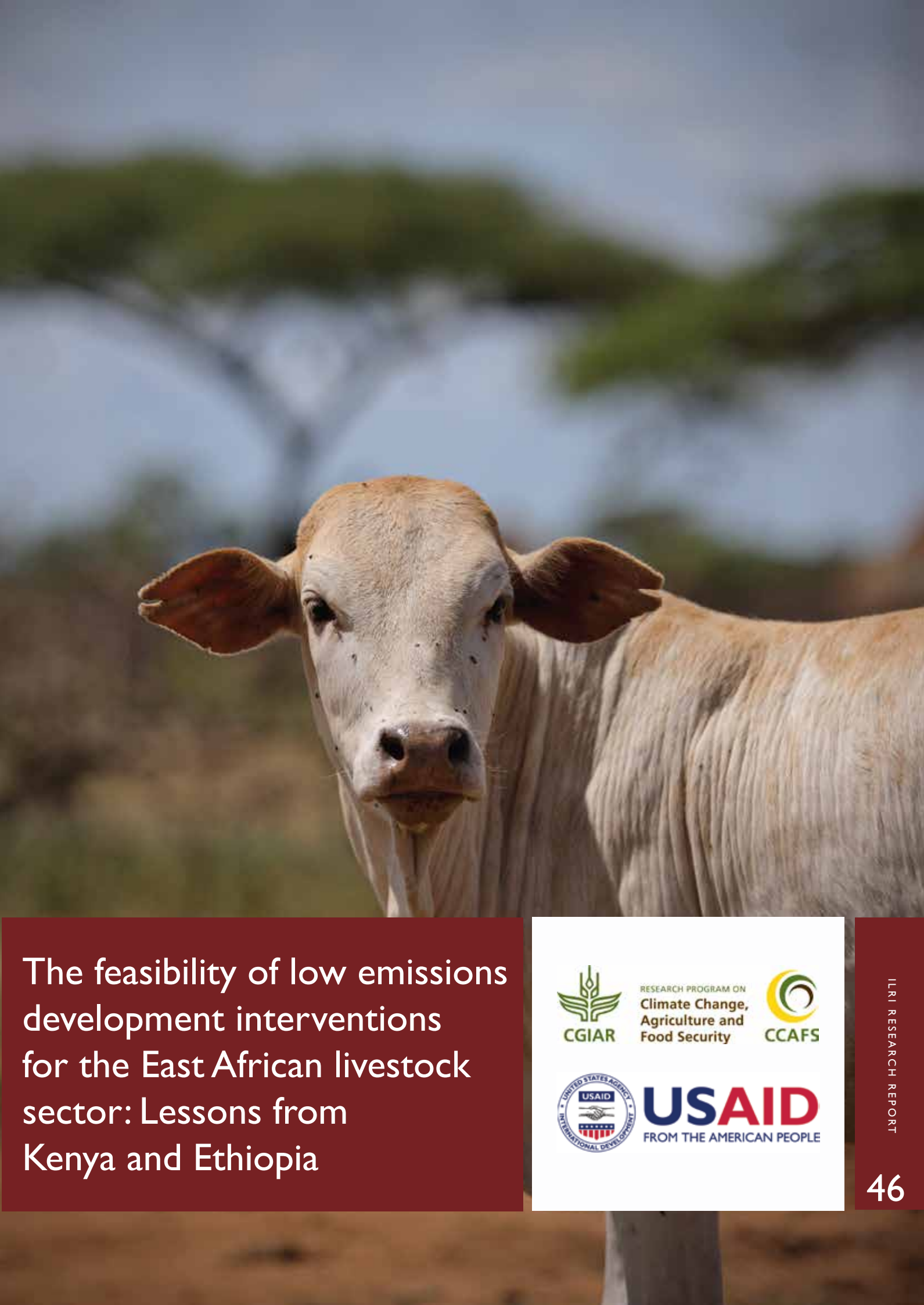

The feasibility of low emissions development interventions for the East African livestock sector: Lessons from Kenya and Ethiopia

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The feasibility of low emissions development interventions for the East African livestock sector: Lessons from Kenya and Ethiopia

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International Livestock Research Institute

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Contents

Summary iv

Why look at feasibility? 1

Low emissions strategies for livestock 2

- Improvements in feed quality and availability 2
- Manure management 3
- Animal husbandry 3

Evaluation of feasibility of LED interventions 5

- Geography 5
- Technical potential 7
- Barriers to uptake 7
- Possible incentives 8

Evaluation of the feasibility of each intervention 8

- Feeding improved forage 8
- Supplementation with feed blocks or other concentrates: 9
- Maize silage 9
- Managing grazing to increase forage availability 10
- Biodigesters 10
- Manure storage and covering 10
- Reducing the burden of disease 11
- Reducing age at slaughter 11
- Artificial insemination 11
- Summary of Interventions 12

Incentives for the top three interventions 13

Conclusions and recommendations 15

References 17

Summary

Improving the productivity of livestock production can have a significant impact on the emissions intensities of greenhouse gases (GHGs) from domestic animals in East Africa, and can help to address the challenges of meeting a growing demand for animal protein within the region. In both Kenya and Ethiopia, governments, public and private sector investors, and farmers are interested in interventions that can simultaneously improve on-farm productivity and profitability as well as meeting nutritional security needs, with reduction of GHG emission intensity being a co-benefit.

This paper examines the potential of nine low emissions development (LED) interventions or measures to reduce emissions intensity – that is the emissions per unit of animal protein produced. These measures fall into three categories: improving feed quality and availability, manure management and animal husbandry.

For feed quality interventions, we looked at improved forage species; supplementation with feed blocks; producing silage from maize; and improving pasture on rangelands. In terms of manure management, we examined the use of biodigesters and manure storage. For animal husbandry, the interventions include reducing the chronic disease burden from intestinal parasites and ticks; slaughtering meat animals at a younger age; and the use of artificial insemination (AI) to improve animal genetics. The interventions were assessed in terms of their suitability for specific farming systems, their technical potential, barriers to adoption and the potential incentives for farmers.

Producing and feeding improved forage would be most suited to intensive and semi-intensive dairy farms, and mixed systems. This could potentially reduce emission intensities by 8-24% in Kenya, and up to 27% on mixed systems in Ethiopia; however, this approach is constrained by a lack of availability of land; capital; and the availability of forage seed of sufficient quality. Investment in local field trials and extension activities to demonstrate the potential of improved fodder species, and increased investment in the forage seed sector would help to overcome these barriers and increase implementation.

Supplementation with feed blocks or other concentrates could be used on intensive dairy farms to boost milk output. Feeding urea-molasses blocks could reduce emission intensities by 6-12% on Kenyan dairy farms, and between 20-27% on Ethiopian systems. Confidence in the quality of feed blocks is a key issue, as farmers do not believe that they always get what they are paying for.

Maize silage is only considered a suitable supplement for intensive dairy systems within Kenya. Although farmers recognize that maize silage could significantly improve milk production, maize silage also competes with land used for maize for human consumption, and requires a high level of technical knowledge and labour input.

Improved grazing management can be suitable for extensive dryland systems, and produce similar mitigation results to improving forage quality. However, this intervention requires improved governance capacities to implement improved grazing regimes and prevent over-grazing. This is a long-term measure, as it would take several years to implement and sustain improved pastures. Grazing management could be improved by activities to strengthen the local and national organizations involved in grazing management. Improving market access would also provide incentives for pastoralists to improve grazing productivity. Ecosystem service payments could potentially encourage managed grazing, but are dependent on funding, and having effective institutions to manage them.

Biodigesters are suitable for intensive dairy farms with 4 to 5 cows or more, and can cut total emissions from manure by 60—80%. The costs of installation, the need to transport liquid slurry and the labour required are the biggest barriers to adoption. Biodigestors offer direct benefits to farmers and are supported by NGOs and the Kenyan and Ethiopian governments.

Manure storage and covering is appropriate for intensive and semi-intensive mixed systems, and can reduce total methane emissions from manure by up to 90%. A lack of knowledge on the benefits of manure composting and spreading to soil fertility is the key barrier to uptake.

Livestock productivity in both countries can be improved by reducing the chronic disease burden, particularly that from intestinal parasites, ticks and tick-borne diseases. The use of antihelmintics in the Kenyan dairy sector could potentially reduce emission intensities by 8-20%, and control of trypanosomiasis could reduce emission intensities by up to 30%. However, farmers do not currently perceive real benefits from this approach. Furthermore, a lack of trust in input quality control, vets and animal health services in the two countries limits uptake.

Reducing the age at which meat animals are slaughtered, in combination with improving feed quality, could help extensive pastoral systems the reduce emission intensity for cattle production by 40%, and 34% for sheep and goats. The approach relies on farmers being able to market their animals and also requires them to have access to sufficient feed and fodder resources to fatten animals early.

Artificial insemination (AI) could aid intensive dairy farms, by improving fertility, helping to introduce improved breeds and replacing less productive animals. The lack of quality services, and the perceived costs and risks involved is the key barrier to farmer uptake of AI.

The three top recommended practices for reducing GHG emissions intensities are increased production of improved forages in mixed systems and intensive dairy, the increased use of biodigestors in intensive dairy and improving the management of grazing for pastoral systems. Each of these practices might be incentivized in different ways, beyond the immediate direct benefit to producers. We note that the basis for any interventions should be access to improved feeds and forages year round.

Promotion of the practices described above have important implications for social equity in the pursuit of low emission development. LED pathways based on intensification, for example of dairy, would likely yield landscape or national-scale emission reductions and economic growth for large operators. However, if intensification also leads to concentration of smallholdings into larger-scale farms due to persistent low profit margins (which has been the pattern in Europe and North America), this would substantially disrupt smallholder livelihoods and rural society in general. This is especially important in the absence of viable livelihood alternatives, which characterizes Kenyan and Ethiopia. As yet, it is unclear if there could be mechanisms to effectively safeguard against such outcomes. What is clear is that these potential outcomes can be anticipated and thus need to be considered and addressed alongside the biophysical target of reducing GHG emission intensities. This implies weighing trade-offs between multiple – and potentially conflicting – biophysical, social and political objectives.

Why look at feasibility?

Livestock production is the largest source of greenhouse gas (GHG) emissions from agriculture (Smith et al. 2014, Tubiello et al. 2014). In terms of global averages, the emission of methane as a result of enteric fermentation in the digestion process of ruminants produces about 40% of the total emissions. In Africa, although total emissions from livestock are still lower than in the member states of the Organization for Economic Cooperation and Development (OECD), the emissions intensities per unit of animal product produced are very high (Herrero et al. 2013), which is a cause for concern given the rapid growth projected for the sector. Since the 2015 Paris Agreement, countries have developed Nationally Determined Contributions (NDCs) to reducing GHG emissions. Across Africa, many NDCs include agriculture, and in some cases specifically mention livestock, as a sector in which GHG emissions can be reduced. Livestock production is therefore an important area to explore in terms of reducing emissions through interventions by improving productivity.

Kenya and Ethiopia both have economically important livestock sectors. In Kenya, the livestock sector contributes about 12% to GDP and 40% of agricultural GDP (IGAD LPI 2011). Kenya has one of the largest dairy sectors in sub-Saharan Africa, contributing 8% of GDP (Odero-Waitituh 2017). In Ethiopia, although the dairy sector is not well developed, livestock production contributes between 25 and 45% of agricultural GDP (Behnke 2011), with a live animal trade valued at over USD 45M in 2008 (Aklilu et al. 2013).

However, inefficient production systems lead to GHG high emissions intensity, measured as the amount of GHG per unit of product (meat, milk, calories, protein). The livestock sectors in both countries face feed shortages, and a lack of investment in improved genetics, animal health services and farm inputs. In both countries, the NDC targets the livestock sector for reducing emissions.

Recent publications (Gerber et al. 2013, Herrero et al. 2013; 2016, Hristov et al. 2013) have summarized a range of technical interventions that, if implemented properly, show promise in helping livestock producers and other value chain actors to reduce emissions intensities from livestock production. However, given the low productivity of most livestock in Africa, there are legitimate concerns about the social and economic feasibility of many of these interventions. For example, unpublished data by ILRI (International Livestock Research Institute) show that despite years of investment in developing and disseminating improved forages for on farm use, uptake in Kenya and Ethiopia remains low.

Achieving the reductions promised in the NDCs will require financial investment; this is explicitly stated by most countries, especially in Africa. One form these investments may take is to provide a range of incentives to promote greater uptake of interventions that show promise to reduce emissions intensities. This study, undertaken at the request of USAID (United States Agency for International Development) and CCAFS (the CGIAR Research Program on Climate Change, Agriculture and Food Security), investigates the social and economic feasibility of interventions in livestock production systems in both Kenya and Ethiopia to reduce the intensity of GHG emissions. The findings should contribute to investment programs which will help both Kenya and Ethiopia meet their NDC and other climate commitments.

Low emissions strategies for livestock

Livestock production results in direct GHG emissions for several reasons. Nitrous oxide and methane emissions from feed production and processing (including land use change) produce 45% of total emissions, and nitrous oxide and methane from manure management and processing contribute another 10% (Herrero et al. 2016). However, these proportions vary substantially by type of system. African systems have become a cause for concern because emissions intensities are high (meaning that GHG per kg of milk or meat is greater for an African cow than a European cow). The demand for livestock products in Africa is likely to increase due to rising incomes and increased urbanization. African livestock farmers could benefit from this increased demand; however increased local production with these high GHG emission intensities could result in higher overall emissions if animal numbers increase.

The main reasons for high emissions intensities in African livestock systems are low productivity and low feed digestibility. If livestock are using energy just to maintain body weight and basic functions, rather than producing meat or milk, the GHG emissions intensities per kg of 'product' are very high. If productivity increases, emissions per unit of animal product will decrease (even if overall methane increases) and ultimately producers should be able to keep fewer, more productive animals.

This study focusses on addressing animal productivity gains, but also looks at manure management. Manure is a significant source of emissions in African systems (around 10%) and better management could provide other productivity benefits, namely improved soil quality and fertility. Emissions from manure are also directly affected by changes in feed.

In Kenya and Ethiopia, livestock production practices (or systems) vary depending on agroecology, culture, and infrastructure. Extensive pastoral systems, largely found in the arid and semi-arid regions, rely on mobility to access grazing and water resources. The systems include cattle, sheep, goats and, increasingly, camels. Although there is an emerging niche market for camel milk, it is valued for home consumption and the primary economic value of these animals is for their sale for meat. In mixed crop–livestock systems, which are found in areas with higher rainfall and population densities, milk is the main economic output from livestock, especially in Kenya. Mixed crop–livestock systems can be more or less intensive. In Ethiopia, because the dairy sector is not as commercial, these mixed systems produce small ruminants and dairy.

We initially selected nine interventions to assess, appropriate in one or more of the production systems found within the two countries. Selection was based on literature reviews and discussions with livestock experts. They are described briefly in the following section.

Improvements in feed quality and availability

Low quality (or digestibility) and quantity of feeds are one of the major constraints on livestock productivity in East Africa (Lukuyu et al. 2011). Studies have shown repeatedly that improving dietary quality and quantity results in live weight gain, which will then reduce emissions intensities through productivity increases. We note that Hristov et al. (2013) summarize the best studies of the effects of improving quantity versus quality, and stress that quality is the key factor influencing

methane production from digestion[3]. We chose three generic options for mixed-crop livestock systems, recognizing that they would need to be tailored to specific community and system needs using participatory evaluation tools developed by ILRI: FEAST and TECHFIT (ilri.org/feast).

1. Feeding improved forage species has been promoted by many to improve overall quality of the diet. The most common practice is to harvest planted fodder grasses and feed them to livestock either as a basal diet or as a supplement, especially during the dry season. Organizations such as ILRI and CIAT have long experience breeding and disseminating improved fodder materials. Limited evidence suggests that some farmers do supplement with improved fodder, particularly in intensive and semi-intensive dairy in Kenya, to maintain or increase milk yield.

2. Supplementation with feed blocks, dairy meal or other concentrates is a more targeted method for improving the quality of the animal's diet. These can be commercially prepared blocks (e.g. urea and molasses) or more simply can be industrial by-products, e.g. residues from breweries. As these concentrates have to be purchased, the costs can be high.

3. Producing silage from maize is a third option for improving livestock feed quality. Conserving maize as silage is especially useful for increasing the availability of high-quality feed during dry conditions. ILRI research has suggested that this is primarily an option for intensive systems in Kenya, where maize is the dominant crop and demand for fodder is high (Lukuyu, personal communication and Lukuyu et al. 2011). The practice is not used in Ethiopia. Other crop residues or by-products (e.g. sweet potato vines) can also be made into silage.

4. In extensive systems, where livestock rely exclusively on grazing to meet their feed needs and feed shortages are a critical constraint, we propose a different strategy focused on improving pasture in rangelands. Rangeland management schemes in combination with improved governance regarding access can lead to greater rangeland productivity and the increased availability of feed.

Manure management

Manure from livestock is a source of nitrous oxide and methane emissions as a result of storage and processing. Methane is released from anaerobic decomposition, while nitrogen is released as ammonia or nitrous oxide (Gerber et al. 2013). On the positive side, manure is a valuable resource containing many essential micro and macro nutrients required for plant growth, and its application to cropland also increases soil quality (Hristov et al. 2013). Although emissions from manure are not as large as from ruminant digestion, the other benefits of manure management suggest that this could be a 'win-win' option. For this study we explored two interventions:

1. Biodigesters which capture the methane from manure and allow it to be used as an energy source, usually for household cooking. In both Ethiopia and Kenya, ongoing projects are promoting the uptake of biodigesters as an alternative energy source to fuel wood or charcoal. An additional benefit is that the slurry can then be applied to cropland (including land being used to produce fodder).

2. Manure storage can be improved by covering heaps over to better maintain anaerobic conditions which reduce nitrous oxide and methane emissions. Although many farmers collect their manure, few store it according to best practice, and even fewer follow best practice when applying it to agricultural fields.

Animal husbandry

In addition to improved productivity through better feed, improved animal husbandry is suggested by many. This includes improving animal health, genetics and overall herd management. Reducing animal numbers and yet at the same time producing the same or even greater quantity of animal product has been the single most influential mitigation strategy in the US and Dutch dairy industries (Hristov et al. 2013).

3 We caution that these studies have all been conducted on animals with a predominantly grain-based diet, so bear little resemblance to any African production systems.

1. Reducing the chronic disease burden on animals can improve productivity. In particular, the treatment of intestinal parasites by regularly using anthelmintics, and the control of tick-borne disease with regular spraying or dipping. Emission intensities are reduced because healthier animals are better able to maintain their milk yields/ body condition.

2. Slaughtering meat animals at a younger age reduces the resources used in maintaining mature but unproductive animals and can reduce the overall emission intensity.

3. Artificial insemination (AI) can be used to introduce improved breeds and genetics. This is the most long-term intervention, but improved breeding is a highlight of many livestock research efforts, including within the CGIAR. Both this intervention and reducing age of slaughter should lead to different herd management, whereby fewer but more productive animals are kept.

Evaluation of feasibility of LED interventions

To evaluate the feasibility of each intervention we considered several criteria, namely geography; technical potential; barriers to uptake; and possible incentives.

Geography

We accounted for geography by mapping out the major livestock production systems in Kenya and Ethiopia, as the systems are quite different in function and structure. In both countries, the primary distinctions are made on the basis of agroecology, cattle densities and milk yields. In Kenya, the main distinction is between dairy and pastoral systems. Dairy is produced primarily on smallholder farms which practice both cropping and livestock production.

We mapped four systems for Kenya: Extensive and semi-intensive pastoral production; semi-intensive and intensive dairy. These areas are shown in figure 1. In Ethiopia, commercial dairy production accounts for only 1% of production, so we only mapped pastoral production and mixed crop–livestock as shown in figure 2. We include data on population densities to indicate potential numbers of farmers who could upgrade their current production practices within a given area. In Kenya, the extensive systems account for the bulk of the land area (over 500,000 Km2 or 80% of total) and the bulk of the cattle (more than 7 million). However, the population densities are low relative to the intensive systems. In Ethiopia, the two main systems – livestock only and rainfed mixed crop–livestock – each cover about half the land area (500,000 km2), with many more cattle found in the mixed systems (over 34 million).

Figure 1. Dairy cattle productions systems in human population densities

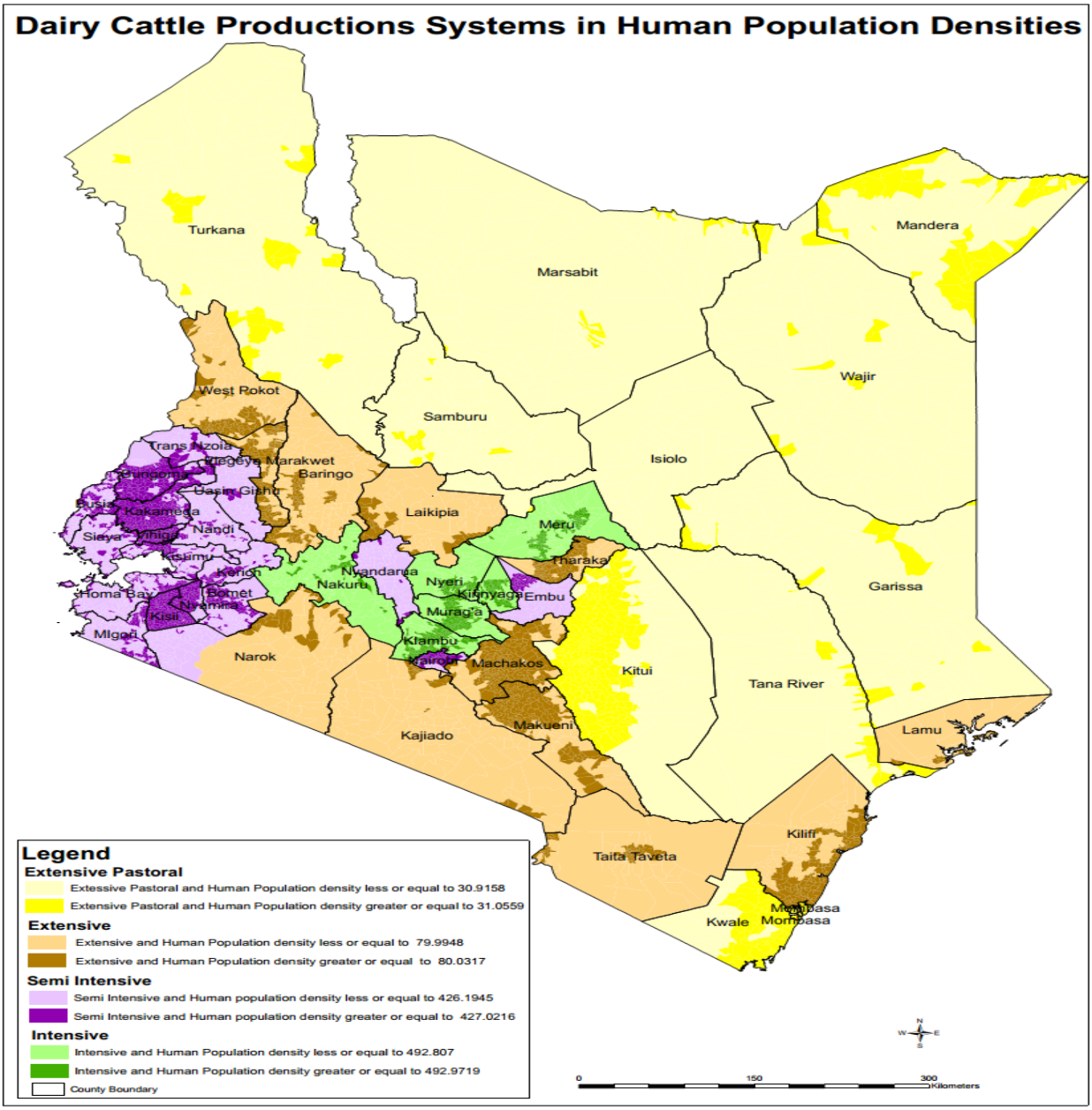
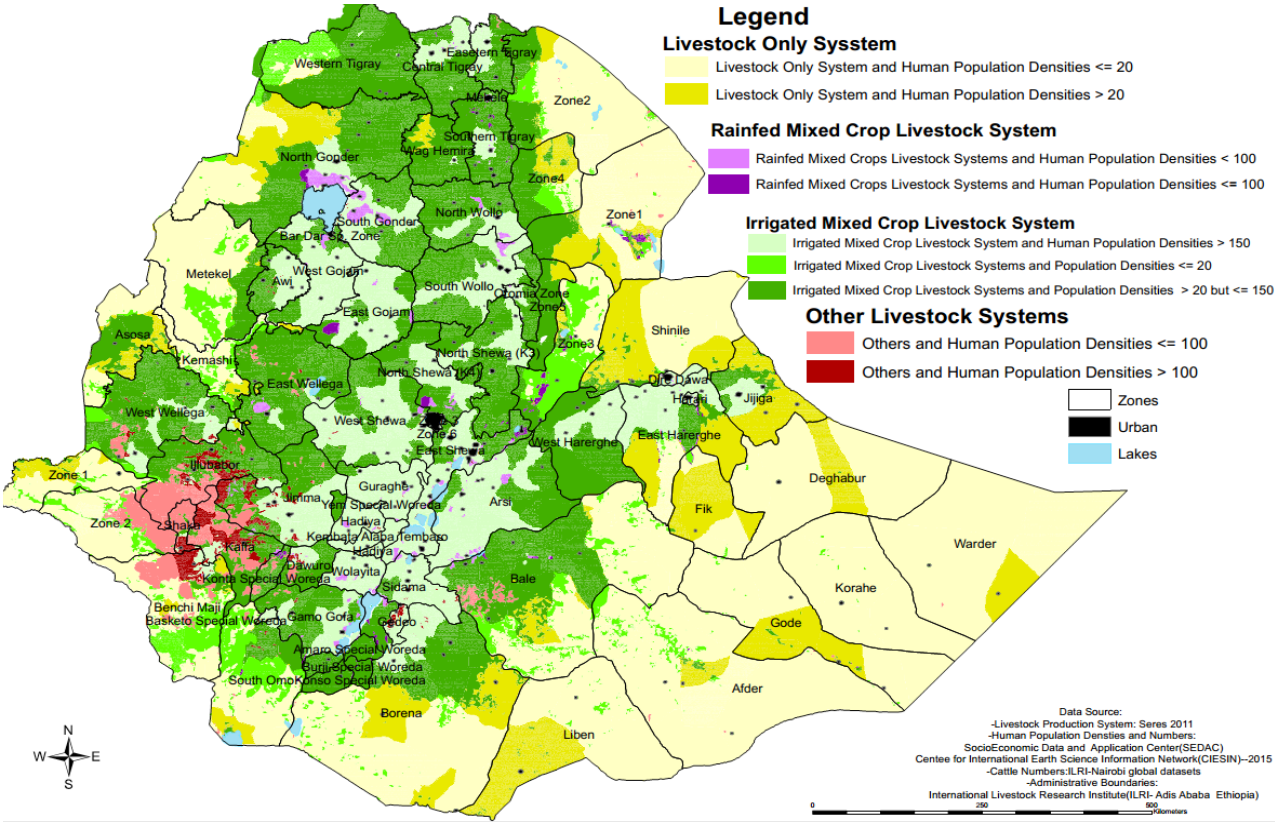


Figure 2. Ethiopia livestock production systems and human population densities



Technical potential

Each intervention is then ranked in terms of published estimates about their technical potential to reduce emissions intensities[4].This does not account for the potential level of farmer adoption, but is instead based purely on the results from technical trials or model estimates of what could be achieved if farmers changed their management practices.

Barriers to uptake

Farmers often do not adopt new technology for a wide variety of reasons, often referred to as 'barriers to adoption'. These factors constrain or prohibit farmers from taking up or using a practice. These barriers can be categorized as follows:

1. Biophysical (e.g. land availability);
2. Informational (e.g. technical knowledge or trust);
3. Market (e.g. access, input and output prices);
4. Organizational (e.g. effective institutions to facilitate collective action).

4 We caution that these estimates are from studies in OECD countries or model-based estimates based upon assumptions and emissions factors from OECD studies.

Possible incentives

Because some barriers are more challenging than other, we next considered potential incentives farmers might have for engaging in the new practices, ways of overcoming these barriers. We identified a variety of approaches.

1. Improved markets (access, prices);
2. Improved input quality and information to evaluate inputs (e.g. fodder evaluation tools);
3. Improved efficiency/ profitability;
4. Regulatory or governance change;
5. Direct benefits (e.g. new source of cooking fuel);
6. Price premiums (e.g. for 'green' or organic milk);
7. Cash payments for provision of ecosystem services;
8. Free services or information (e.g. veterinary advice, milk collection).

We then gathered information on what would be needed to implement the top three interventions, and discussed other policy or institutional reforms that would be needed with the key national stakeholders. Farmer interviews helped to identify current practices and barriers to adoption. We collected data through focus group discussions consisting of farmers with one or two extension agents, and expert interviews. The discussions were held in each one or more locations representing the three production systems in both Kenya and Ethiopia. In total, 24 discussions were held with an average of 8 participants (30% women). We note that as we relied on extension agents to convene the groups, we probably spoke with more 'progressive' farmers, already likely to be using one or more practices.

Evaluation of the feasibility of each intervention

The degree of market orientation is the major precondition across all systems and interventions for 'upgrading' the use of any of the interventions. Unless farmers are intentionally and consistently producing with a commercial orientation, most of the interventions are too expensive to be profitable, given the low prices for milk and livestock.

A second overarching issue is that farmers indicated lack of trust in many input providers, who are not accountable for the delivery of poor quality services or products. We further note that farmers do not consider interventions in isolation. For example, a sufficient basal diet is widely seen as a pre-requisite for increasing investment in improved genetics and the use of dietary concentrates or silage. While animal health is often stressed by experts as another pre-condition, farmers interviewed were not as concerned about this issue.

Feeding improved forage

This is suited to intensive and semi-intensive dairy farms and to a lesser degree for mixed crop–livestock systems, because it requires the collection and (ideally) storage of fodder to feed to animals that reside largely on farm, with limited grazing.

Estimates of potential to reduce emissions intensities (through improving quality and quantity of feed) range from to 8 to 24 % in intensive and semi-intensive dairy systems in Kenya, and 27% in mixed systems in Ethiopia (FAO and NZAGGRC et al. 2017a, b), provided leguminous species are included with grasses. This reinforces the point that the quality of the feed matters. Low rates of adoption of improved fodders have been found in Kenya and Ethiopia (Tuefel, personal communication); Lukuyu et al. 2011; FAO 2012), although Tuefel found it is more popular in systems with higher cattle and human population densities. As dairy production is much less intensive in Ethiopia relative to Kenya, experience with and

use of planted fodder on a regular basis is less common there. Producers interviewed for this study, all of whom currently feed fodder to varying extents, listed three main barriers to a higher level of use.

First is low availability of land on which to plant more fodder crops. Given small land holdings overall, fodder crops are mostly grown on the margins of farms where food crops are not grown. Most farmers are not able to achieve the recommended daily feeding levels even in the wet season, and all face significant shortfalls in fodder availability during the dry season. If production increases to the point that fodder can be conserved for the dry season, then adequate storage facilities are often required. This requires further capital investment. In addition, on-farm storage facilities would take up even more space on already space-constrained plots. Collective fodder bank facilities may provide a viable alternative, but these require physical infrastructure, transport logistics, and institutional capacity for effective management.

Secondly, farmers deliberately pursue a diversified cropping strategy and are reluctant to specialize in fodder production for dairy at the cost of their own food production. This is consistent with weakly developed fodder markets and limited experience with commercial fodder production by most smallholder farmers.

Lastly, farmers often have poor access to improved forage seeds, which is compounded by weak extension services and fodder markets. Because improved forage quality is so fundamental to so many other improvements, this is the intervention selected for a more detailed investment plan.

Supplementation with feed blocks or other concentrates:

This intervention is suitable for intensive dairy as a supplement to boost milk production. FAO NZAGGRC et al. (2017a, b) estimated that supplementing feed with urea-molasses blocks could reduce emissions intensities by 6 to 12% in dairy systems in Kenya, and between 20 and 27% in Ethiopia. Most intensive dairy producers interviewed report that they use some type of concentrate supplementation, especially during the dry season. However, few follow recommended feeding regimes, largely due to high costs involved and low returns from increasing production. Access to improved dairy breeds is an additional important factor, as improved breeds are more efficient users of dairy meal. Finally, variability and uncertainty in the quality of concentrate products is a barrier to more widespread use because farmers are not always confident that they are getting what they pay for.

Box 1

If a 5-kg bag of concentrate costs KES750 per month and can feed three cows then this will total KES9,000 costs. If milk production increased by 2 L per day, income would increase by KES6,300 annually, not enough to offset costs of purchased concentrate.

Maize silage

Maize silage is only suitable as a dietary supplement for intensive dairy systems within Kenya.

It is considered as low methane producing feed, and will have a similar impact to including concentrates in the diet (Hristov et al. 2013).

Farmers interviewed recognized that silage could substantially improve milk production, especially during the dry season. However, maize silage also competes with maize for human consumption, although it may make sense in areas where maize crops often fail, or where other products such as sweet potato vines and Napier grass can be used.[5] As with improved forage, land availability is the key constraint. The second constraint is the technical knowledge required to produce maize silage, as well as high labour and input costs. Because ensiling is a complex process it requires knowledge and skill to successfully implement and rotten silage cannot be used. Farmers thus see investment in ensiling as risky.

5 Sweet potato vines are growing in popularity, and ILRI for example has conducted a successful series of training modules on ensilage of sweet potato vines.

Box 2

Maize silage requires an investment per acre of KES21,800 versus only 9800 for grain. This is at the opportunity cost of profits from grain of 40,000 per acre. The same hectare could produce 3 tons of silage, which will feed a cow for a month as a basal diet, or be stretched to one year if there are other fodders available. Even if milk production were to increase by 10 litres per day, with current prices of KES35/litre, costs are still not recovered as the additional income is only KES10,500 in a month.

Managing grazing to increase forage availability:

This is suitable for extensive dryland systems. Feeding more forage, even in the form of grazed grass, will have the same mitigation potential as the first option[6]. However, any improvements in rangeland quality require improved governance, to ensure that access is controlled and over-grazing prevented. In Kenya, the recommended approach is to create and strengthen local grazing management local organizations in combination with county and national land use planning processes.

In Ethiopia, the basic process is the same, but some projects rely on traditional grazing rules whilst others favour state associations and government structures. This is the most long-term of the feeding improvement strategies, as it can take several years for grazing improvements to be implemented and sustained, and for wide spread increases in fodder availability to be seen. It is difficult to estimate the total costs of managed grazing because the interventions needed are at multiple levels, from national to local. ILRI and others (e.g. USAID) have been working in both Ethiopia and Kenya to promote better grazing practices.

Biodigesters

Although biodigesters are mentioned in both the Kenya Dairy NAMA and the Ethiopian CRGE, currently they are only suitable for intensive dairy farms practicing zero grazing and with a minimum of 4 to 5 cows. If efficiently used and maintained, using a biodigester can cut 60 to 80% of the total emissions from manure (LRG-SAI 2015). The biggest barrier is the upfront installation costs (KES70,000–80,000 in Kenya). These could be recovered with energy savings, from reduced use of fuel wood or regular cooking gas. Because the bioslurry emerges in a liquid state, transport of the slurry is the main challenge to spreading it on to crop fields. Thirdly, there are the increased labour requirements. Up to 30 to 60 minutes each day is needed to add water to the manure, which must be mixed in a 1:1 ratio. Lastly, increased knowledge and skill is required to install and maintain biodigesters and trusted technical staff are required. However, we consider this approach promising because it is the only intervention to offer a direct benefit; it is also supported by NGOs and is a priority for both governments of Kenya and Ethiopia.

Manure storage and covering

This is appropriate for intensive and semi-intensive mixed systems. Chadwick et al. (2011) find that for nitrous oxide emissions to be reduced from the 1 to 10% lost in stored heaps; anaerobic (i.e. without oxygen) conditions must be maintained.

Total methane emissions from manure can be reduced by up to 90% if the heaps are kept covered with an air tight cover or if they are frequently turned to aerate.

However, Hristov et al. (2013) note that while turning solid manure to aerate can reduce methane emissions; it can increase nitrous oxide emissions. In our focus groups, all livestock keepers heap their manure in various ways, but very few cover it or turn it regularly. Furthermore, they do not currently see benefits to either covering or composting because the

6 We are not considering carbon sequestration.

improved quality of the composted manure is not readily apparent. The key barrier to uptake is lack of information on the benefits of manure composting and spreading for improved soil fertility. A study in Ethiopia also found that farmers did not consider manure to have fertilizer value, nor did they have sufficient knowledge on manure management (from extension officers or others) (Teenstra et al. 2014).

Reducing the burden of disease

Intestinal parasites, ticks and tick-borne diseases are found in all livestock systems and represent a considerable drain on livestock productivity. A 2013 study from sheep in Scotland found that proper deworming contributed to better weight gain in lambs, and lowered GHG emissions intensities by 10% (Kenyon et al. 2013). FAO NZAGGRC (2016a) estimate that deworming could reduce intensities by 8 to 20% in the Kenyan dairy sector, and that control of trypanosomiasis can reduce intensities by 30% (although not a tick-borne disease, the estimates of impact are useful).

Deworming is a common practice, but interviewed farmers reported uneven implementation, often only in response to signs of infestation. It is viewed as only marginally contributing to gains in milk productivity, by 0.5 L per day. In the case of tick management, whilst many producers use acaricides, their use is often inefficient and variable. A lack of trust in agricultural vets is also a barrier. Overall, none of the farmers saw improved health as a major priority.

Box 3

In Kenya, regular deworming could bring in an additional KES4,650 per year per animal, based upon a KES600 per year cost and milk prices of KES35 per litre, assuming an additional 0.5 litres per day. In Ethiopia, the costs are subsidized.

Reducing age at slaughter

This is suitable for extensive pastoral systems, as they concentrate on producing live animals. However, it assumes a commercial orientation for production, which is not always in evidence in extensive pastoral systems. Grewer et al. (2016) estimated for Kenya that a combination of a lower slaughter age and improved feed quality could reduce emissions intensities by 34% for cattle and 40% for sheep and goats; with the lower age at slaughter having the major impact. This strategy requires greater market orientation by pastoralists, which remains a key issue in both Kenya and Ethiopia. In addition to improved market access the approach also needs efficient fodder production and fattening operations, as well as incentives for pastoralists to sell their animals at a younger age in more productive states.

This approach has more potential in Ethiopia, where fattening operations are more common and there are stronger links to a thriving export market. As this is a complex intervention, requiring better herd and breeding management, improved participation in markets, and higher livestock prices for producers, we do not include cost estimates.

Artificial insemination

Artificial insemination is suitable only for intensive dairy, where most producers keep mixed breeds and recognize that improved breeds are key for improving milk production. To impact on emissions, producers would need to replace less productive animals with improved breeds (or cross-breeds). Published estimates from the UK found that reducing the number of replacements in the herd could reduce methane emissions by 24% (Garnsworthy 2004 in Hristov et al. 2013). The farmers interviewed noted that the key barrier to more AI use are limits on the number of trusted providers, particularly given the need for AI to happen at the precise moment in a cow's cycle. The quality of veterinary service providers in these countries is not properly monitored.

Many also see AI as a risky investment. Failure is common (50 to 60%) and blamed on poor timing or the use of expired straws. In Ethiopia, traditional breeding with a bull is still widely preferred. A study from Kenya (Omondi et al. 2016) found that farmers would be willing to invest in AI (despite a reported decline in demand) if the quality of services provided

improved (e.g. were provided through dairy hubs and used imported semen). All producers noted that for investments in improved genetics to be viable farmers need to be able to provide better nutrition - an additional constraint. This conclusion is supported by scientific research as well – the first step to improve fertility is to improve animal nutrition (Hristov et al. 2013).

Box 4

In Kenya, the cost of basic AI ranges from KES700 to 1500 per insemination. Using imported or sexed semen greatly increase the cost, up to KES10,000. Returns on the investment are harder to estimate. The two studies we found indicate low adoption rates and unclear returns for the reasons listed above.

Summary of Interventions

In the table below we make a qualitative summary of the criteria which indicate the major issues constraining widespread farmer investment in greater uptake of theses interventions.

Intervention	Production system	Technical potential	Social feasibility[5]	Affordability[6]
Improved forage	Mixed crop–livestock in both countries	Moderate	Low given land and market constraints	Low
Supplementation with concentrates	Intensive or semi-intensive dairy	Moderate	Moderate – cost is main limitation	Low
Maize silage	Limited dairy in Kenya	Low	Low –competition for use and technical skill required	Low
Managed grazing	Extensive livestock in both countries	Low to moderate	Moderate, but very long term	N/A
Biodigesters	Intensive dairy in Kenya	High (for manure emissions)	High for zero grazers	Low (high upfront costs)
Improved manure storage	Dairy in Kenya	Low	Low–little farmer interest and knowledge	High (but high labour demands)
Animal health	All systems	Moderate	Moderate–main barrier is farmer interest	Low to moderate
Reduced age at slaughter	Extensive livestock in both countries	Low	Low–requires significant investment	N/A
Artificial Insemination	Intensive dairy in Kenya	Moderate (Kenya) to high (Ethiopia)	Low given costs and credibility issues	Low to moderate

5. Although in the text above details the specific constraints, here we summarize them with a qualitative ranking.

6. We use the term affordability to refer to whether or not farmers can afford the interventions, given their current management regimes and cost structures.

Incentives for the top three interventions

Based upon geography, technical potential, the farmer interviews and discussions with national stakeholders, the three top recommended practices for reducing GHG emissions intensities are increasing the production of improved fodders in mixed systems and intensive dairy, the increased use of biodigestors in intensive dairy and managed grazing for pastoral systems.

Estimating national impacts on mitigation targets and productivity can be made with some rough calculations. However, these should be taken as only broadly indicative at best because there is so much uncertainty in the data inputs.

Improved fodder in mixed systems and intensive dairy in both Kenya and Ethiopia: Based upon calculations from the GLEAM model, the dairy cattle sector in Kenya is estimated to be responsible for 12.3 million tonnes CO2 eq, with 48% coming from semi-intensive and 21% from intensive systems. Intensities are 2.1 kg CO2 eq/kg FPCM[7] for intensive systems and 4.1 for semi-intensive. The greatest gains in both productivity and reductions in emissions intensities are in semi-intensive systems, where supplementation can reduce intensities by 24% and increase productivity by 32% (FAO NZAGGRC 2017a). In Ethiopia, the dairy sector produces 116.3 million tonnes CO2 eq. with intensities of 18.9 in mixed crop livestock systems, which produce 72% of the milk. FAO NZAGGRC 2017b estimate that emissions intensity reductions of 27% are possible, with a similar productivity increase as the two are directly related. The gains in Ethiopia are higher due to lower baseline productivity.

Biodigesters in intensive dairy in Kenya: this will have no impact on productivity, but could reduce the 10% of total emissions from manure management by 60 to 80%, following from Chadwick et al. 2011 summary of best evidence to date.

Managed grazing in extensive systems in Kenya and Ethiopia: We do not have information on this for reasons explained earlier.

Each of these practices might be incentivized in different ways, beyond immediate direct benefit to producers.

Improved fodder production, while widely recognized as the most pressing need, is also perhaps the most challenging due to the lack of availability of crop land. Field trials comparing the relative costs and benefits of expanded fodder production in relation to diversified cropping strategies would improve the available information to farmers, enabling them to decide whether specialization in fodder and dairy is a more viable economic strategy than a fully diversified farm. Investment in the fodder seed sector would also help alleviate shortages of high quality seed material, but the effectiveness of this is still contingent on having sufficient land available for planting.

Biodigestors have been promoted in Kenya, especially in for the dairy sector, by various international NGOs for many years now. Many intensive dairy farmers are sufficiently incentivized by the immediate direct benefits of reduced fuel costs and smokeless kitchens; however only those with the significant capital at hand can reap these benefits. The Kenya Biogas Program has indicated that they no longer subsidize installation of biodigestors, but some masons trained in construction of biodigestors have started to offer payment plans to mitigate the challenge of the high installation costs. A key technical challenge is the transport of the bioslurry produced by biodigestors, but this could be addressed by incentivizing farmer innovation in this area.

7 Fat and protein corrected milk (FPCM)

Improving grazing management in extensive pastoral systems is a challenge of strengthening institutional effectiveness. To be effective at a landscape level this will need to involve the pastoral communities themselves as well as local land use planning officials. While strengthening institutions may provide an important push, simultaneous attention to improved market access can provide a pull incentive for intensification. Ecosystem service payments could, in principle, incentivize managed grazing, but would be contingent upon effective institutions for benefit sharing, as well as someone willing to pay for it.

Conclusions and recommendations

This study suggests that all of the interventions will require one or more investments to increase their social and economic feasibility. However, these investments could greatly improve the productivity of livestock systems and potentially the profitability for producers and other value chain actors. This makes a more compelling case for actors across the value chain.

In terms of specific recommendations by system, we deliberately looked at interventions for all the main production systems, and indeed find potential for all systems. There are more options for intensive and semi-intensive dairy than extensive. It is easier to engage with dairy producers and the options are more straightforward to implement. We emphasize that those producers with greater market orientation or support for engaging with markets are more likely to improve production practices. Poorer producers and pastoral producers are at a disadvantage and often lack the necessary access to capital to invest up front in new technologies. Pastoral producers face a range of issues limiting their market participation and investment in improved livestock productivity.

Although women are responsible for many livestock husbandry tasks, especially in dairy systems, they also face barriers to adopting improved practices. Women rarely have control of decisions regarding either the animals or the milk, not to mention the income derived from sales. Tavenner and Crane (2016) summarized studies from dairy systems in Kenya showing that women are constrained relative to men in participation in formal markets as well as dairy hubs. These constraints include access to credit and lower levels of education. An exception to this are evening milk sales, where women often have more control. These sales are usually through the informal market as formal market sales are paid in monthly installations, and women often lose control over that money. Tavenner and Crane (2016) also caution that women already have a heavy labour burden and are unlikely to adopt practices that will add to this unless there is a corresponding additional direct benefit.

Reducing GHG emissions and fostering development is by necessity a multi-faceted process. Not only should it reduce the intensity of GHG emissions per unit of production, but it should also contribute to social and economic development outcomes by improving human well-being while minimizing environmental impact. As with any initiative that seeks to achieve multiple objectives, there are trade-offs to be made.

Most of the LED practices described in this paper are based on improving the efficiency of livestock production and involve intensification. Examining how intensification has unfolded in North American and Europe over the last 50 years or more can be instructive. The achievement of technical production efficiencies, it has culminated in industrial production which corresponded with heavy concentration of land ownership and far fewer people engaged in agriculture. This has been driven by the need to achieve economies of scale to remain viable, among other factors.

When promoting LED intensification in the East African livestock sectors, prioritizing the technical solutions would potentially lead to increased concentration within the sector and a move towards fewer larger operations. Thus, reduced emission intensity could easily come at the cost of the displacement of a large portion of the rural population, who would most likely become landless urban poor. This would undermine development objectives by diminishing human well-being and social stability.

The question then becomes how to navigate the trade-offs between optimal technical efficiencies and human well-being in low emission development. There is no simple formula for this, just a need for policy makers and donors to decide which objective is their top priority and which for objective are they willing to accept sub-optimal outcomes. We strongly recommend that rural development goals supporting smallholder viability should be prioritized over optimizing technical production efficiencies in the interest of minimizing GHG emissions intensity.

Discussions with national policy partners in Kenya and Ethiopia both indicated that despite a continued commitment to reducing emissions from the livestock sector, as stated in various strategy documents summarized in the introduction, little implementation has taken place. In Kenya, only the dairy value chain is attracting investment interest; hence there is great interest in information on feasibility and costs of interventions for dairy. It is likely that the Dairy NAMA proposal submitted to GCF will be supported by IFAD for further development, and Robin Mbae from State Department of Livestock is convening a workshop in January on methods for Tier 2 reporting. There is significant interest in options for pastoral systems because they make up the bulk of the area and livestock numbers. However, there is also some scepticism about how to make progress in those systems given low levels of investment and the need for substantially enhanced institutional capacities.

In Ethiopia, implementation is also slow. While the CRGE lays out priority options, it is the responsibility of each line ministry to implement. The Livestock Master Plan lays out various scenarios for growth of the livestock sector, and a study was completed to estimate how emissions reductions could be compatible with these scenarios. They look at only dairy and poultry, because the fattening value chain is not considered as high a priority investment. The dairy system in this analysis includes traditional mixed systems. They prioritize increased numbers of crossbreed cows, combined with AI plus improved feed and health (YONAD 2015).

In both countries, finance for adaptation is a greater priority and represents the bulk of donor commitments. For example, the World Bank has large investments in the livestock sector in both countries, but mitigation is only considered as a co-benefit.

References

Aklilu, Y., Little, P.D., Mahmoud H. and McPeak, J. 2013. Market access and trade issues affecting the drylands in the Horn of Africa. Technical Consortium for Building Resilience to Drought in the Horn of Africa, Nairobi, Kenya.

Behnke, R. 2011. The contribution of livestock to the economies of IGAD member states: study findings, application of the methodology in Ethiopia and recommendations for further work. IGAD LPI Working Paper No. 12-10

Chadwick, D., Sommer, S., Thorman, R., Fangeiro, D., Cardenas, L., Amon B. and Misselbrook, T. 2011. Manure Management: Implications for greenhouse gas emissions. Animal Feed Science and Technology 166-167: 514-531.

Food and Agriculture Organization of the United Nations (FAO) Conference Report 2012. Successes and failures with animal nutrition practices and technologies in developing countries: A synthesis of an FAO e-conference. *Animal Feed Science and Technology* 174 (2012):211–226.

FAO and New Zealand Agricultural Greenhouse Gas Research Centre (NZAGGRC). 2017a. Options for low emission development in the Kenya dairy sector - reducing enteric methane for food security and livelihoods.

FAO and New Zealand Agricultural Greenhouse Gas Research Centre (NZAGGRC). 2017b. Supporting low emissions development in the Ethiopian dairy cattle sector: reducing enteric methane for food security and livelihoods.

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

Grewer, U., Bockel, L., Nash, J. and Galford, G. 2016. Resilience and Economic Growth in Arid Lands: Accelerated Growth in Kenya. Mitigation co-benefits of herd size and feed quality management. Info Note. CCAFS.

Herrero, M., Henderson, B., Havlik, P., Thornton, P.K. Conant, R.T., Smith, P. Wirsenius, S., Hristov, A.N., Gerber, P., Gill, M., Butterbach-bahl, K., Valin, H., Garnett T. and Stehfest. E. 2016. Greenhouse gas mitigation potentials in the livestock sector. Nature climate change. DOI: 10.1038/NCLIMATE2925.

Herrero, M., Havlik, P., Valin, H., Notenbaert, A.M., Rufino, M., Thornton, P.K., Blummel, M., Weiss F. and Obersteiner. M. 2013. Global livestock systems: biomass use, production, feed efficiencies, and greenhouse gas emissions. PNAS 110(52): 20888-20893.

Hristov, A.N., Oh, J., Lee, C., Meinen, R., Montes, F., Ott, T., Firkins, J., Rotz, A., Dell, C., Adesogan, A., Yang, W., Tricarico, J., Kebreab, E., Waghorn, G., Dijkstra, J., Oosting, S. 2013. Mitigation of greenhouse gas emissions in livestock production – A review of technical options for non-CO2 emissions. Edited by PJ Gerber, B. Henderson and H. P.S. Makkar. FAO Animal Production and Health Paper No. 177. FAO, Rome, Italy.

IGAD Livestock Policy Initiative 2011. Livestock's Contribution to Kenya's Economy: 150% Higher than Previously Thought. IGAD LPI Brief 11.

Kenyon, F., Dick, J.M., Smith, R.I., Coulter, D.G., McBean, D., Skuce, P.J. 2013. Reduction in Greenhouse Gas Emissions Associated with Worm Control in Lambs. Agriculture 3: doi: 10.3390/agriculture30x000x.

LRG-SAI. 2015. Reducing greenhouse gas emissions from livestock: Best Practice and Emerging Options. Livestock Research Group (LRG) of the Global Research Alliance on Agricultural Greenhouse Gases (GRA) and Sustainable Agriculture Initiative (SAI) Platform.

Lukuyu, B., Franzel, S., Ongadi, P.M. and Duncan, A.J. 2011. Livestock feed resources: Current production and management practices in central and northern Rift valley provinces of Kenya. Livestock Research for Rural Development 23(2) http://www.lrrd.org/lrrd23/5/luku23112.htm

Odero-Waitituh, J.A. 2017. Smallholder dairy production in Kenya; a review. Livestock Research for Rural Development 29 (7).

Omondi, I.A., Zander, K.K., Bauer S. and Baltenweck. I. 2016. Understanding farmers' preferences for artificial insemination services provided through dairy hubs.. Animal. DOI: 10.1017/S1751731116002354

Smith P., Bustamante, M., Ahammad, H., Clark, H., Dong, H., Elsiddig, E.A., Haberl, H., Harper, R., House, J., Jafari, M., Masera, O., Mbow, C., Ravindranath, N.H., Rice, C.W., Robledo Abad, C., Romanovskaya, A., Sperling, F. and Tubiello, F. 2014: Agriculture, Forestry and Other Land Use (AFOLU). In: [Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Farahani, E., Kadner, S., Seyboth, K., Adler, A., Baum, I., Brunner, S., Eickemeier, P., Kriemann, B., Savolainen, J., Schlömer, S., von Stechow, C., Zwickel T. and Minx, J.C. (eds.)]. *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Tavenner, K. and Crane. T.A. 2016. Best practice guide to socially and gender-inclusive development in the Kenyan intensive dairy sector. ILRI project report. Nairobi, Kenya: ILRI.

Teenstra, E., De Buisonje, F. Ndambi, A. Pelster, D. 2015. Manure Management in the (Sub-) Tropics: Training Manual for Extension Workers. Wageningen, Wageningen UR Livestock Research, Livestock Research Report 919.

Tubiello, F.N., Salvatore, M. Condor Golec, R.D. Ferrara, A. Rossi, S. Biancalani, R. Federici, S. Jacobs, H. Flammini, A. 2014. Agriculture, Forestry and other Land Use Emissions by Sources and Removals by Sinks. 1990-2011 Analysis. FAO Statistics Division Working Paper Series ESS/14-02. FAO, Rome Italy.

YONAD Business Promotion and Consultancy PLC. 2015. Livestock Investment Implementation Plan: Poultry and Dairy Value Chains. Submitted to Global Green Growth Institute on behalf of Federal Democratic Republic of Ethiopia, Ministry of Agriculture-CRGE unit.

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