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Economic performance and greenhouse gas emissions of two typical beef production systems in Eastern Kenya

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Abstract
Kenya has one of the major cattle populations in Eastern Africa, of which around three-quarters are beef cattle. Especially for households in the arid and semi-arid regions of Kenya, beef cattle production is an important economic activity. Located in less favourable production environments, low opportunities for cropping or dairy production exist. The production systems in arid and semi-arid lands suffer climate change more directly, being less resilient to weather shocks. At the same time, they are a hotspot of greenhouse gas (GHG) emissions per kilogram produced. In the recent past, Kenyans' meat consumption has been rising, with beef representing 74 % of the annual intake in 2018. The expected further increase due to economic growth and a growing population offers economic opportunities to local producers. Despite the importance of developing pathways for sustainable beef production, only little data is available, particularly on the farm-level economics and GHG emissions related to the specific beef production systems.
Based on the typical farm approach (TFA), we identified two beef production systems in Eastern Kenya: a pastoral beef production system and an agro-pastoral production system combining beef production with cropping. Data has been collected through expert interviews and producer focus groups in Isiolo County for the pastoral beef production system and in Kitui County for the agro-pastoral beef production system. We carried out an analysis of the economic performance, including factor use, production inputs, and farm outputs. We estimated the GHG emissions associated with beef production at farm-level by applying IPCC 2019 methodology. Based on literature research and expert information, we model locally appropriate production scenarios addressing herd management and feeding strategies. In an ongoing analysis, we assess their impacts on economic performance and GHG emissions and discuss potential co-effects between climate change mitigation and adaptation. Our results contribute to the understanding of beef production at farm-level and identify leverages for more sustainable beef production in typical Eastern Kenya production systems. This study contributes to a flagship project of the Global Research Alliance on Agricultural Greenhouse Gases (GRA), called Economics of GHG mitigation at farm level in global cattle production systems.

Keywords: Beef production, climate change mitigation, farm economics, greenhouse gas emissions

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Introduction

Kenya is number three in terms of cattle population in Eastern Africa, with around three-quarters of it being beef cattle (FAO 2018; FAOStat 2023). The majority of Kenya´s cattle herd is raised in its arid and semi-arid lands (ASALs). For households in the arid and semi-arid regions of Kenya, beef cattle production is an important economic activity, as low opportunities for cropping or dairy production exist due to limited rainfall and strong seasonality in water and forage supply. These production systems are prone to climate risks and variability, showing low resilience to weather shocks such as recurring droughts (Mbae et al. 2020). At the same time, GHG emission intensity of beef in Eastern Africa, including Kenya is among the highest globally (Herrero et al. 2013).

Future trends might stress this situation: Kenyans' meat consumption has been rising over the last years and it is expected to grow further due to an increase in population and economic growth. Beef contributed 74 % to the annual meat intake in 2018 (Kenya National Bureau of Statistics 2019). Despite Kenya being a net importer, this trend offers market opportunities to local producers. On the other hand, Kenya's updated Nationally Determined Contribution aims to reduce GHG emissions by 32% by 2030 compared to the business-as-usual scenario (Government of Kenya 2020). Reducing agricultural emissions, especially those related to livestock, plays an important role in achieving this goal. While engagement in the dairy sector is underway, the beef sector's contribution remains undefined (CCAC et al. 2021; Mbae et al. 2020).

Against the backdrop of these perspectives, this study aims to analyse the status quo of typical beef production systems in Kenya concerning their economic and environmental performance as a starting point for the identification of sustainable development strategies.

Material and Methods

Data collection took place in April 2019. The TFA was applied (Chibanda et al. 2020) to identify typical beef production systems in Kenya. This approach engaged national research partners, regional livestock officers, and local producers. Two typical beef production systems - a pastoral beef production system located in Isiolo County and an agro-pastoral production system combining beef production with cropping in Kitui County - were identified and described in size, performance, animal husbandry practices and factor input. A brief description of the typical beef farms is shown in *Table 1*.

For the economic analysis of beef production, the TIPI-Cal tool was used (Deblitz n.d.). The GHG emissions associated with beef production at farm-level were estimated following the 2019 refinements to 2006 IPCC Guidelines (IPCC 2019), applying Tier 1 for crop and forage production and Tier 2 for animal and manure-related emissions. Nutritive characteristics of forages and feedstuff were derived from public databases (Feedipedia (INRA et al. 2012-2019), SSA Feeds (ILRI 2020)).

Table 1: Typical farm characterisation

Indicator/Production system	Pastoral	Agro-pastoral
Size of herd	20 cows + belongings	3 cows + belongings
Feeding strategy	Grazing large areas	Grazing large areas
Manure management	Pasture deposition, dry lot (cows)	Pasture/paddock deposition
Age of first calving	2 – 3 years	6 – 7 years
Calving percentage	66%	66%
Age of finishers sold	730 days	730 days
Average daily weight gain (finishing)	222 g/day	103 g/day
Mortalities	30% calves, ~ 5% growing animals, 8% mature	20% calves, 5% growing animals, 3% mature
Feed ration characteristics	Pasture, drought reserve, minerals for lactating cows	Pasture, crop residues, drought reserve

Results and Discussion

The results of the economic analysis are shown in *Figure 1* in cash costs of production. Costs associated with land do not occur, as communal resources are used. Opportunity costs for family labour are not reflected in this analysis.

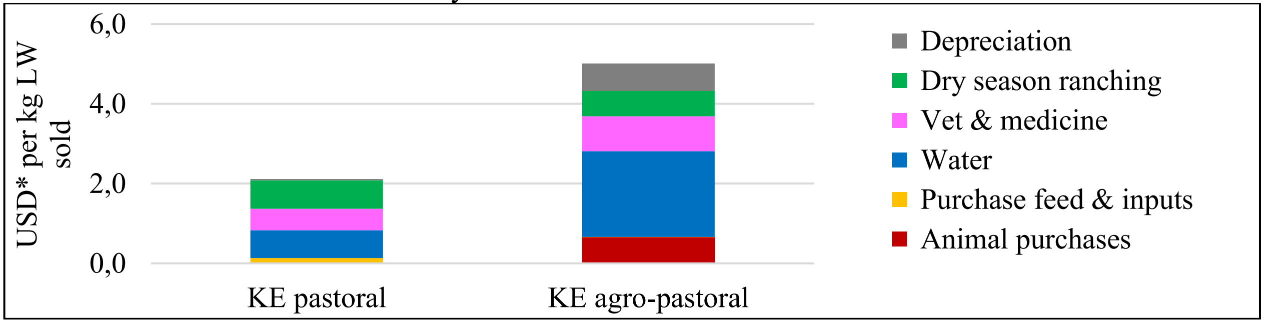

Figure 1: Costs of production per kg live weight (LW) sold, 2018 price data: 101 KSH = 1 USD)

Water and feed in dry seasons account for more than 50% of the costs for means of production for both typical production systems. However, the total levels of costs of production per kg LW sold differ strongly. The pastoral system relies on significant communal resources. Additionally, the mobility of the herd yields higher productive performance in the cow-calf (age of first calving) and finishing enterprise (average daily weight gain). In contrast to this, the agro-pastoral production is bound to a specific location and available resources at specific costs, especially for watering. This impacts the costs of production and limits performance potential.

The GHG analysis (*Figure 2*) reveals the dominance of methane emissions in these extensive production systems. Due to climatic conditions, manure emissions are low. As the feeding relies on natural pastures and crop residues, feed-associated emissions are negligible.

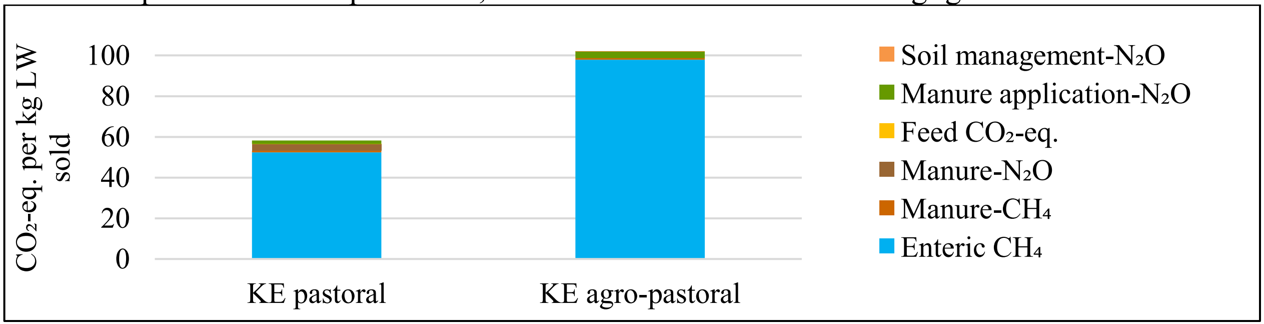

Figure 2: GHG emissions per kg live weight (LW) sold**,** GWP CH_4: 28, N_2O: 265

The GHG emissions per kg LW sold include the whole production cycle including the emissions associated with the mother cow herd up to finishers sold. Of these GHG emissions, around 85% can be allocated to the cow-calf enterprise. This highlights the crucial role of husbandry practices of cows, calves and replacement stock. High mortality rates on the one hand and the high age of first calving in the agro-pastoral system on the other hand lead to comparably high GHG emission intensities.

Developing locally appropriate GHG mitigation strategies should focus on the provision of access to adequate feed and water. These are pre-requirements to improve the low herd performance, expressed i.e. in the age of first calving in the agro-pastoral system and the average weight gain. The high mortality despite the high share of veterinary costs among the costs of production indicates that also health status of individual animals and the herd as a total is linked to an insufficient supply of the above-mentioned resources. Results from available case studies show that these strategies might imply triple-win situations: decreasing GHG emissions while increasing producers' profits and resilience to climate change. In the specific conditions of the analysed systems, adoption barriers might however be high, as this could imply a shift from the use of communal or common goods and services to private investments and thus require producers' to access substantial financial resources.

Conclusions and Outlook

Our analysis contributes to the understanding of typical Eastern Kenyan beef production systems at farm-level. Both can be described as low-input systems that are adapted to local conditions but show high vulnerability to external factors. In our analysis, we identify improving the quantity and quality of production inputs such as feed and water as important leverages for more sustainable and resilient beef production. However, implementing the right strategies that lead to this end requires additional research and collaborative work of producers, researchers and policymakers.

There is a need for further investigation of farm-level implications of GHG mitigation in beef production systems, especially with a focus on available and accessible resources at farm and regional levels and their future development as well as potential mitigation-adaptation co-effects.

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References

CCAC; GoK; FAO (Eds.) (2021): Methane mitigation from the dairy sector in Kenya's Nationally Determined Contribution (NDC). Case study. Available online at https://www.fao.org/3/cb6751en/cb6751en.pdf, checked on 10/19/2023.

Chibanda, Craig; Agethen, Katrin; Deblitz, Claus; Zimmer, Yelto; Almadani, Mohamad. I.; Garming, Hildegard et al. (2020): The Typical Farm Approach and Its Application by the Agri Benchmark Network. In *Agriculture* 10 (12), p. 646. DOI: 10.3390/agriculture10120646.

Deblitz, Claus (n.d.): Model profile TIPI-CAL / TYPICROP. Available online at https://www.thuenen.de/en/thuenen-institute/compound-structures/the-thuenen-modelling-network/models/model-profile-tipi-cal-/-typicrop, checked on 10/20/2023.

FAO (Ed.) (2018): ASL 2050: Africa Sustainable Livestock 2050. Livestock production systems spotlight: Kenya. Cattle and poultry sectors, checked on 2/14/2019.

FAOStat (2023): Crop and Livestock products. Regions: Eastern Africa, Stocks, Live animal: Cattle. Year: 2021. Available online at https://www.fao.org/faostat/en/#data/QCL, checked on 10/19/2023.

Government of Kenya (2020): Kenya's Updated Nationally Determined Contribution (NDC). 2020-2030. Available online at https://unfccc.int/sites/default/files/NDC/2022-06/Kenya%27s%20First%20%20NDC%20%28updated%20version%29.pdf, checked on 10/19/2023.

Herrero, Mario; Havlík, Petr; Valin, Hugo; Notenbaert, An; Rufino, Mariana C.; Thornton, Philip K. et al. (2013): Biomass use, production, feed efficiencies, and greenhouse gas emissions from global livestock systems. In *Proceedings of the National Academy of Sciences of the United States of America* 110 (52), pp. 20888–20893. DOI: 10.1073/pnas.1308149110.

ILRI (Ed.) (2020): SSA Feeds. Addis Ababa, Ethiopia. Available online at https://feedsdatabase.ilri.org/.

INRA; CIRAD; AAFZ; FAO (Eds.) (2012-2019): Feedipedia. Animal Feed Resources Information System. Available online at https://www.feedipedia.org/.

IPCC (Ed.) (2019): 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4: Agricultre, Forestry and Other Land use. With assistance of E. Calvo Buendia, K. Tanabe, A. Kranjc, J. Baasansuren, M. Fukuda, Ngarize S. et al. Japan: IGES. Available online at https://www.ipcc-nggip.iges.or.jp/public/2019rf/vol4.html, checked on 1/11/2021.

Kenya National Bureau of Statistics (2019): Enhanced Food Balance Sheets for Kenya. 2014-2018 Results. Available online at https://www.knbs.or.ke/?wpdmpro=enhanced-food-balance-sheets-for-kenya-2014-2018-results, checked on 8/11/2020.

Mbae, R.; Kimoro, B.; Kibor, B.; Wilkes, A.; Odhong', C.; van Dijk, S. et al. (2020): The Livestock Sub-sector in Kenya's NDC: a scoping of gaps and priorities. Global Research Alliance on Agricultural Greenhouse Gases (GRA) & CGIAR Research Program on Climate Change Agriculture and Food Security (CCAFS). Available online at https://hdl.handle.net/10568/110439, checked on 10/19/2023.