency that limits the production performance of ruminants. As a result of this process, ruminants lose between 2-12% of the gross dietary energy in the form of methane, depending on the quality and quantity of diet. Thus, it is essential to look for options to reduce CH_4 emissions through improving feed conversion efficiency, which also translates into higher productivity and improved food security. Increasing productivity of dairy systems can benefit millions of poor livestock keepers manifested through higher incomes, improved food security and nutrition wellbeing.



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