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A partial Life Cycle Assessment of smallholder livestock systems in Western Kenya

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What will the study do?

To identify factors that contribute to excessively high greenhouse gas (GHG) emissions in African smallholder livestock production systems. This knowledge will;

i. Facilitate higher resource use efficiency
ii. Result to better livelihoods and lower climate impacts

Background

- Livestock are important assets in Africa, helping improve the nutritional status of their owners, and contributing to economic growth.
- Livestock mostly kept in smallholding enterprises but are characterized by low productivity due to;
  - ✓ **Poor feeding - poor feed quality and quantity**
  - ✓ **Poor animal husbandry practices**
- Livestock production systems have a substantial contribution to greenhouse gas emissions in the Agricultural sector.

Background

- African countries use Tier 1 estimates- they are CRUDE and have HIGH uncertainties.

- Tier 2 emission factors alone will not explain the reasons for emissions efficiency variability across smallholder farms (Goopy et al., 2018; Ndung'u et al., 2019).

- Calculating the total direct and indirect GHG emissions associated with the livestock products (also know as **emission intensity**) has been demonstrated to better inform on the resource use efficiency and sustainability of livestock systems (Moran & Wall, 2011).

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Background

- Emission intensity is measured by using the life cycle assessment (LCA) method.
- LCA has a unique way of quantifying GHG emissions throughout the life cycle of a product.
- In LCAs, GHG emissions must be referenced to a functional unit (FU) which is the quantity of a value associated with the purpose of a system.
- The aim was to develop baseline information on the emission intensities of smallholder livestock systems in western Kenya.

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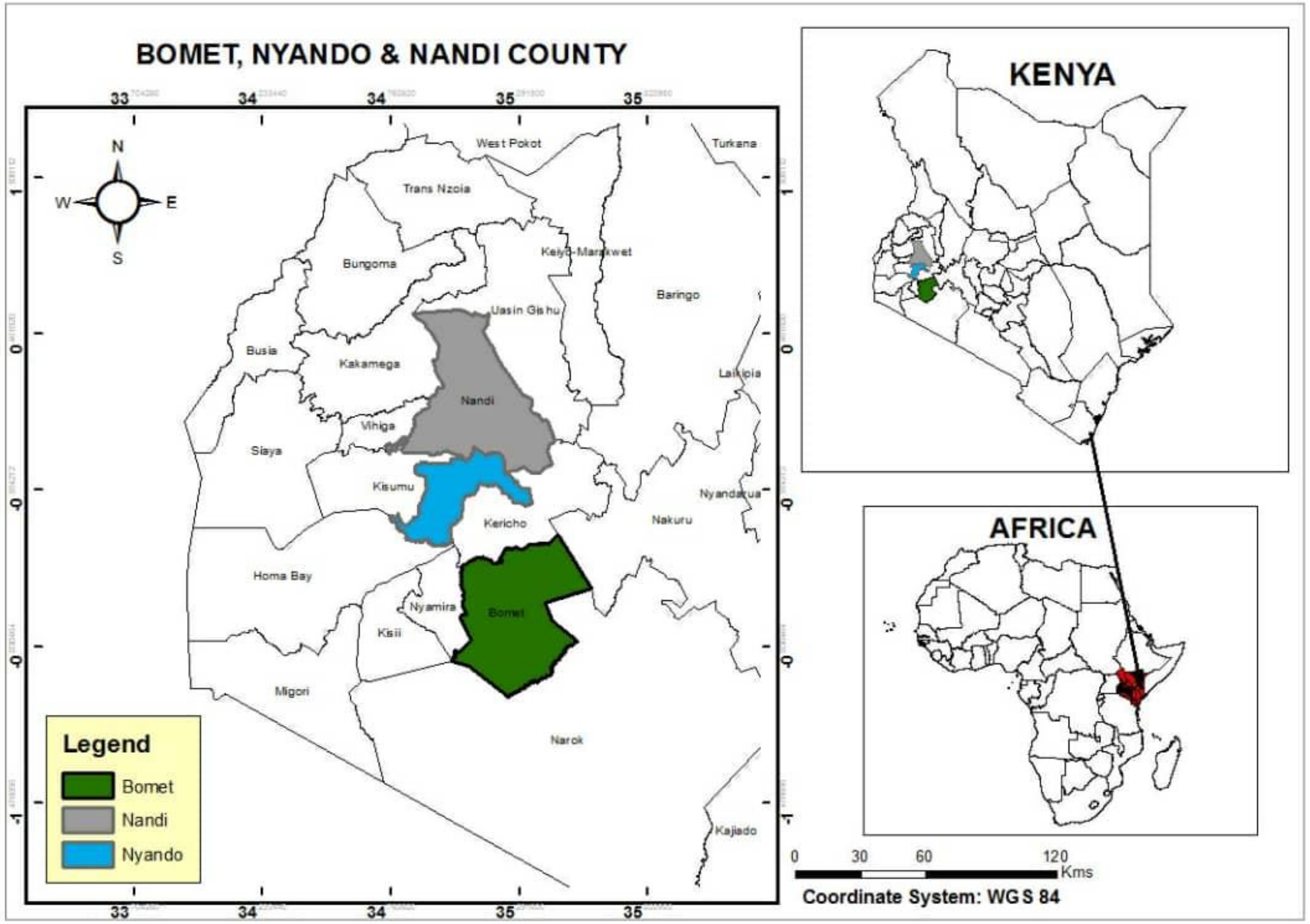
Research questions

1. Do emissions intensities vary between smallholder farms in a similar locality?

2. What is the carbon hotspot in smallholder livestock systems?

3. What are the drivers of emissions intensities in smallholder livestock systems?

Study Sites



- Study site: Nyando, Nandi and Bomet in Western Kenya.
- Farm sample size: 313 smallholding farms located across different agro-ecological zones defined by altitude, rainfall and temperature.
- Herd sample size: >3000 cattle of varied age groups.
- Type of data: Animal production and feed basket data measured on a seasonal basis in order to capture, seasonal effects, movement of animals in and out of farms and start and end of lactation(s).

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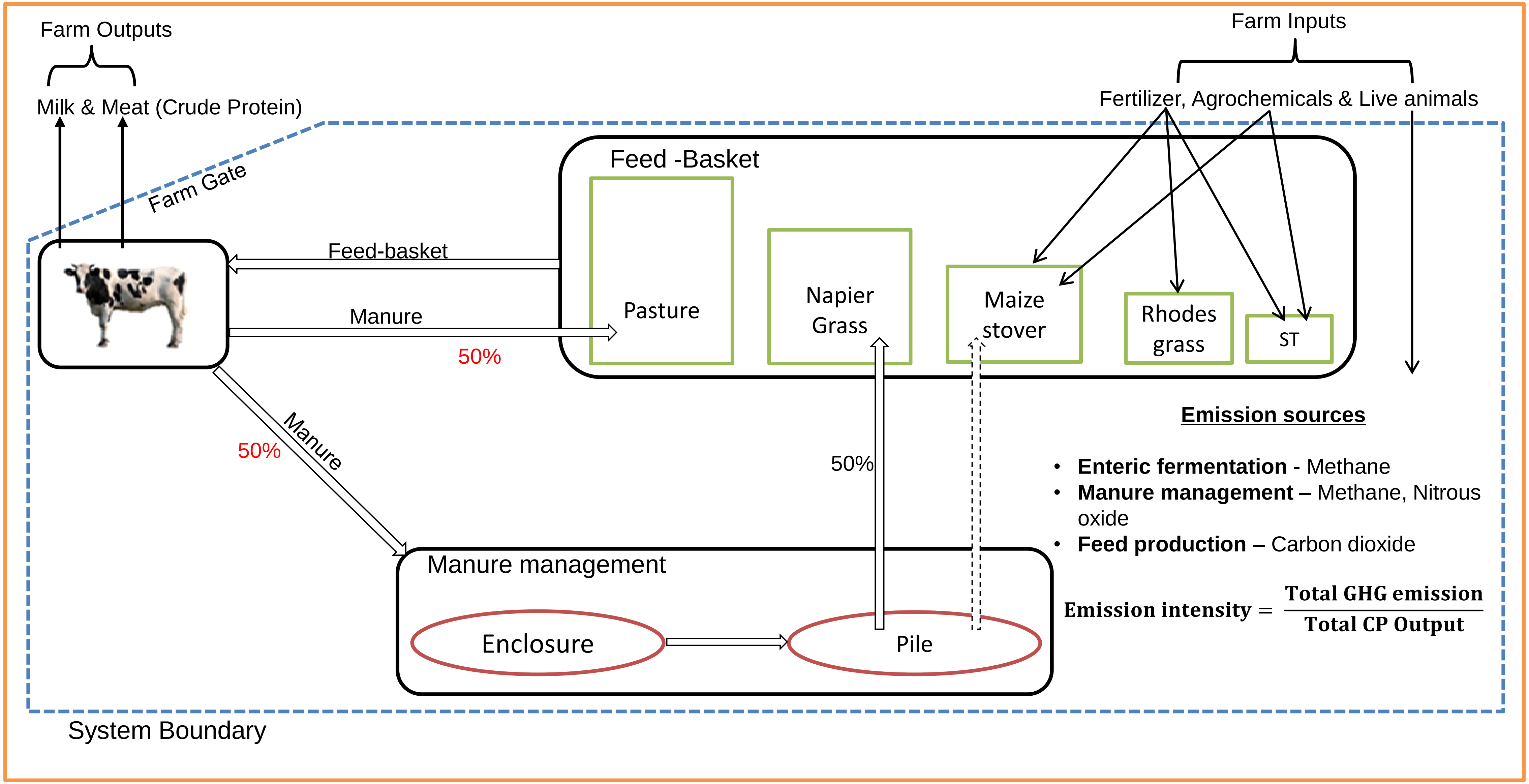
Life Cycle Assessment: Cradle to Farm Gate



Emission sources

- **Enteric fermentation** - Methane
- **Manure management** – Methane, Nitrous oxide
- **Feed production** – Carbon dioxide

$$\textbf{Emission intensity} = \frac{\textbf{Total GHG emission}}{\textbf{Total CP Output}}$$

Materials and Methods

- Enteric methane emissions estimates were calculated using metabolizable energy requirement (MER) approach.

- Manure emissions were calculated following IPCC guidelines.

- Emissions were initially calculated on an animal-by-animal basis and subsequently summed for each farm.

- The functional unit was set as kg Crude Protein (CP), encompassing both meat and milk production.

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Data Source

Agricultural Systems 161 (2018) 72–80

Contents lists available at ScienceDirect

Agricultural Systems

journal homepage: www.elsevier.com/locate/agsy

A new approach for improving emission factors for enteric methane emissions of cattle in smallholder systems of East Africa – Results for Nyando, Western Kenya

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ARTICLE INFO

Keywords:
Enteric methane
Ruminant
Cattle
GHG inventory
East Africa

ABSTRACT

In Africa, the agricultural sector is the largest sector of the domestic economy, and livestock, are a crucial component of agriculture, accounting for ~45% of the Kenyan agricultural GDP and > 70% of African agricultural greenhouse gas (GHG) emissions. Accurate estimates of GHG emissions from livestock are required for inventory purposes and to assess the efficacy of mitigation measures, but most estimates rely on TIER I (default) IPCC protocols with major uncertainties coming from the IPCC methodology itself. Tier II estimates represent a significant improvement over the default methodology, however in less developed economies the required information is lacking or of uncertain reliability. In this study we developed an alternative methodology based on animal energy requirements derived from field measurements of live weight, live weight change, milk production and locomotion to estimate intake. Using on-farm data, we analysed feed samples to produce estimates of digestibility by season and region, then and used these data to estimate daily methane production by season, area and class of animal to produce new emission factors (EF) for annual enteric CH_4 production. Mean Dry Matter Digestibility of the feed basket was in the range of 58–64%, depending on region and season (around 10% greater than TIER I estimates). EFs were substantially lower for adolescent and adult male (30.1, 35.9 versus 49 kg CH_4) and for adolescent and adult female (23.0, 28.3 versus 41 kg), but not calves (15.7 versus 16 kg) than those given for "other" African cattle in IPCC (Tier I) estimates. It is stressed that this study is the first of its kind for Sub-Sharan Africa relying on animal measurements, but should not automatically be extrapolated outside of its geographic range. It does however, point out the need for further measurements, and highlights the value of using a robust methodology which does not rely on the (often invalid) assumption of *ad libitum* intake in systems where intake is known or likely to be restricted.

1. Introduction

In Africa, the agricultural sector is the largest sector of the domestic economy, employing between 70% and 90% of the total labour force (AGRA, 2017).

Livestock, whether based on pastoralism or as part of mixed cropping/livestock systems, are a crucial component of agriculture and it was estimated that livestock contributes to about 45% to the Kenyan agricultural gross domestic product (ICPALD, 2013). The impact of livestock on the environment in Africa is high and it is estimated that > 70% of African agricultural greenhouse gas (GHG) emissions are due to livestock production, dominated by CH_4 emissions from enteric fermentation (Tubiello et al., 2014; http://www.fao.org/faostat/en/#data/GT). Whilst an accurate picture of GHG emissions from livestock is required for inventory purposes, there is also a pressing need to ensure that estimates of livestock GHG emissions reflect the actual case both for national reporting and development and monitoring, reporting and verification (MRV) of nationally determined contributions (NDC) on mitigation of GHG emissions from the livestock sector (Bodansky et al., 2016).

There are extant studies which comprehensively model ruminant livestock emissions using a digestion and metabolism model (RUMINANT), spatially explicit data on livestock numbers and generalized assumptions on regional feed availability and digestibility (Herrero et al., 2008, 2013; Thornton and Herrero, 2010). Other studies (Tubiello et al., 2014) rely on TIER I IPCC protocols (Dong et al., 2006)

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https://doi.org/10.1016/j.agsy.2017.12.004
Received 20 June 2017; Received in revised form 12 December 2017; Accepted 13 December 2017

CSIRO PUBLISHING

Animal Production Science
https://doi.org/10.1071/AN17809

Improved region-specific emission factors for enteric methane emissions from cattle in smallholder mixed crop: livestock systems of Nandi County, Kenya

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Abstract. National greenhouse-gas (GHG) inventories in most developing countries, and in countries in Sub-Saharan Africa in particular, use default (Tier I) GHG emission factors (EFs) provided by the Intergovernmental Panel on Climate Change (IPCC) to estimate enteric methane (CH_4) emissions from livestock. Because these EFs are based on data primarily from developed countries, there is a high degree of uncertainty associated with CH_4 emission estimates from African livestock systems. Accurate Tier II GHG emission reporting from developing countries becomes particularly important following the Paris Climate agreement made at COP21, which encourages countries to mitigate GHG emissions from agricultural sources. In light of this, the present study provides improved enteric CH_4 emission estimates for cattle in Nandi County, Western Kenya, representing a common livestock production system found in East Africa. Using the data from measurements of liveweight and liveweight change, milk production and locomotion collected from 1143 cattle in 127 households across 36 villages over three major agro-ecological zones covering a full year, we estimated total metabolic energy requirements. From this and assessments of digestibility from seasonally available feeds, we estimated feed intake and used this to calculate daily CH_4 production by season, and, subsequently, created new EFs. Mean EFs were 50.6, 45.5, 28.5, 33.2 and 29.0 kg CH_4/head.year for females (>2 years), males (>2 years), heifers (1–2 years), young males (1–2 years) and calves (<1 year) respectively, and were lower than the IPCC Tier I estimates for unspecified African adult cattle, but higher for calves and young males. Thus, using IPCC Tier 1 EFs may overestimate current enteric CH_4 emissions in some African livestock systems.

Additional keywords: Africa, cattle, dry matter digestibility, feed basket, greenhouse gas, liveweight.

Received 13 November 2017, accepted 2 May 2018, published online 1 August 2018

Introduction

Methane emissions from enteric fermentation have been identified as a key source of greenhouse-gas emissions (GHG) from agricultural sources in developing countries (Tran *et al.* 2011). This is because most developing countries depend largely on the agricultural sector for economic production and development, with livestock-related emissions, specifically enteric fermentation, dominating national GHG emission inventories. The Intergovernmental Panel on Climate Change (IPCC) has developed three different approaches for estimating enteric methane (CH_4) emissions. Tier I estimates use default emission factors (EFs) developed to represent the GHG emissions from livestock systems in different geographic regions on the basis of livestock census data and assumptions regarding the systems themselves (Spurlock *et al.* 2012). It is recognised that Tier I estimates have shortcomings, both because they are derived from data from livestock systems in developed economies ('adjusted' to fit the conditions of developing countries) and by their nature, as the approach cannot accommodate changes to emissions brought about by changes to livestock production systems. Tier II estimates can represent a substantial increase in the precision of CH_4 emissions from livestock because they better define animals, productivity, management and feed through using actual measurements of these characteristics (Tubiello *et al.* 2013).

Kenya's agricultural sector accounts for 58.6% of the country's total GHG emissions (the largest emitter) and emissions related to livestock production account for 96.2% of agricultural emissions (Tubiello *et al.* 2014). The bulk of these emissions can be attributed to the 1.8 million smallholder dairy farms owning ~2.64 million

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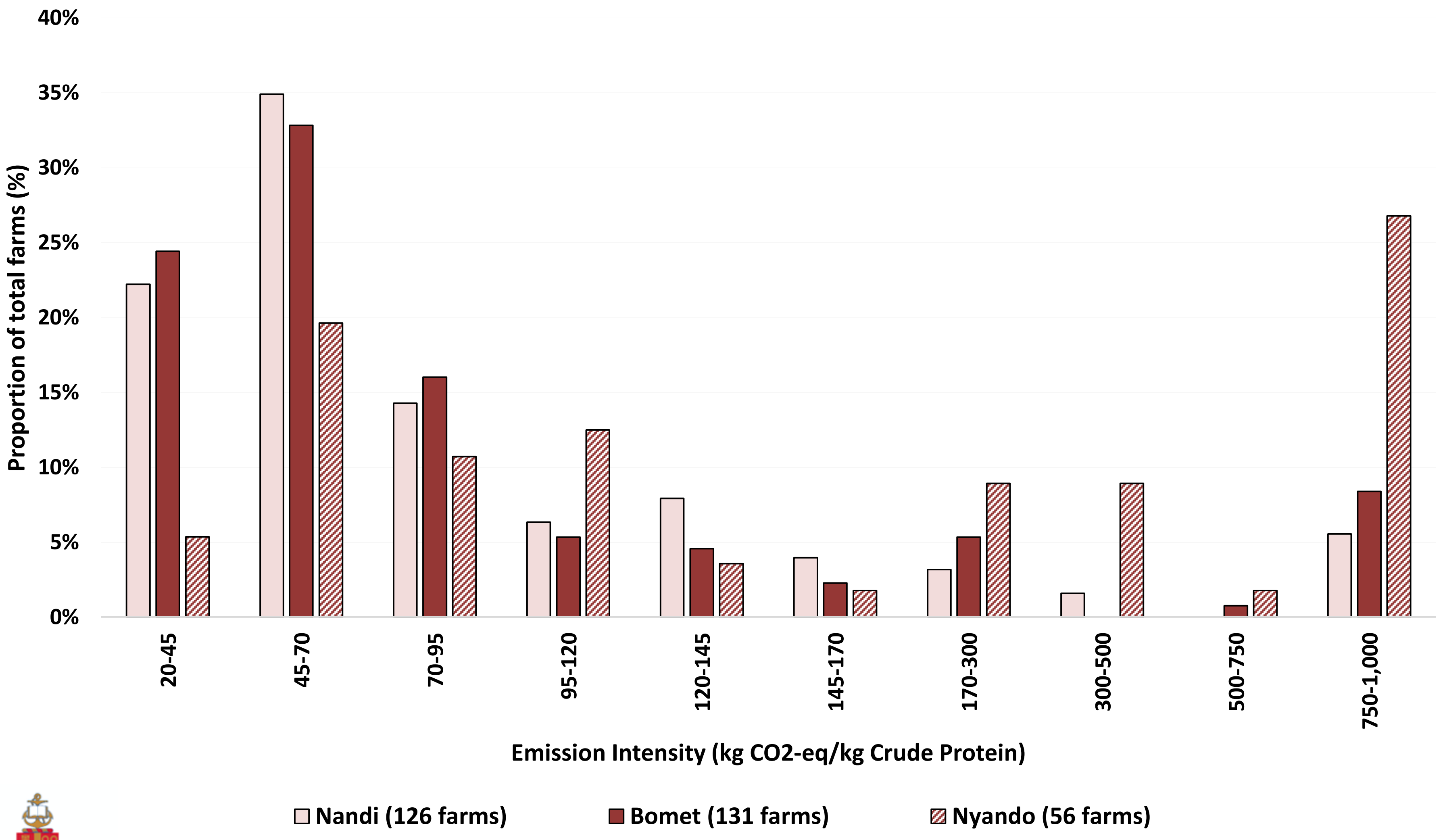
Results: Emissions Intensities Distribution



Because of the skewed data, **median** was used as the measure of central tendency;

- Nyando:128 kg CO_2-eq/kg CP
- Nandi: 67 CO_2-eq/kg CP
- Bomet: 66 CO_2-eq/kg CP

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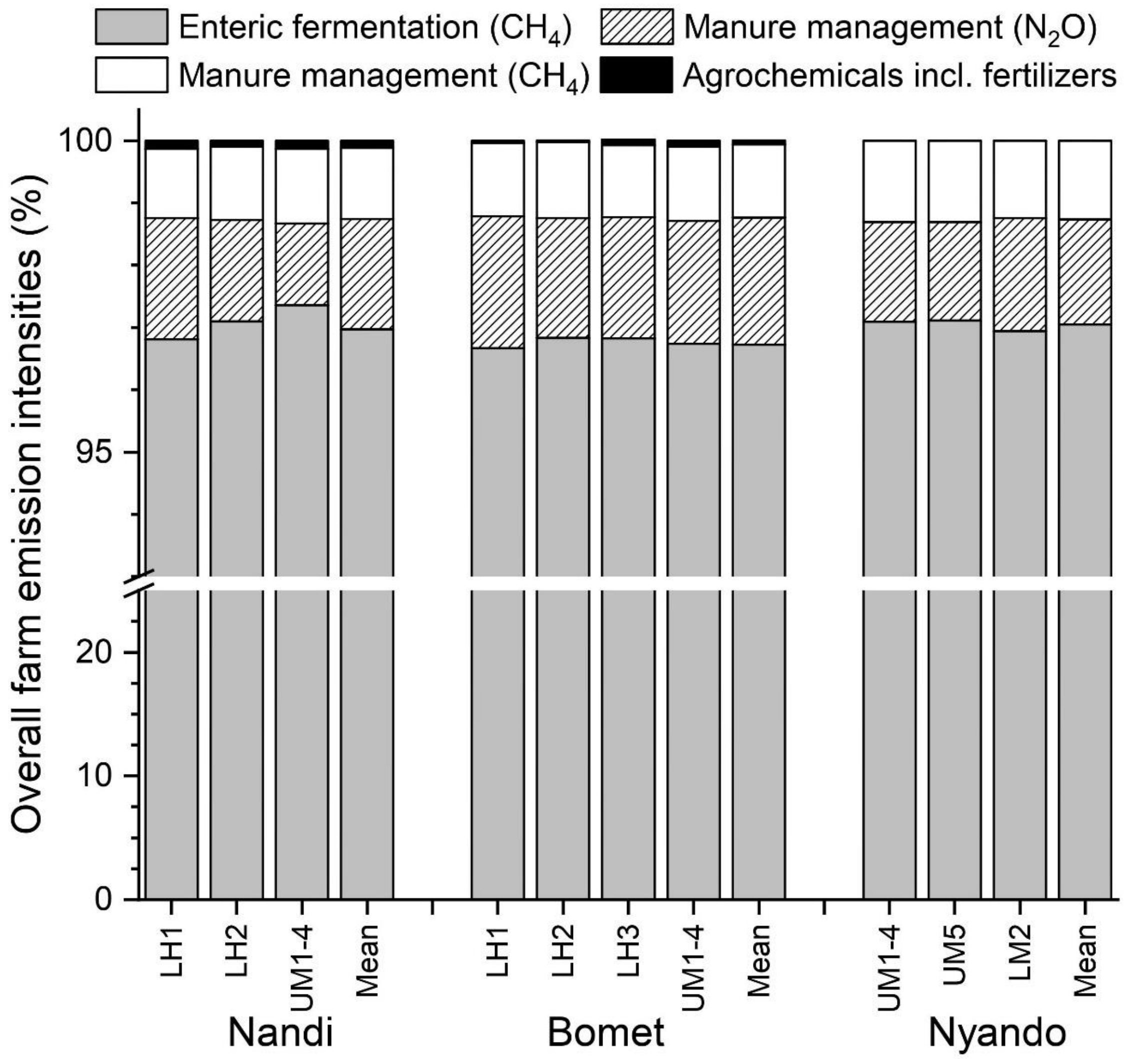
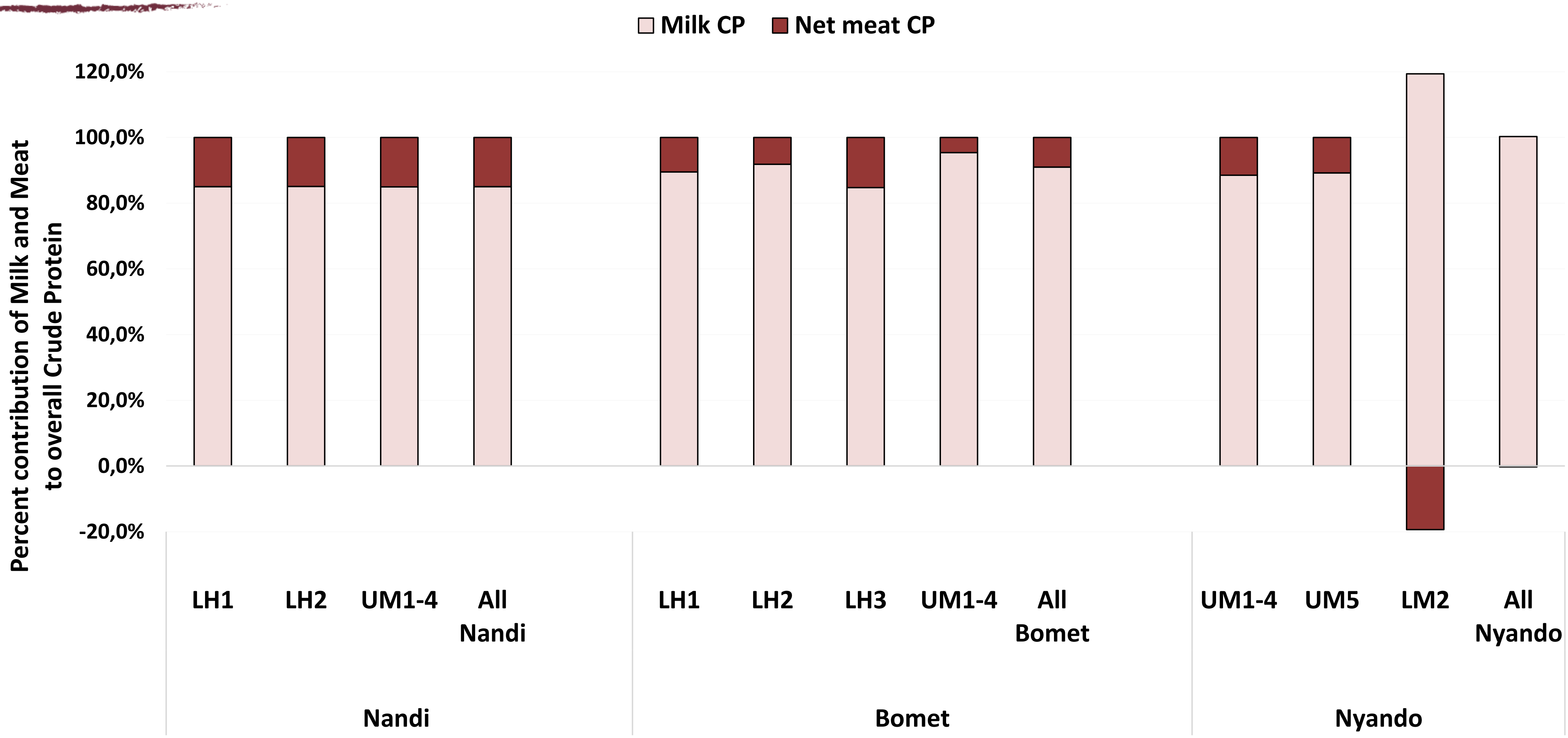
Results: Contribution of Emission Sources

- Enteric fermentation drove emissions on all farms in all regions
- The livestock systems in this study were low input in terms of fertilizers, off-farm feeds and mechanization
- Emissions from manure management were low because of using emission factors derived from local management conditions.



Results: Contribution of Milk and Meat to total output



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Effect of Herd Management on Emissions Intensities

- Having more animals was shown not to be the most efficient.

- Emissions efficiency was driven by;

  a) high (per cow) milk yield;
  b) high sale of animals for meat;
  c) having high proportions of (productive and fertile) females in the herd.

- Pursuing focused management objectives have the potential to move low input smallholder farms towards;
  - reducing GHG emissions per unit of milk and meat produced,
  - potentially lowering GHG emissions from ruminant production.

Take home message

- This work has shown that there are highly emission efficient farms even at low input levels.

- There is a presence of farms of very high and very poor efficiencies.

- Improve the productivity on per animal basis and restructure the herds to have more productive animals in the herd and primarily females who would increase milk output.

Conclusion

- This LCA is first of its kind that accounts for direct emissions from smallholder livestock systems in Kenya and it provides a benchmark for further LCAs.

- Focus on increasing on-farm output while constraining further increases in enteric methane emissions by moving towards an “efficient frontier”.

- Benefits of reducing farm EIs in smallholder farms are;
  i. Move smallholder farms toward a low carbon future,
  ii. Increasing household incomes and,
  iii. Food secure world

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What next?

- Provide guidance for sustainable livestock sector development in sub-Saharan Africa e.g., improved feeding regimes.

- Explore the potential of improving individual animal productivity to reduce emissions intensities.

- Build on the existing database by collecting more activity data and for longer periods- reduce uncertainty levels.

- Conduct more comprehensive and national smallholder LCA with indirect emissions and carbon offsets accounted for.

Acknowledgement

Thank you to our sponsors and partners!

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