African livestock GHG research, including barriers to uptake of technology (or required incentives)

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https://mazingira.ilri.org/

Claudia Arndt, PhD

Senior Scientist & Team Lead of the Mazingira Centre
International Livestock Research Institute (ILRI)

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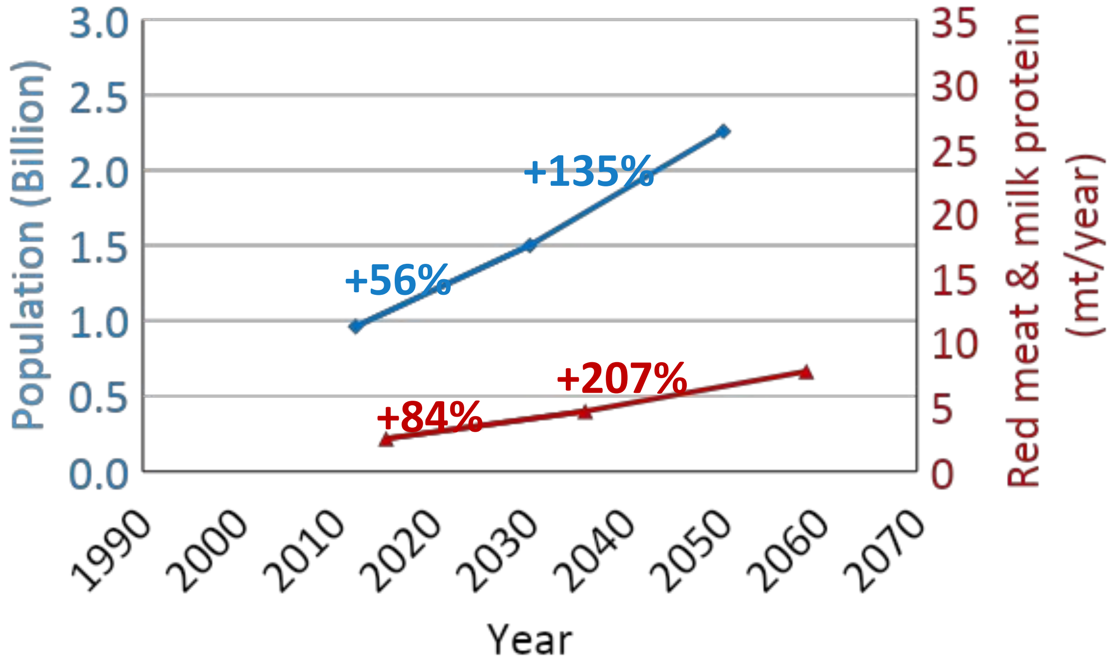
LRG Annual Meeting
Lyon, France
1st September 2023

Livestock Demand in Africa

Projected Growth in Population and Animal Protein Demand in



Red meat & milk protein (g/capita/d)		
2010	2030	2050
7.2	8.5	9.4

+15% **+10%**

MT: Million metric tons

Source: Modified after Henchion et al., 2021 and FAO.

Prevalent Livestock Systems

Smallholder systems

Humid & Sub-humid areas

- Own 80% of arable land (<10 ha)
- Small livestock holdings (<10 cattle)
- Mixed cattle herd composition (~45% adult females)
- Milk productivity: ~4 liters/day

Sources: Lowder et al., 2016; Ndung'u et al., 2022; Rahimi et al., 2022; Coppock et al., 1986

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Pastoralist/agropastoral systems

Semi-Arid & Arid areas

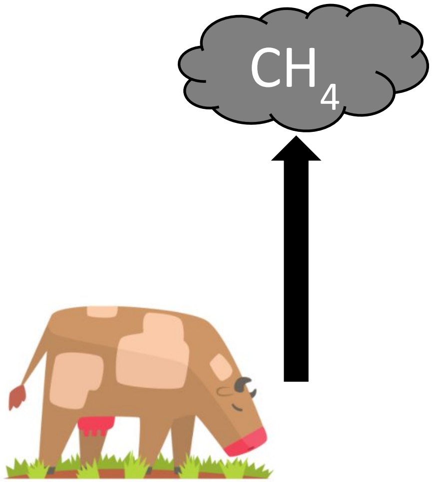
- Larger, multi-species herds
  - 48% cattle
  - 46% small ruminants
  - 6% camels
- Milk productivity: <2 liters/day

Sources: Lowder et al., 2016; Ndung'u et al., 2022; Rahimi et al., 2022; Coppock et al., 1986

Research on GHG Emissions From Livestock in Sub-Saharan Africa is Limited

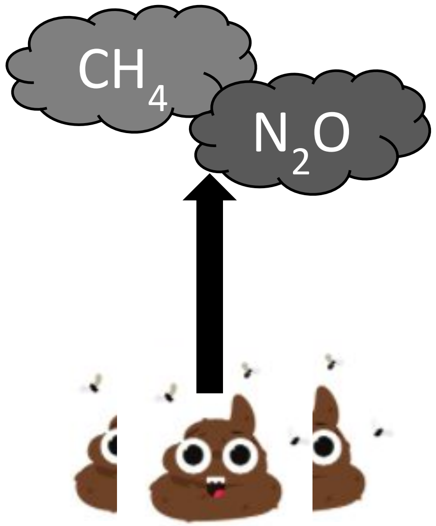
Enteric CH_4 Emissions

- 14 studies for cattle
- 6 studies for small ruminants



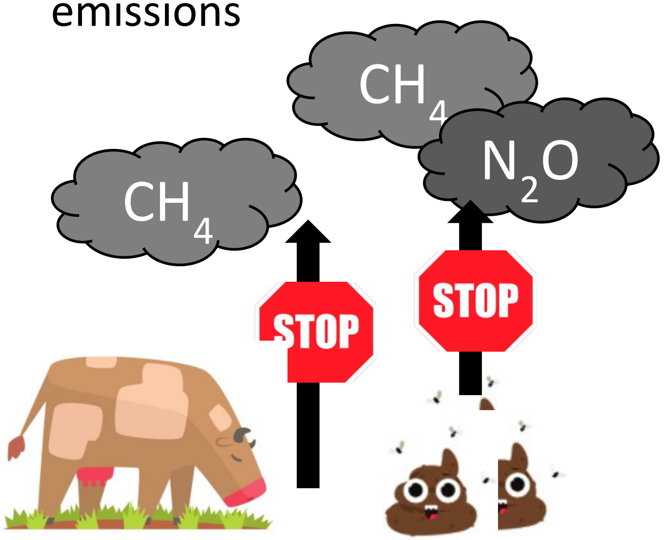
Manure GHG Emissions

- 6 studies for cattle manure
- No studies for small ruminants



Mitigation

- 5 cattle and 2 sheep studies on enteric CH_4 emissions
- No studies on manure GHG emissions



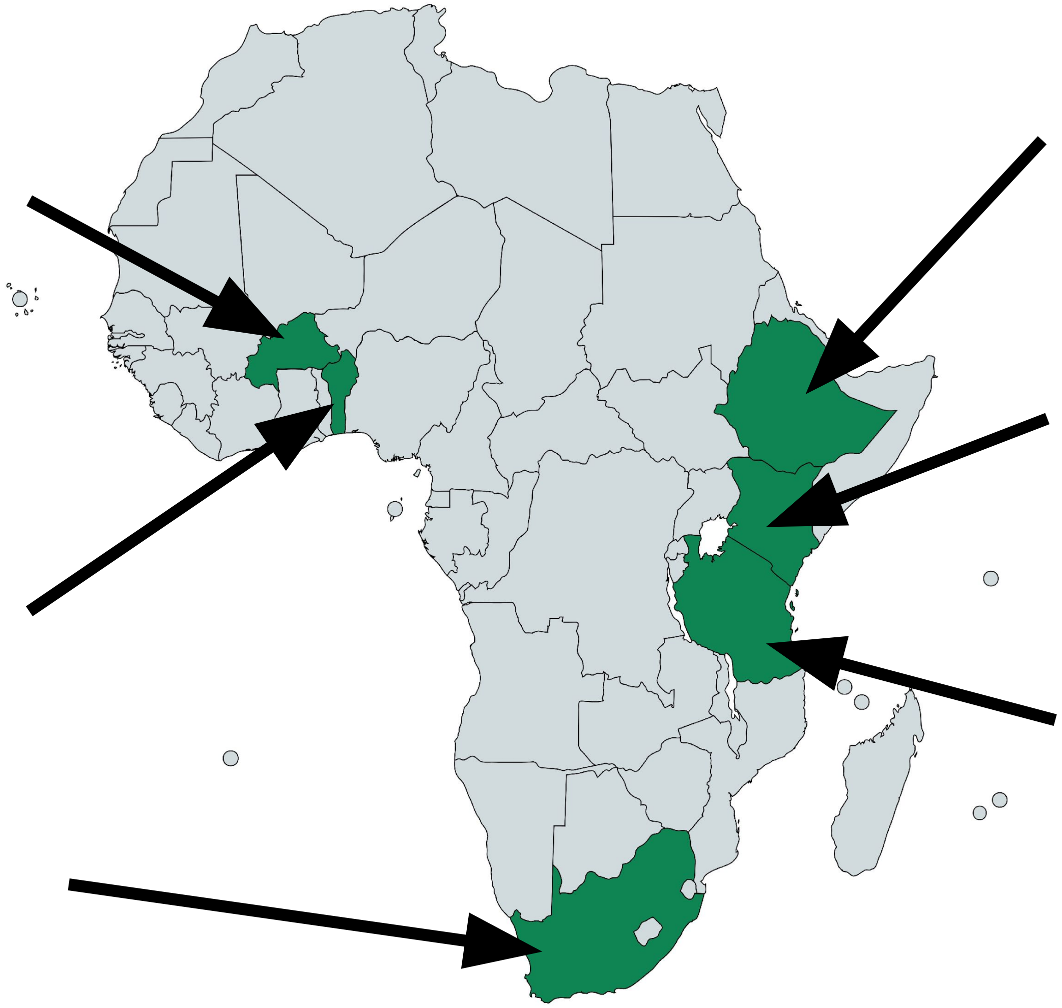
Source: Graham et al., 2022

Locations With Equipment to Measure Enteric Methane

Burkina Faso
- 1 GreenFeed for small ruminants & 1 for cattle

Benin
- 1 GreenFeed for cattle to be delivered

South Africa
- Cattle & small ruminant chambers
- 3 GreenFeed for cattle to be delivered
- SF6
- Laster methane detector



Ethiopia
- 1 GreenFeed for cattle

Kenya
- Cattle and small ruminant chambers
- SF6 under development

Tanzania
- Methane Laser

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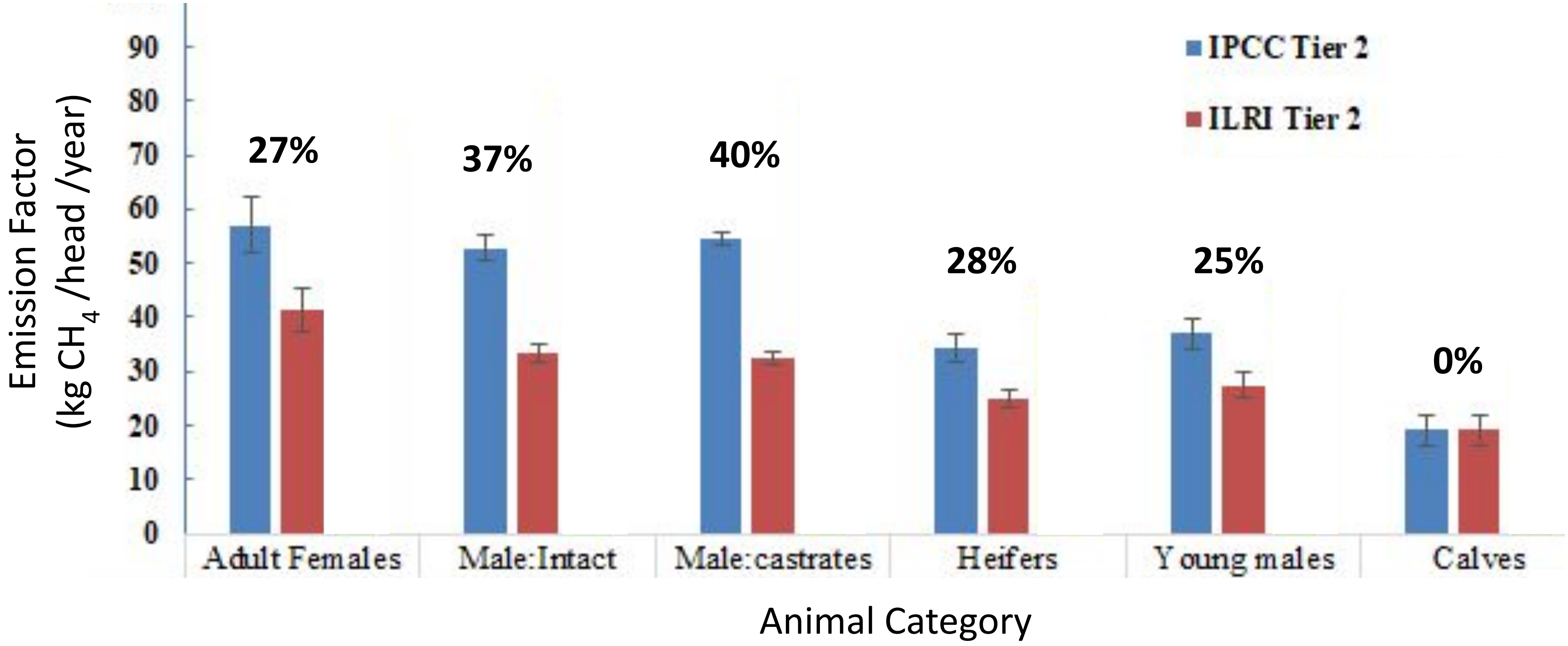
Enteric CH_4 Emission Factors are Different Between Tier 2 Models



Error bars are 95% confidence interval

Source: Balcha et al. manuscript submitted

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Climate Smart Agricultural (CSA) Practices are important

Republic of Kenya

KCSAP

Kenya Climate Smart Agriculture Project (KCSAP)

1. Increased productivity
2. Adaptation and resilience to climate change
3. Reduced greenhouse gas emissions

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□ Production increases and mitigation potential of CSA practices needs to be measured to determine what CSA practice should be promoted in what production systems

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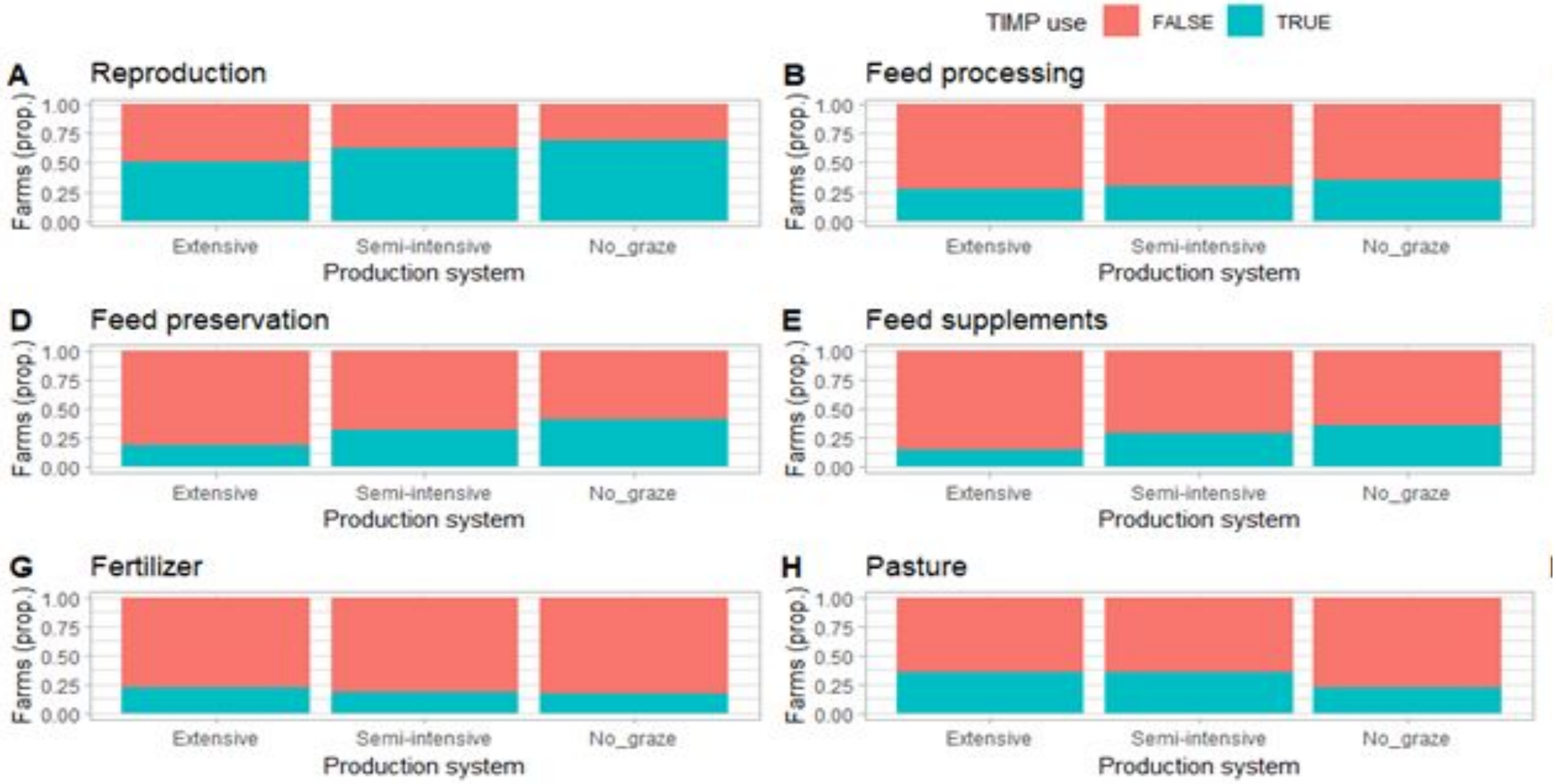
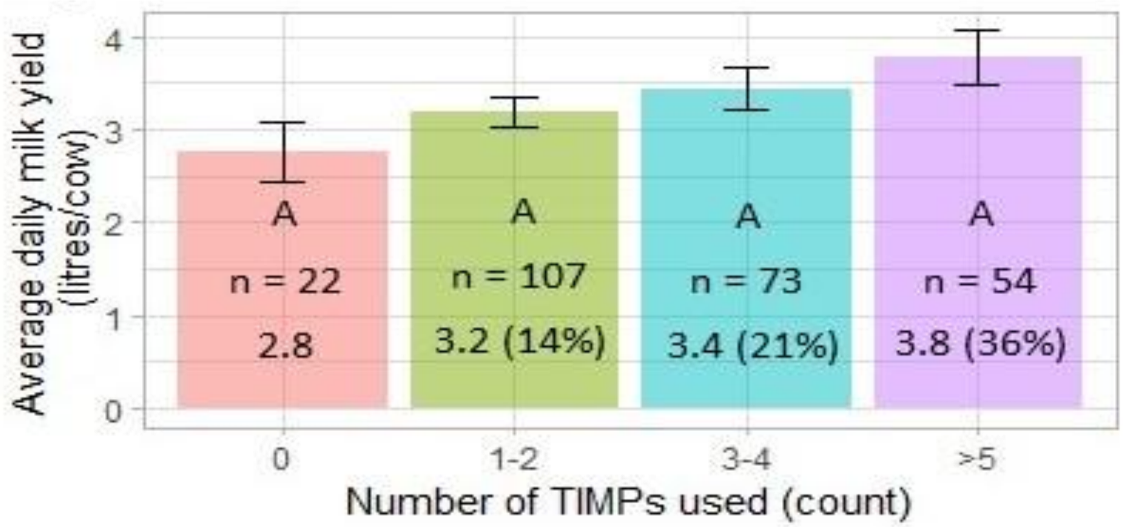
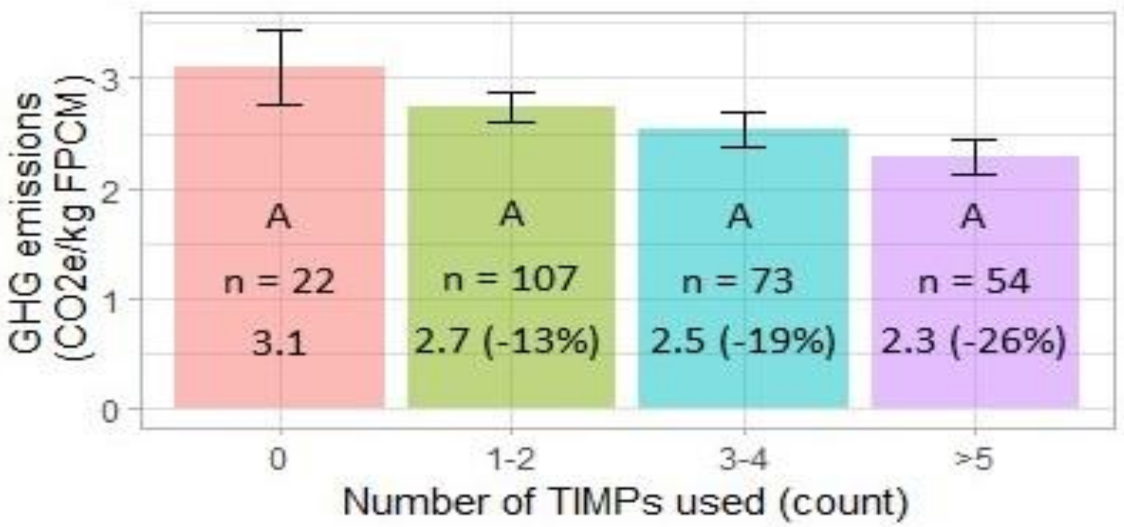
CSA Adoption Varies By Production System



Effects Of CSA Practices On Production And Emission Intensity By System

- Greatest production and mitigation gains were reached in extensive systems





Source: Caulfield et al. manuscript submitted

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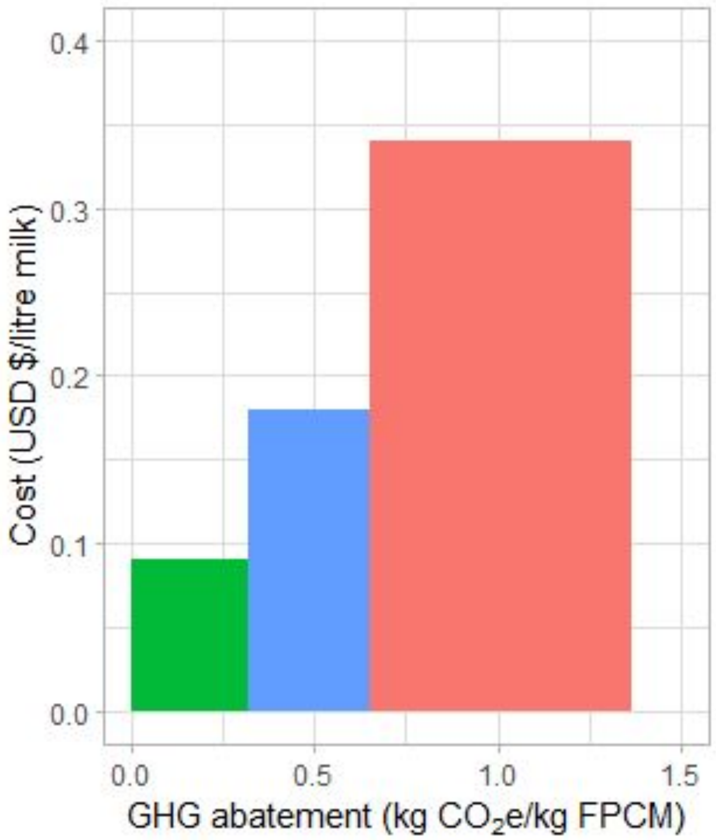
Marginal Abatement Cost Curves For The Use Of Different Numbers Of CSA Practices

 Upfront investment costs are a potential barrier to CSA adoption

Cost of implementation of CSA Practice

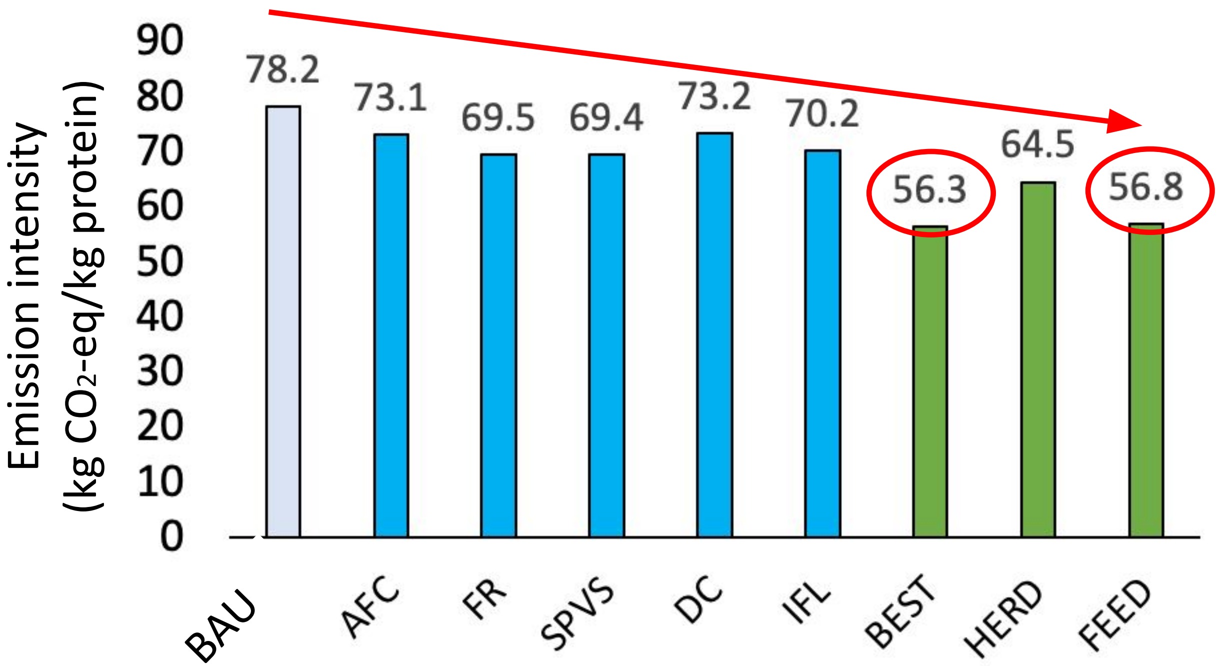


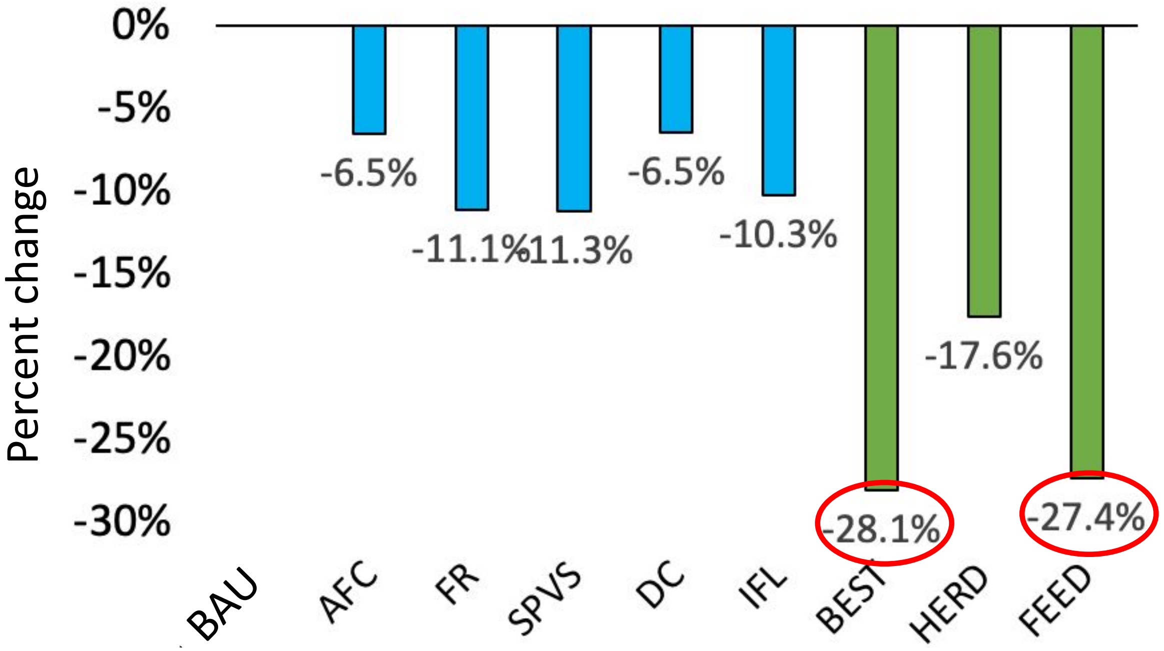
Cost of implementation of CSA techniques when including additional milk production

Source: Caulfield et al. manuscript submitted

GLEAM-i Modelling using CSA Practices

- Emission intensities decreased in all scenarios





AFC: Age at first calving
FR: Fertility Rate
SPVS: Sweet Potato Vine Silage
DC: Dairy Cubes (concentrate)

IFL: Improved Feeding Level
SPVS: Sweet Potato Vine Silage
BEST BET (FR + SPVS + IFL)
HERD (AFC + FR)
FEED (SPVS + DC + IFL)

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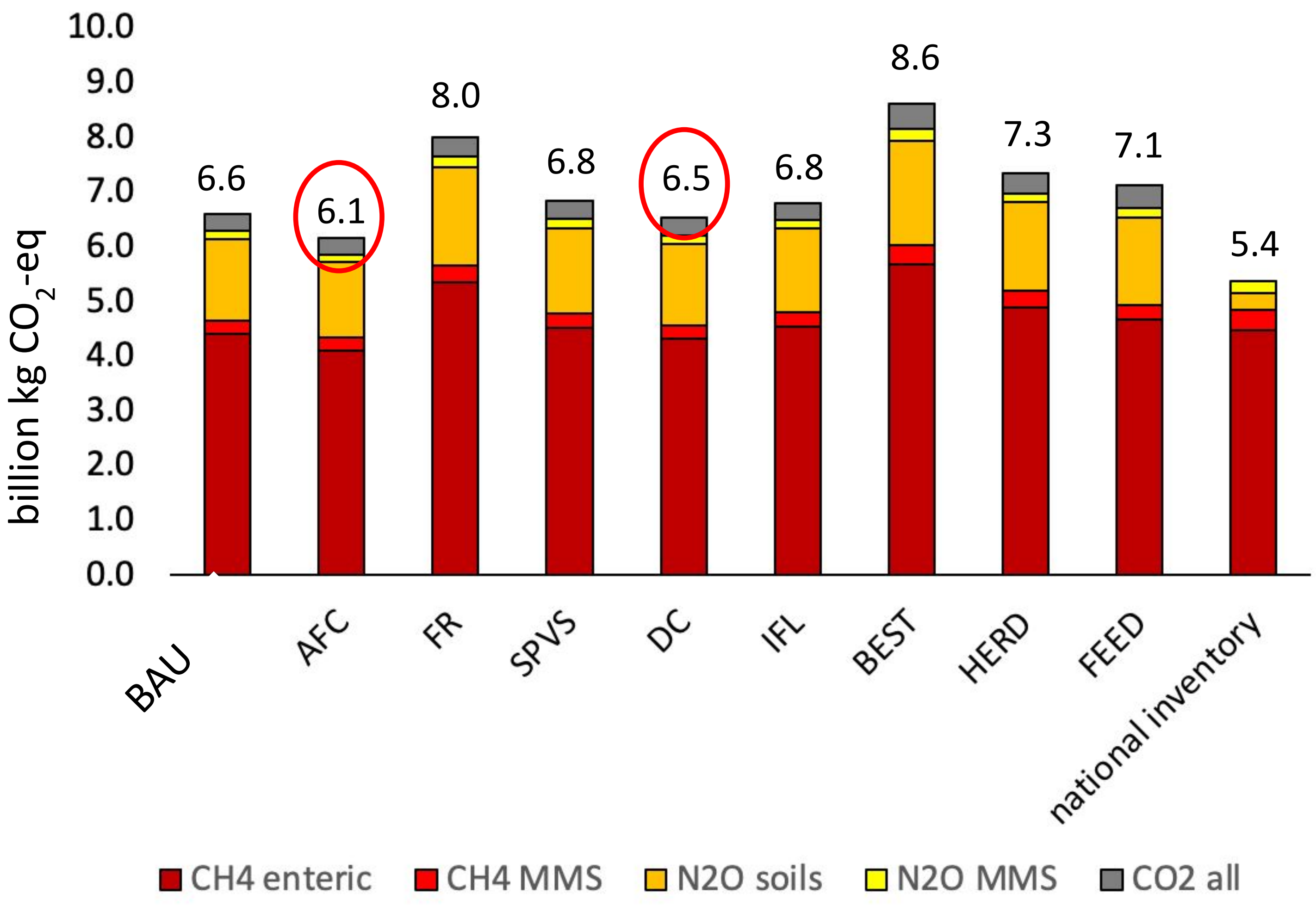
Source: Graham et al. under development

Absolute emissions

- Absolute emissions went up in most scenarios, except AFC and DC



AFC: Age at first calving

DC: Dairy Cubes (concentrate)

Manure Emissions

- N_2O emission factors lower than IPCC Tier 1 default for solid storage (2019 refinement)
   - Importance of regional country-specific EFs that represent the systems

- Manure from well fed cattle contains more N and has a lower C:N ratio
   - Feeding cattle well improves the manures fertilizer value
   - Greater N_2O emissions

- No difference in manure chemistry between grass diets

Source: Leitner et al., 2021

African Biogasdigester Component (ABC) Program (2022-2025)

- Aims to facilitate the shift in the biodigester market from its pioneering to the expansion phase
- >80% of rural households use wood or charcoal for fires in Kenya

  □ Biogasdigesters can reduce deforestation

- 2 improved breed/4 local cattle breeds provide enough manure for a 6-8 m^3 farm-scale digesters
  - 4-5 hours of cooking/day
  - Saves 5-8 tCO_2e/year in deforestation (3-5 tons of dry wood)
  - Potential for 18.5 million farm-scale digesters in Africa

    □ 6 tCO_2e mitigated * 18.5 million digesters = 100 million tCO2e/year

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Mitigate+: Research for Low-Emission Food Systems
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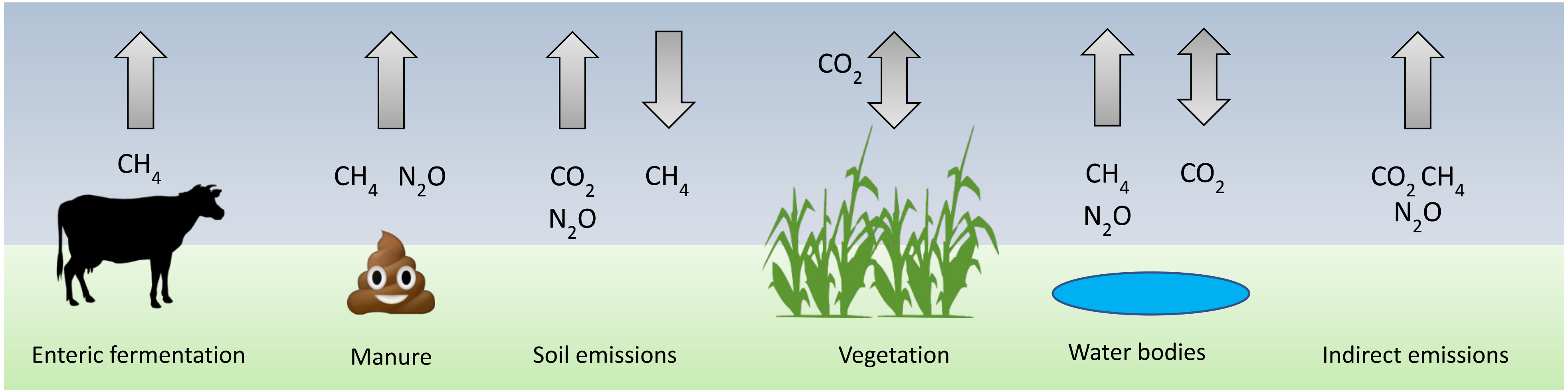
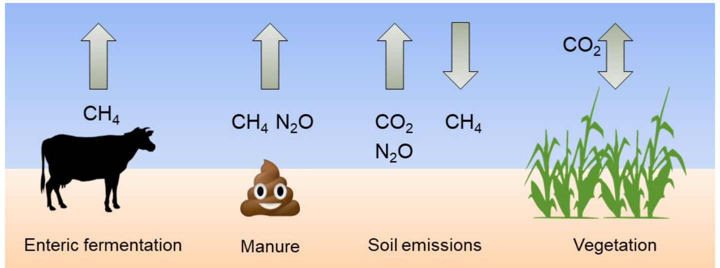
GHG emissions from rangelands – sources and sinks



Ecosystem carbon exchange using Eddy Covariance (EC) towers



Eddy tower at Kapiti Research Station

- **Ecosystem-scale CO_2, CH_4 and H_2O exchange** in savanna & dryland agriculture systems
- Additionally, linked to vegetation activity (monitoring of sun-induced fluorescence, biomass productivity & quality

Merbold et al, manuscript in preparation
Vincent Odongo, ongoing research
Tagliabue et al, manuscript submitted

Agroscope

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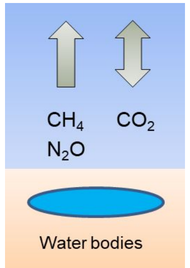
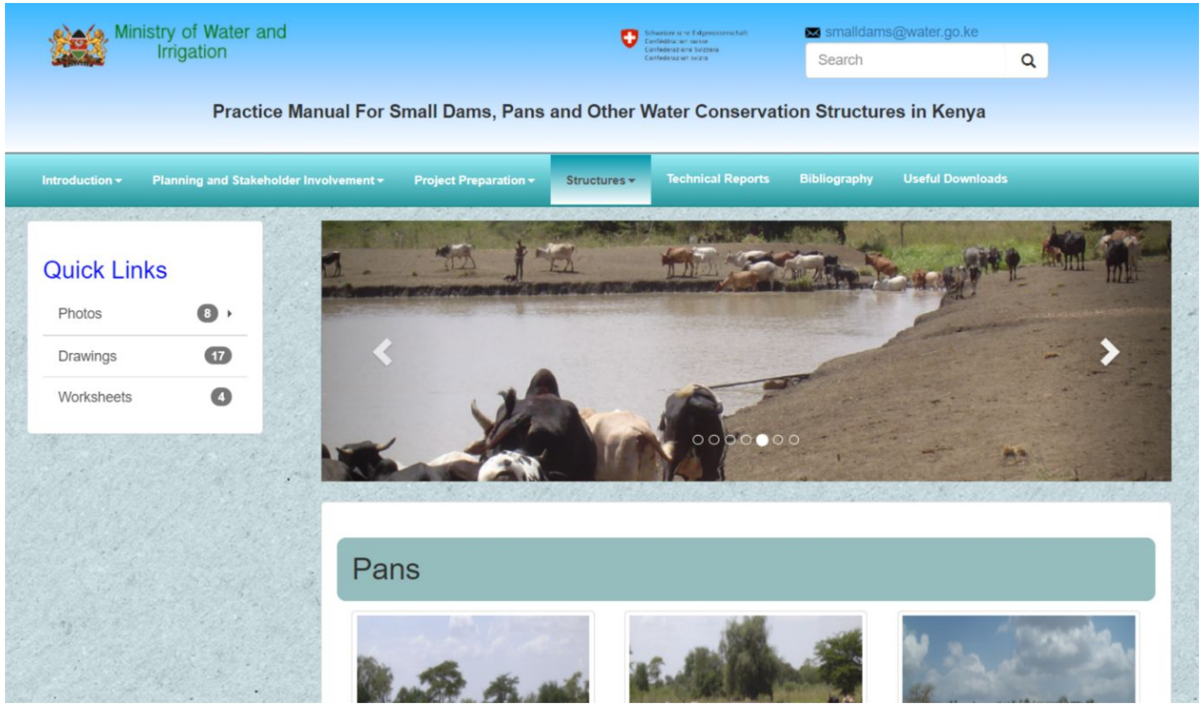
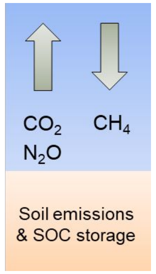
GHG emissions from water pans

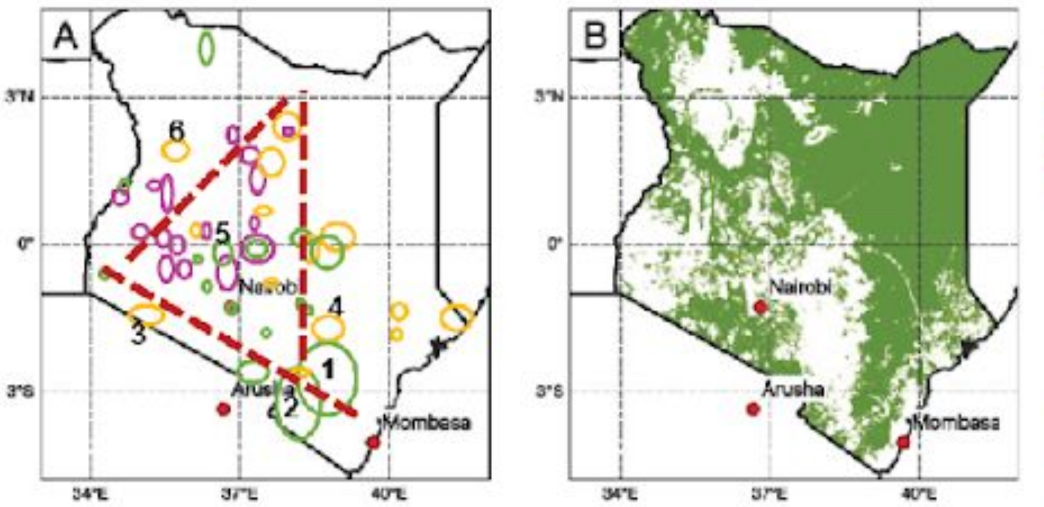


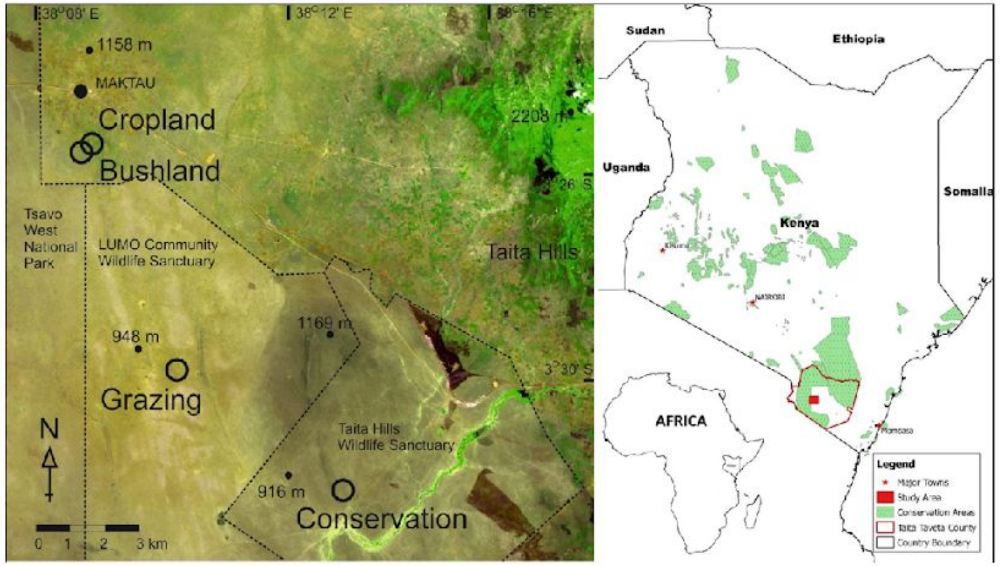


Soil GHG emissions and SOC storage



- Published GHG emissions for different land-use systems in the drylands of Southern Kenya
- Impact of livestock & wildlife grazing on soil CO2 flux
- Savanna GHG emissions
- Upcoming measurements on SOC stocks and sequestration potential in grasslands across Kenya across gradients of climate, soil, and degradation





Takeaways

- Current capabilities for monitoring mitigation and adaptation fall short of NDC goals
- Funding allocations for equipment and capacity building are inadequate to address existing gaps
- Development of local equations to estimate emissions is crucial for accurate inventories
- Optimizing production systems can lead to substantial benefits
- CSA practices will be most important to reduce emission intensities and meet rising demands
- A collaborative approach at national and international levels, involving governments, researchers, industry professionals, and farmers, is essential for success

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Need for funding and capacity building

- Funds for equipment is needed but are not enough!

- When equipment funding is given, long-term funding should be supplied to maintain the use of infrastructure
  – Lots of white elephants in Africa

- Funding schemes need to be put in place to increase human capacity. Progress can be accelerated by collaborations with researchers outside of Africa

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SAVE THE DATE!!!

9th GGAA

International Greenhouse Gas & Animal Agriculture Conference

Location

- Nairobi, Kenya

Date

- October 2025

Please email us for regular updates:

claudia.arndt@cgiar.org

Thank you very much for your attention!

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https://mazingira.ilri.org/

Better lives through livestock

Claudia Arndt, PhD

claudia.arndt@cgiar.org

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RUFORUM Capacity Building in Agriculture

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Barriers to the uptake of biodigesters and the way forward

- Barriers to uptake:
  - High upfront cost (500 – 1000 USD)
  - Lack of fiscal incentives, such as subsidies, government grants, and loans
  - Policy and strategic goals for upscaling are not adequately supported
  - Weak coordination between government agencies and other stakeholders
  - Volatile carbon market with high transaction costs and low volume
  - Absence of standards for biodigesters, as well as certification and licensing for installers and enterprises
  - Limited awareness of biodigester benefits and inadequate training for users.
  - Insufficient trained personnel and R&D to foster technology innovation

- Recommendation to increase adoption:
  - Establish financing mechanisms and PPP to upscaling, reduce costs and facilitate installment payments
  - Back policies and strategic goals with robust political support and fostering enabling environments
  - Initiate multi-stakeholder platforms with enhanced coordination
  - Develop localized and robust MRV for the biogas sector to set GHG reduction target, track progress and enhance the integrity of carbon offset
  - Encourage carbon credit aggregation
  - Formulate standards and certification processes for biodigester installers
  - Raise awareness and offer training to end-users
  - Develop comprehensive training curriculums
  - Enhance R&D to develop affordable and efficient technologies

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Climate-Smart Practices – Dairy Value Chain

Kenya Climate Smart Agriculture Project (KCSAP)

CSP Category	Individual practice
Reproduction	Artificial insemination (AI) services; Breeding improvements
Feed processing	Chaff cutter; Improved machinery
Fodder improvement	Improved fodder; Fodder establishment; Fodder improvement
Feed preservation	Feeds preservation; Hay; Silage making
Feed supplements	Dairy concentrates; Own farm feed formulations; Feed formulation
Health	East Coast Fever vaccination
Fertilizer	Fertilizer use
Pasture interventions	Improved pasture; Legumes mixed with Kikuyu grass; Pasture management; Pasture establishment and management
Feeding of by-products	Use of maize stovers
Water harvesting	Water harvesting
Stall feeding and housing improvements	Semi-zero grazing unit; Zero grazing unit; Improved housing; Improved dairy unit; Improved housing; Dairy unit improvement
Milk Marketing	Milk marketing

Research Hub-Livestock Biogas and Bioslurry Value Chain Development

- Equipped with lab-scale and on-farm biodigesters, biogas analyzers and lab equipment for feedstock, nutrient and pathogen analysis
- Serves as hub for research, capacity building, sample analysis services and scientific exchange in Africa
- Build evidence, tools and methods on GHG mitigation potential and socio-economic, health, gender, and environmental co-benefits of on-farm biodigesters
- Innovate biodigester technologies which are efficient and tailored to the energy needs of farms, various organic wastes and agro-ecologies
- Increase stakeholder capacity to access and utilize robust and localized MRV biogas sector data for GHG inventory, carbon and climate financing, policy-making and guiding best practices
- Promote the expansion of on-farm biodigesters in African nations, increasing from the current 103,044 units to the potential target of 32.9 million households, based on the technical potential determined by available water and manure

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Projects and capacity building-Biogas and Bioslurry

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- On-farm data to determine biogas and biofertilizer production and use, and their socio-economic, health, gender, and environmental co-benefits (ABC & Mitigate+)
- Generating holistic insights of the successes, challenges, and future prospects of biogas programs in Sub-Saharan African countries
- As part of lessons learned from multi-country biogas programs in sub-Saharan regions such as the African Biogas Component (ABC; https://english.rvo.nl/subsidies-programmes/african-biodigester-component-abc) and the African Biogas Partnership Program (ABPP; https://www.africabiogas.org/)
- ABPP and ABC provides clean energy and biofertilizer to over half a million people
- Optimizing biogas process and technology to maximize biogas and biofertilizer yield and quality
- Generating robust and localized MRV for livestock biogas sector
- Field measurement and self-reported health benefits of biodigesters (indoor air quality, pathogen reduction, diarrheal, occupational health, eye and respiratory infections)
- Currently training 3 PhD students and 2 MSc students
- Future research plan on production of alternative protein from manure, biogas and renewable energy sources

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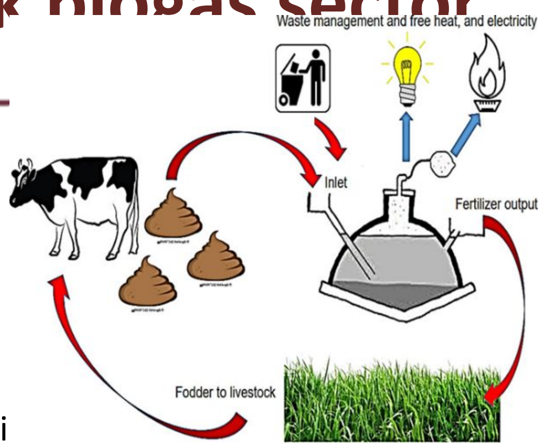
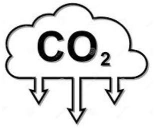
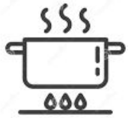
Opportunities, potential and success in African livestock biogas sector



- Anaerobic Biodigester turns livestock manure to biogas and nutrient-rich bioslurry
- Biodigester contributes to 14 outs of 17 SDGs (directly to six of SDGs)
- Development opportunities:
  - **2.8 B people globally (900 M Sub-Saharan Africa)**, globally still cooking using dirty fuels (IRENA, WHO, 2022)
  - Cooking with dirty fuels kills **3.2 M people** each year globally due to indoor air pollution, higher than the combi fatality by HIV AIDS, Malaria and TB.
  - Annual global cost of cooking with dirty fuels is **USD 2.4 T**; **USD 1.4 T** for health; **USD 0.8 T** for women's lost of productivity and **USD 0.2 T** for climate problems
- Technical potential of manure-fed household biodigesters in developing countries to be over 150 M units (Asia 100 M; Africa 32.9 M; Central and Latin America 20 M)





1.2B Tree can be saved	**750M Tons CO_2e** can be mitigated	**219B Hours of cooking** on clean energy	**3.2B Tons of manure** can be upcycled	**900M ha land** can be fertilized

- No. of installed biodigester: Africa **103,044**; China & India **40 M**; Other Asian nations **1M**
- Multi-country biogas programs: African Biogas Component (ABC) and the African Biogas Partnership Program (ABPP)- over 0.5 millions benefited

ABC; https://english.rvo.nl/subsidies-programmes/african-biodigester-component-abc
ABPP; https://www.africabiogas.org/

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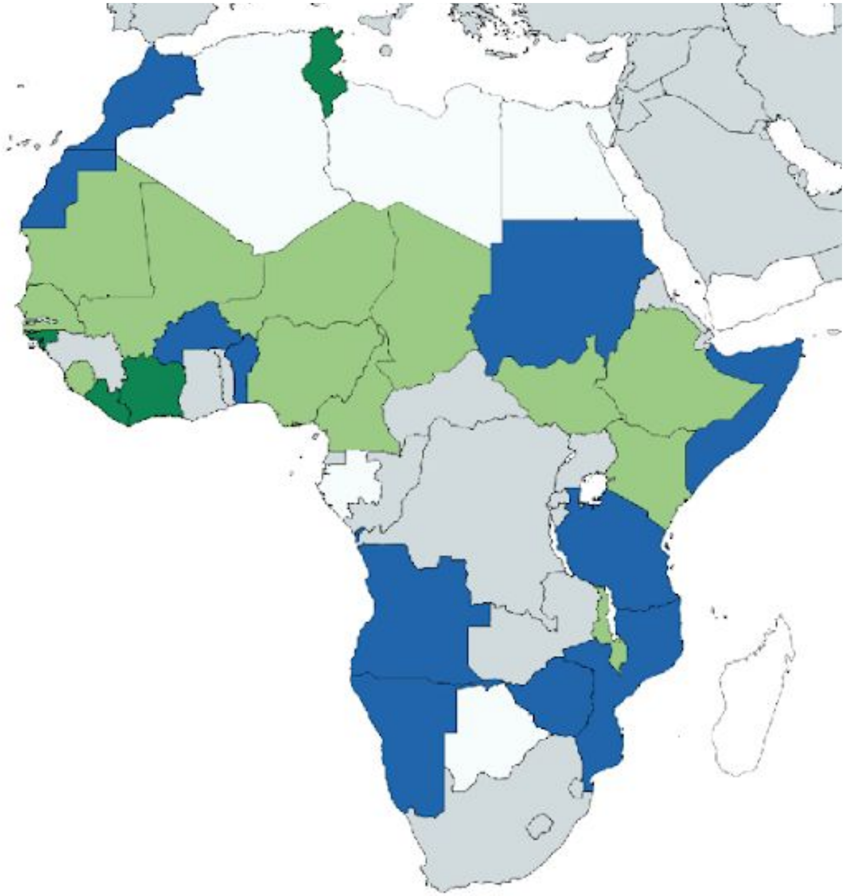
Countries that Include Livestock in New & Updated NDCs



Out of 54 African countries:

- 16 countries include **Mitigation & Adaptation** measures
- 5 countries include livestock **Mitigation** measures

- 14 countries include **Adaptation** measures
- 9 countries include no livestock measures
- 10 countries include no new or updated NDCs

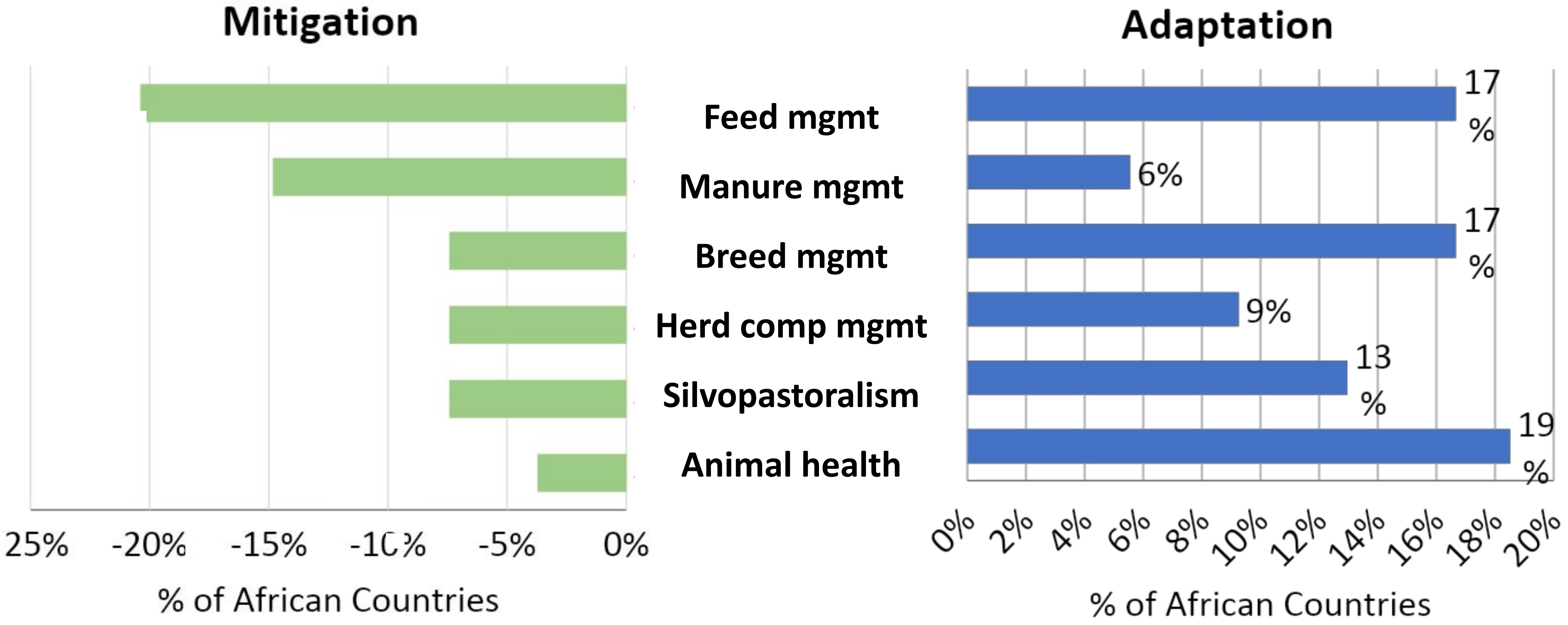
Adaptation addresses the impacts of climate change

Mitigation addresses the causes of climate change

Both approaches are needed in developing countries!

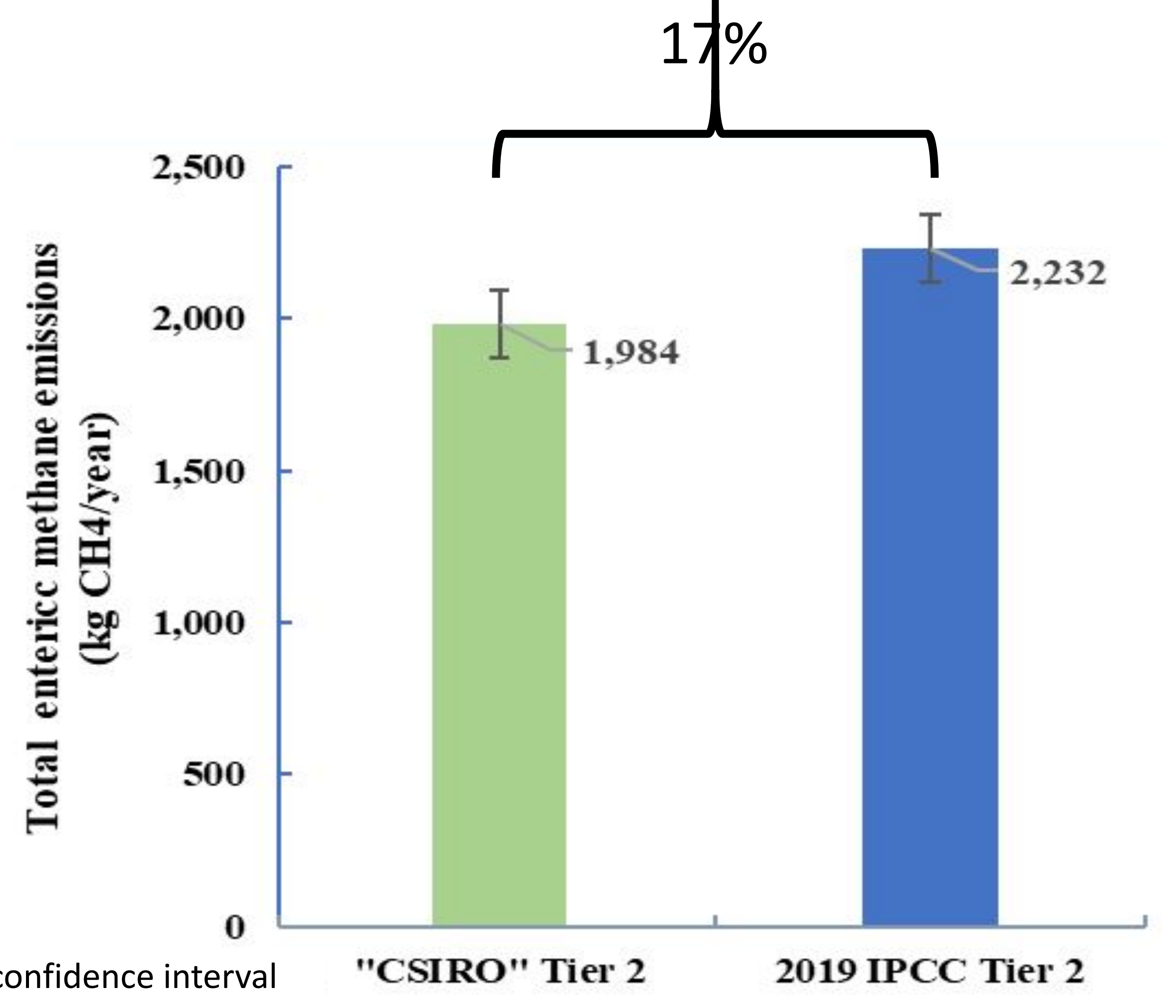
Source: Modified Rose et al., 2021 &
https://ccafs.cgiar.org/index.php/resources/tools/agriculture-in-the-ndcs-data-maps-2021

Mitigation & Adaptation Strategies in NDCs of African Countries



Source: Rose et al., 2021 and
https://ccafs.cgiar.org/index.php/resources/tools/agriculture-in-the-ndcs-data-maps-2021

Preliminary Results - Enteric CH4 Emission Factors For Cattle are Significantly Different Between 2 Models Based on Global North Data

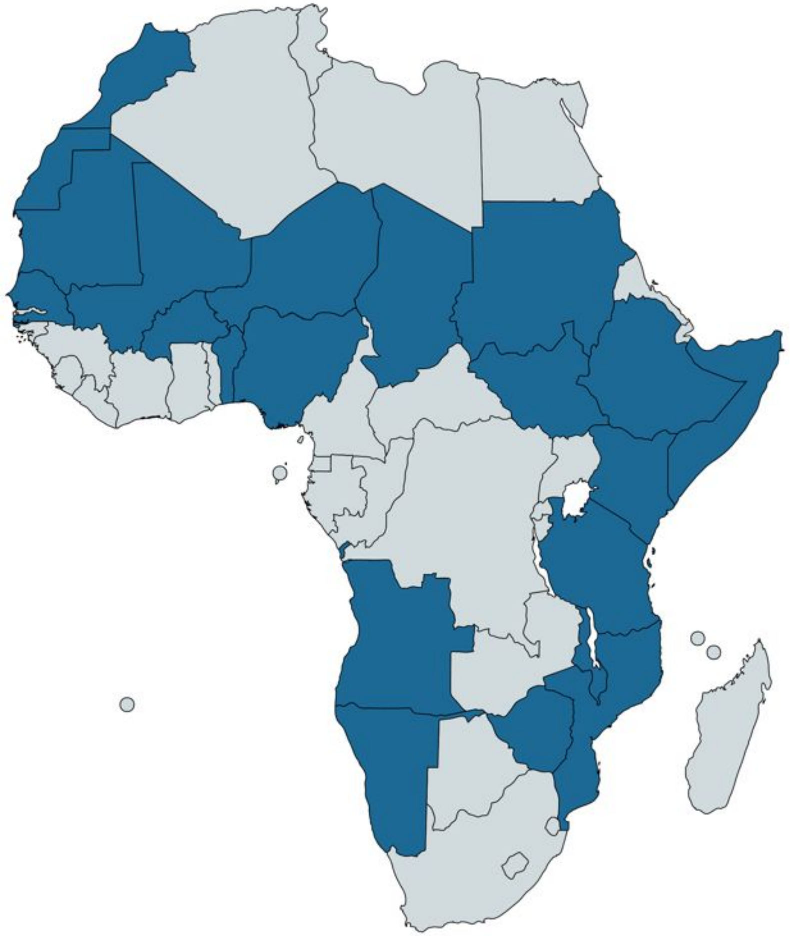


Error bars are 95% confidence interval

Source: Balcha et al. manuscript under development

No Capacity to Track Livestock Adaptation

Countries with livestock adaptation in their new or updated NDCs



- Currently no international reporting on Adaptation Tracking
  - First instrument designed and nearly completed

Source: Todd Crane (ILRI); perso
communication .