Better lives, better planet
through livestock

Sustainable management of soils and landscapes in pastoral and agro-pastoral systems for resilient livelihoods

Anthony Whitbread, Program Director, Livestock, Climate, Environment, ILRI
a.whitbread@cgiar.org

Nigerian Soil Science Society lecture
Nigeria 25 May 2026

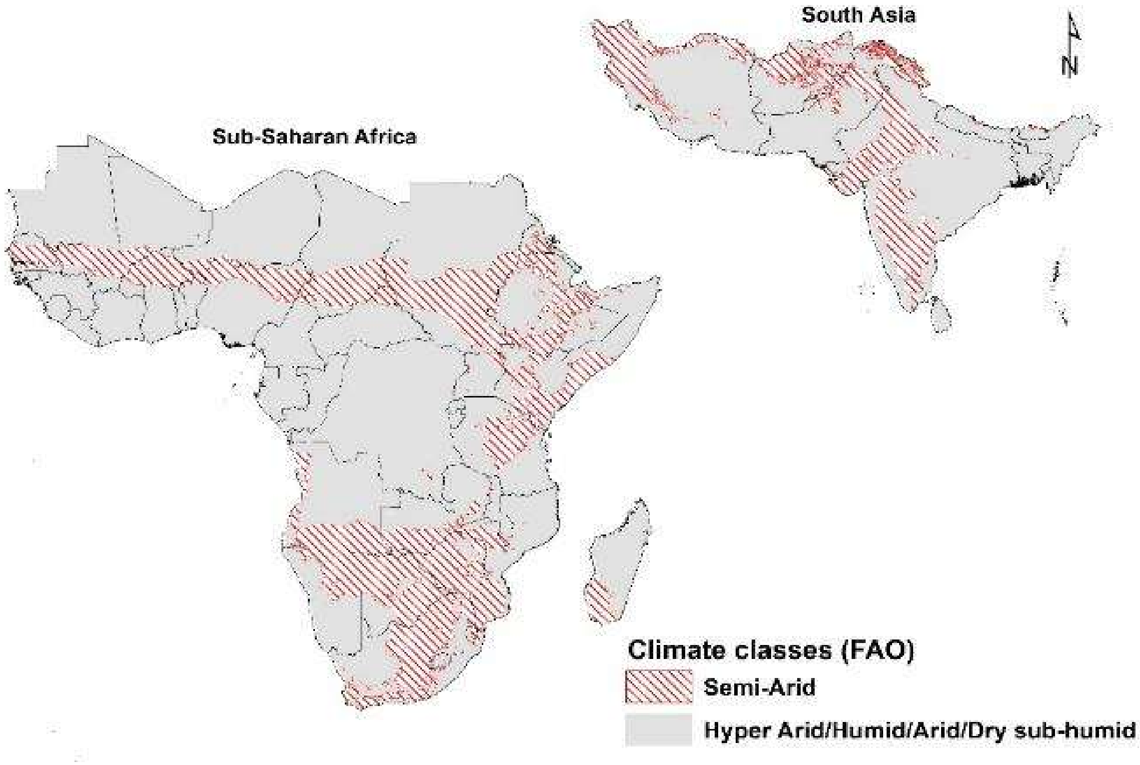
rainier climate

ILRI
INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE
CGIAR

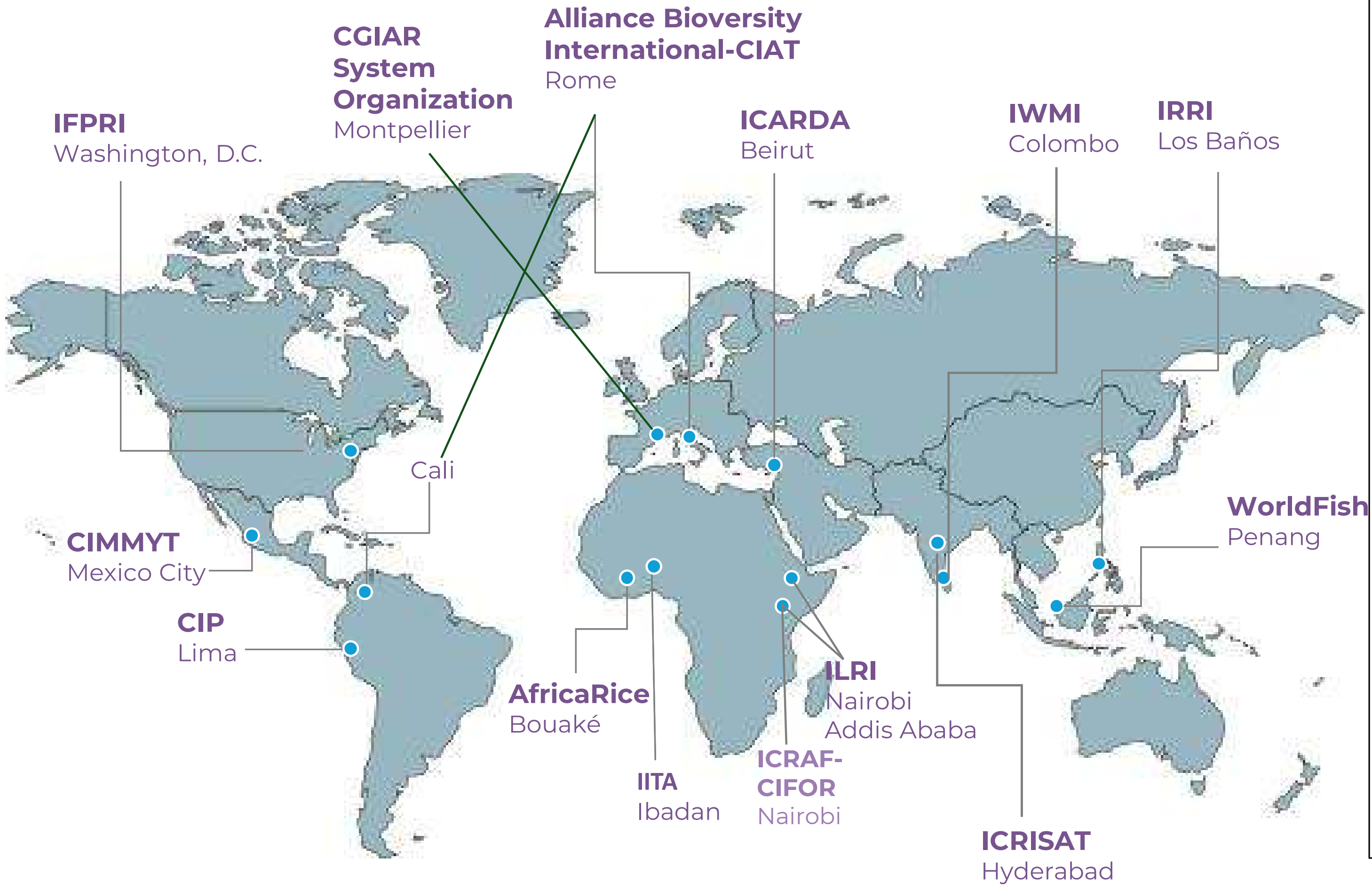
Better lives,
better planet
through livestock

Outline

- The CGIAR & ILRI
- The development challenge
- Framing the climate smart livestock approach to the climate and soils agenda
- Examples of managing soils in pastoral and agropastoral settings.
  - GHG inventories
  - Moving to a systems perspective
- Conclusions



CGIAR: Global mandate, local presence



- The world's **largest publicly funded** agricultural research network committed to agriculture innovation for **Farmers and Food Systems** in the developing world.
- Global presence across four continents with nearly **10,000 staff** of **128 nationalities**
- Local presence in nearly **90 countries**
- **3000+** partners
- **50 years'** experience
- **10-fold** return on investment

ILRI offices and staff worldwide

Better lives through livestock

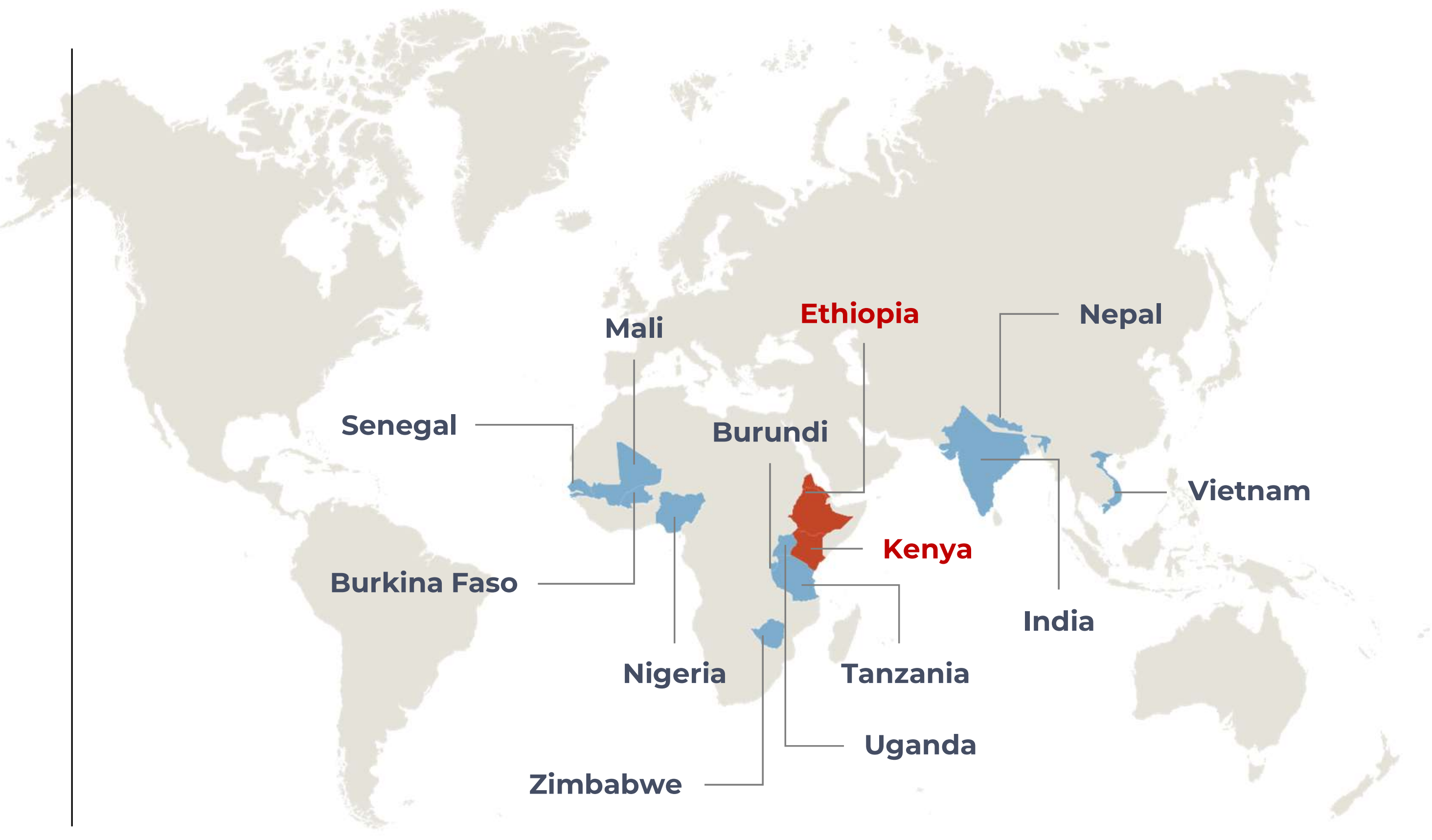
ILRI is co-hosted by both the governments of Ethiopia and Kenya, with offices in 8 other countries in Africa (Burkina Faso, Burundi, Mali, Nigeria, Senegal, Tanzania, Uganda and Zimbabwe); 3 countries in Asia (India, Nepal and Vietnam).

ILRI has over **700 permanent staff** (with a gender breakdown of 40% female and 60% male).

ILRI established in 1994 based on merger of the two centres:

International Laboratory for Research on Animal Diseases–ILRAD (est. 1973)

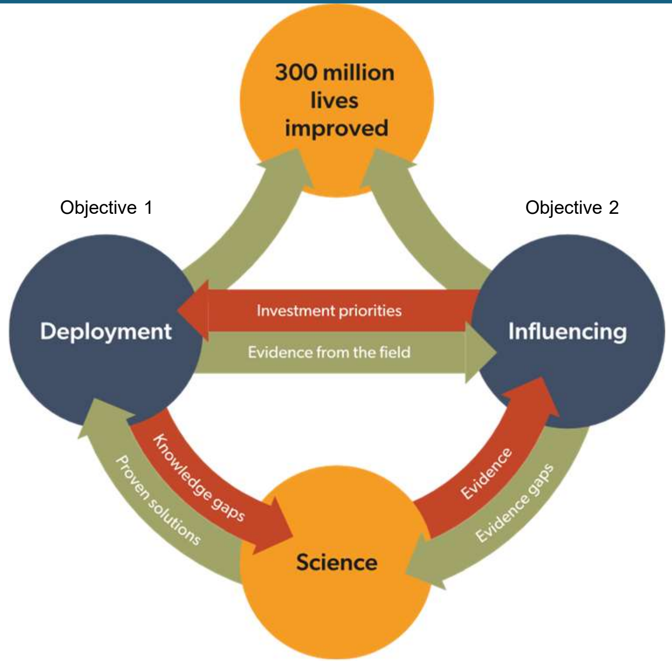
International Livestock Centre for Africa – ILCA (est.1974)



Corporate Mission and strategic objectives

ILRI's mission is that:
Peoples' lives in low- and middle-income countries are improved through livestock science that contributes to equitable and resilient livestock systems in order to deliver food systems transformation with climate and environmental benefits.

Strategic objective 1: Co-design and deployment of sustainable science-based livestock solutions



Strategic objective 2: Leveraging science for policy and investment decisions

The development challenge

Rapid population increases

2050: Asia 5.3 billion (+41%)
Africa 2.5 billion (+209%)

2100: Asia 4.8 billion
Africa 4.5 billion

Urbanization

2018: -55%

2050: -68%

Demographic shifts
High income inequality
Climate change
Natural resource degradation

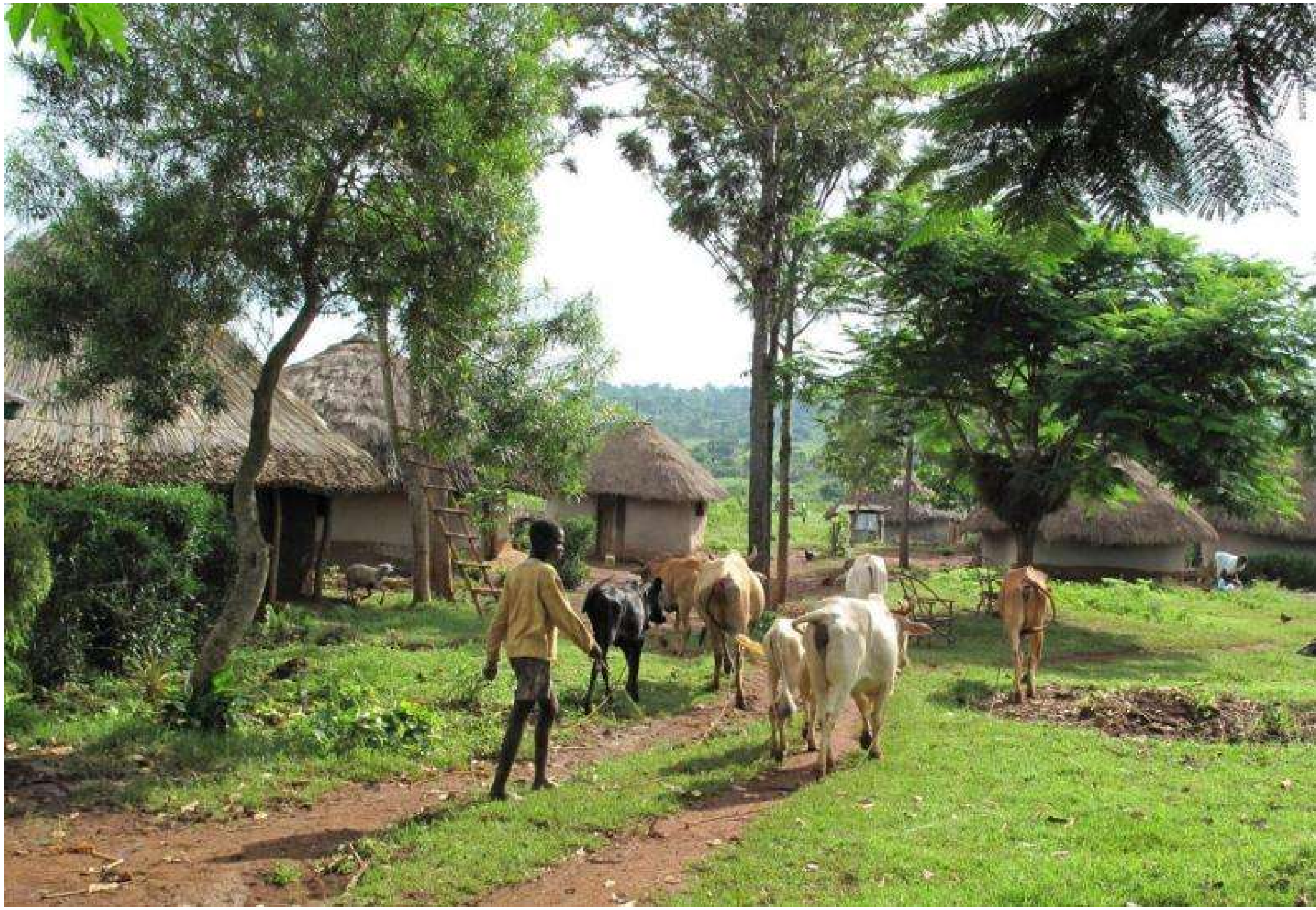
Pastoral communities in transition

- Pastoral systems are in transition: pressures of degradation, climate, population, conflict.
- Droughts have increasing severity and frequency: '…three consecutive droughts capped by the worst March-April-May (MAM) rains in 73 years, famine looms in southern Somalia…'

- Poverty rates, food insecurity, and malnutrition remain high
- Conflict, banditry and theft
- Data scare: Rangeland condition/water sources/markets/HH dynamics, GHG's and mitigation pathways

Crop-livestock systems

- Farm size decreasing
- Integration (crop/livestock) limited
- Expansion into more marginal areas and often not 'climate smart.'
- Natural resource base degrading.
- Competition for forage resources.



What is **climate-smart livestock** (CSL)?

Three Core Goals

- Increase **Productivity**: Producing more food (milk, meat) per animal or per unit of input, meaning fewer emissions per product.
- Enhance **Resilience** (Adaptation): Helping livestock and farmers withstand climate shocks (heatwaves, floods, disease) through better breeds or diversified systems.
- Reduce **Emissions** (Mitigation): Lowering GHG emissions (methane, nitrous oxide) from feed, manure, and energy use.

What is **climate-smart livestock** (CSL)?

Soil is fundamental

- Increase **Productivity**:

  Maintain soil fertility, nutrient and water holding capacity.

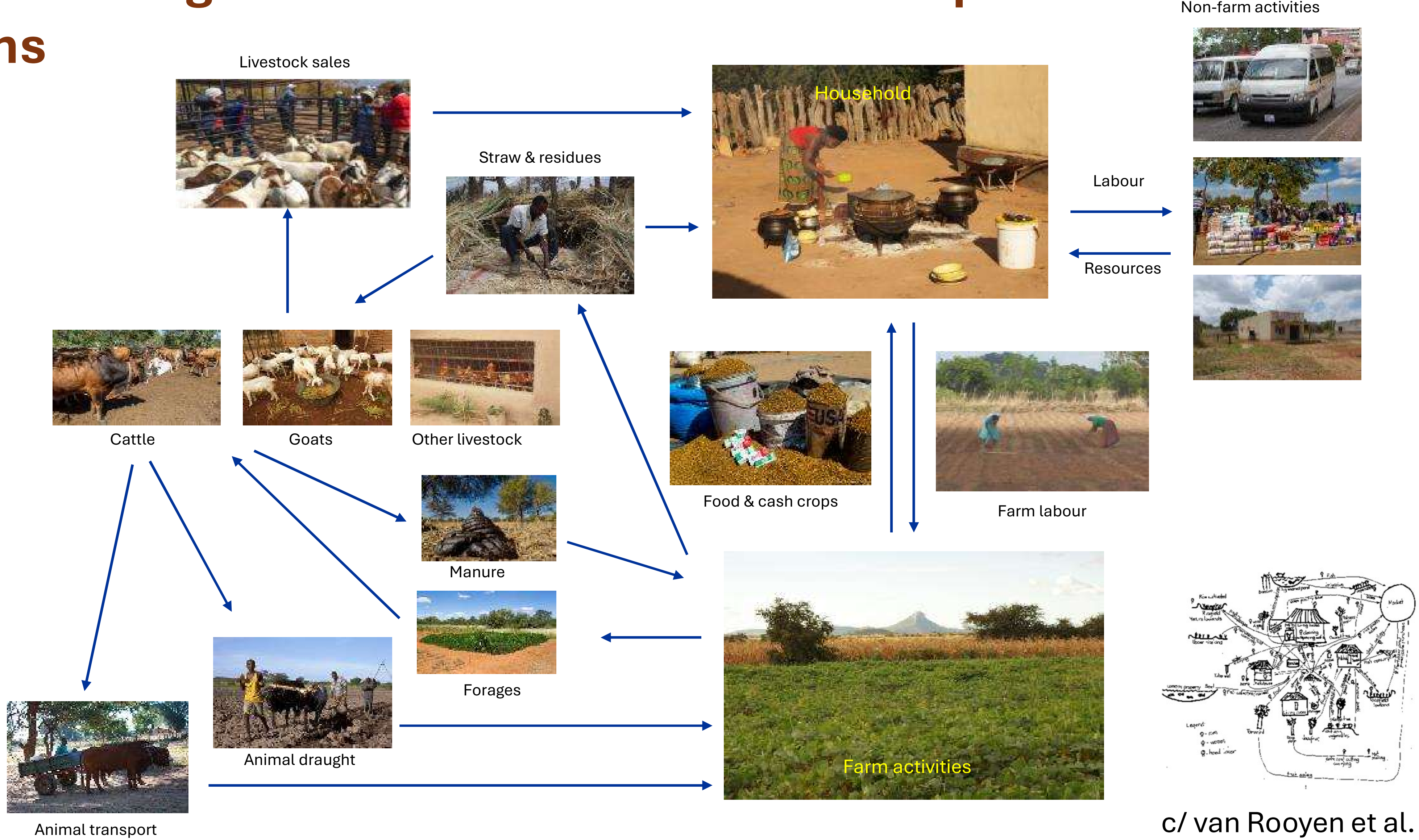
- Enhance **Resilience** (Adaptation):

  Soil fertility to support diversification and intensification strategies

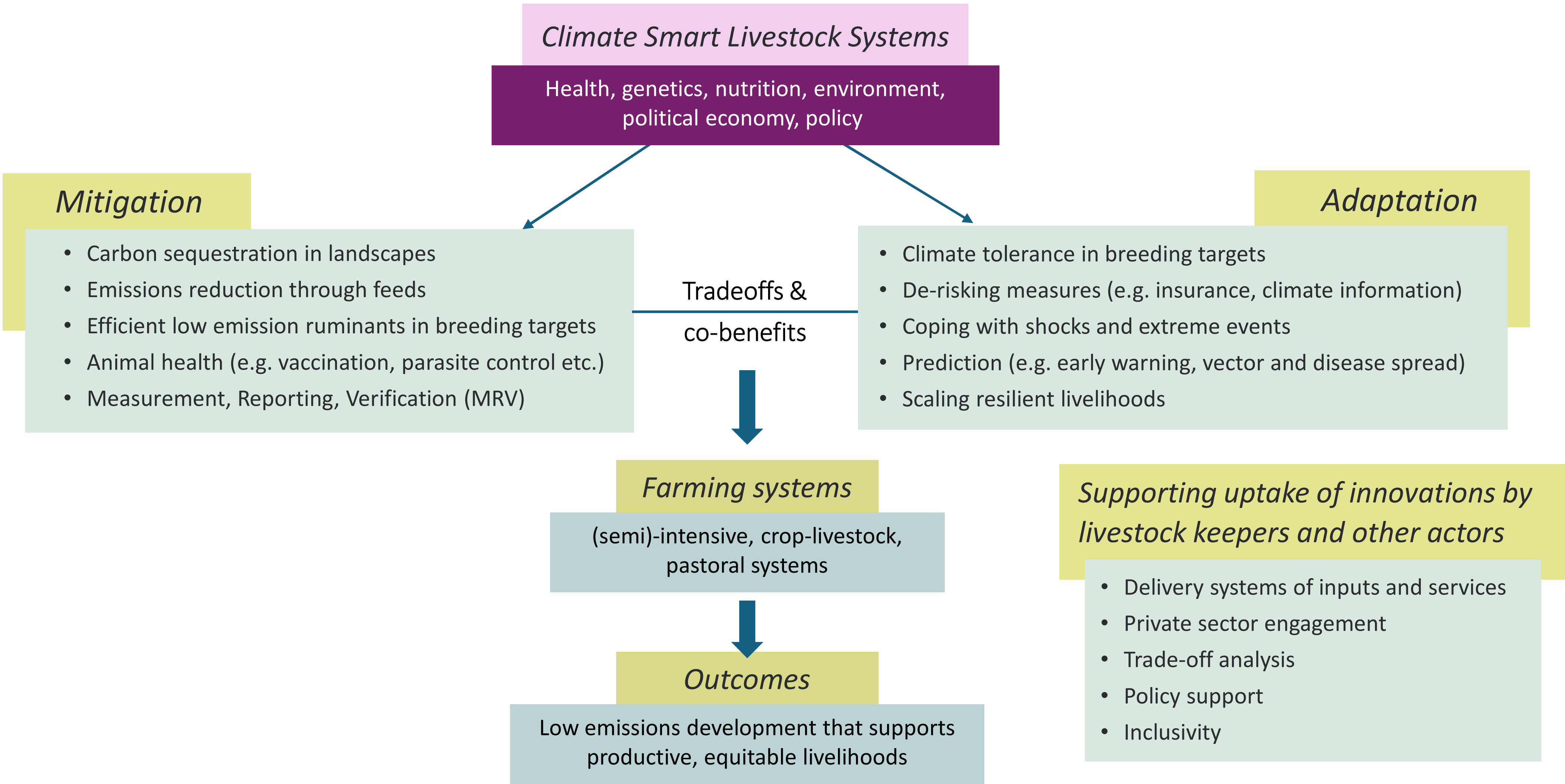
- Reduce **Emissions** (Mitigation):

  Soil organic matter, sequestration of carbon into soils

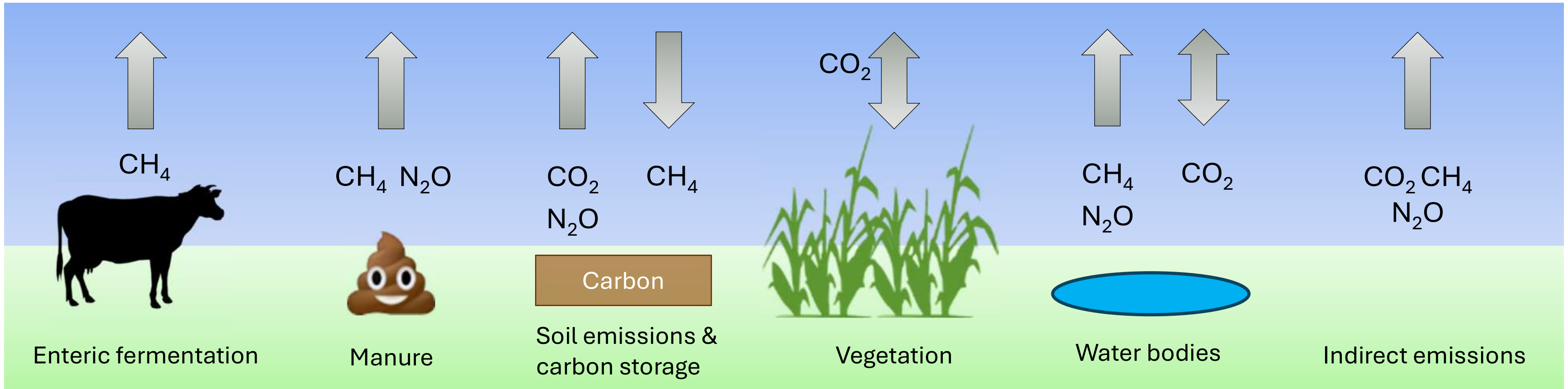
Smallholder agriculture – households as complex systems



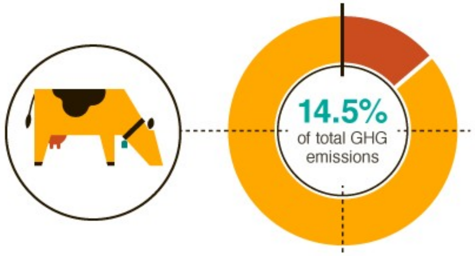
c/ van Rooyen et al.


Climate Smart Livestock Systems
Health, genetics, nutrition, environment, political economy, policy
Mitigation
Carbon sequestration in landscapes
Emissions reduction through feeds
Efficient low emission ruminants in breeding targets
Animal health (e.g. vaccination, parasite control etc.)
Measurement, Reporting, Verification (MRV)
Tradeoffs & co-benefits
Adaptation
Climate tolerance in breeding targets
De-risking measures (e.g. insurance, climate information)
Coping with shocks and extreme events
Prediction (e.g. early warning, vector and disease spread)
Scaling resilient livelihoods
Farming systems
(semi)-intensive, crop-livestock, pastoral systems
Outcomes
Low emissions development that supports productive, equitable livelihoods
Supporting uptake of innovations by livestock keepers and other actors
Delivery systems of inputs and services
Private sector engagement
Trade-off analysis
Policy support
Inclusivity

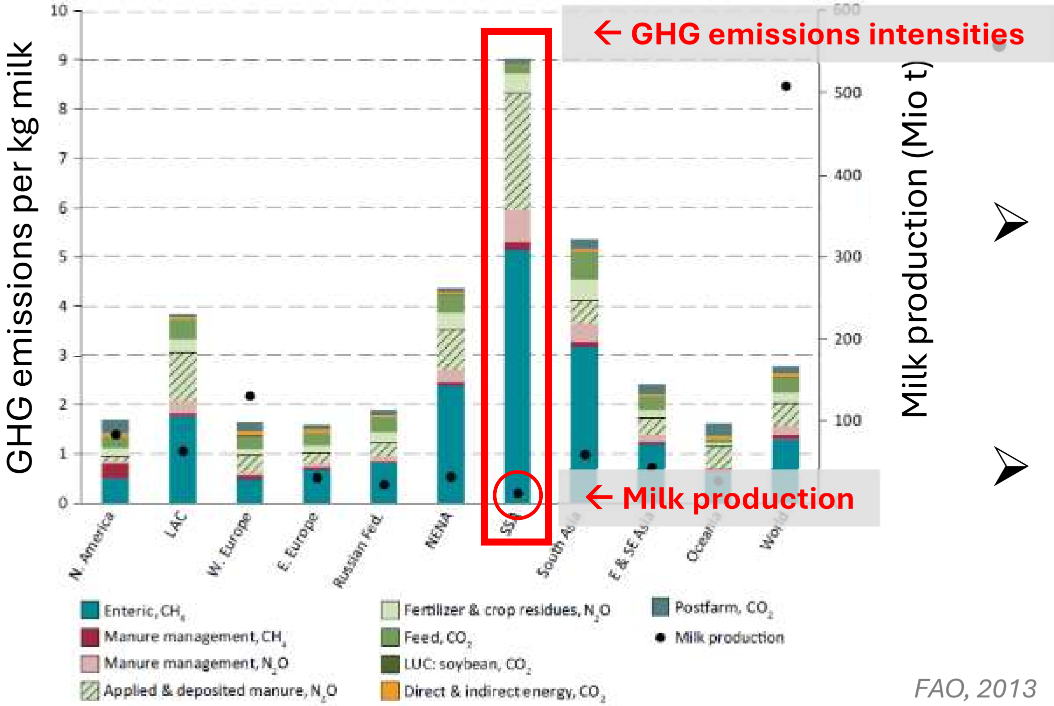
Greenhouse gas emissions from rangelands



Why do we want to measure GHG emissions in rangelands?



GHG emissions intensities



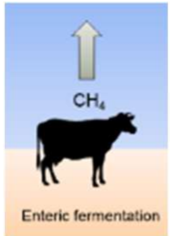
FAO, 2013

- 14.5% of total global GHG emissions originate from livestock
- Low livestock productivity in SSA particularly in extensive livestock systems (= rangelands)
- High GHG emissions intensities (GHG emissions per kg of product) in SSA

➢ Critical need to increase productivity to ensure food & nutrition security of the population

➢ Need for low-emissions development to ensure climate change mitigation & adaptation

Enteric CH_4 emissions from livestock (indirect estimation)



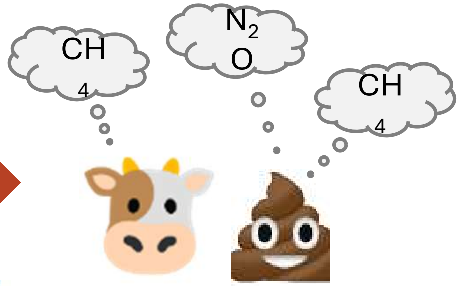
Input data

Animals | Feed

Milk | Manure

Equations

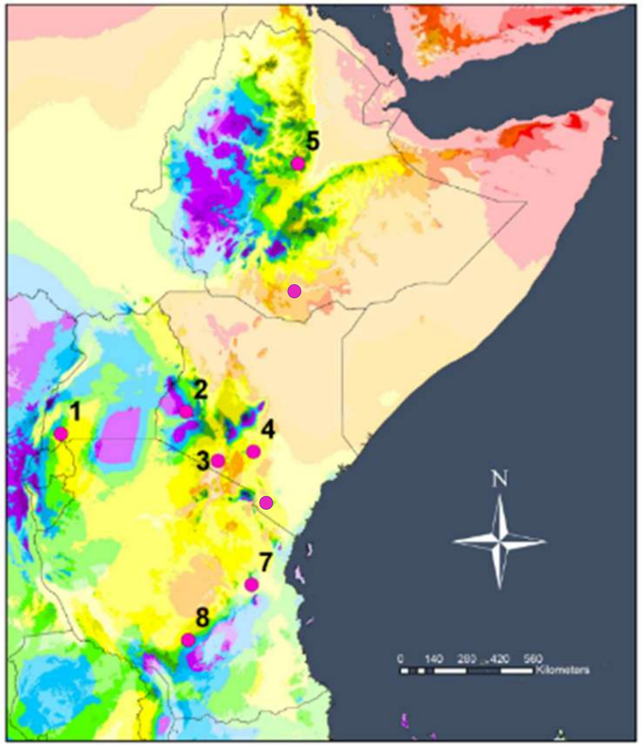
GHG emission factors



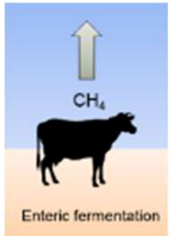
Pastoral sites we've worked in so far:

- Borana (Ethiopia)
- Kajiado, Machakos, Taita (Kenya)
- Mvomero (Tanzania)
- Isingiro & Kiruhura (Uganda)
- Ougadougou (Burkina Faso)

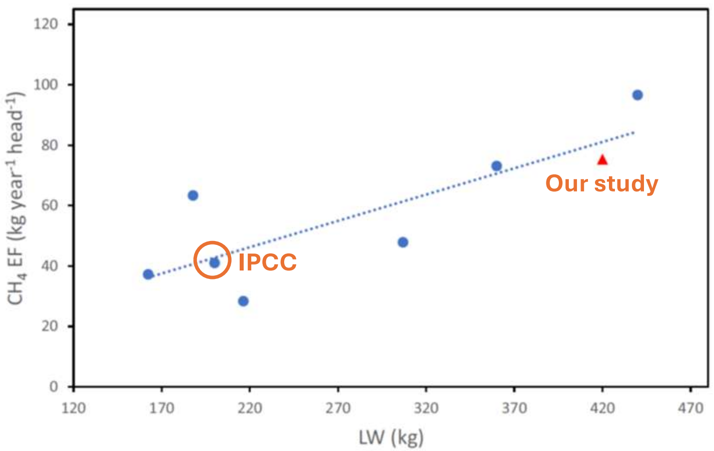
Upscaling & LCAs, national GHG reporting

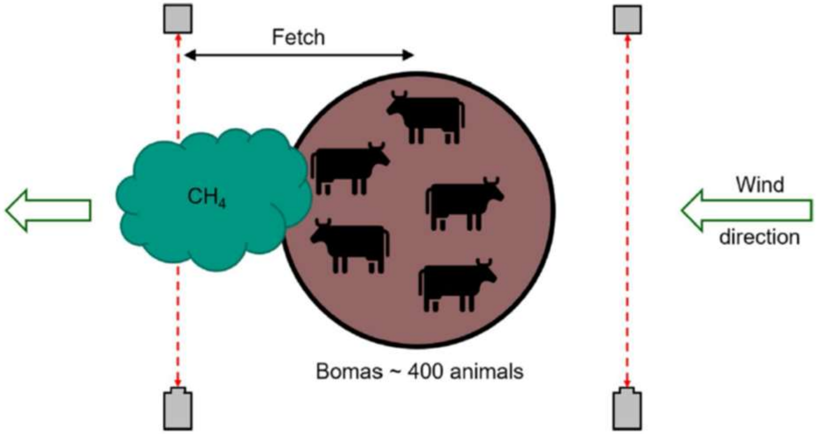


Enteric CH_4 emissions from livestock (measurements)



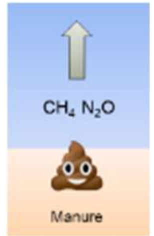
- Measurement of CH_4 emissions from cattle in bomas using open-path laser spectroscopy
- Proof-of-concept in Kapiti
- Emission factor 75 kg CH_4 head^{-1} yr^{-1}
(IPCC beef default for SSA = 41 kg CH_4 head^{-1} yr^{-1})
- Similar setups can be used elsewhere for livestock in bomas or feedlots





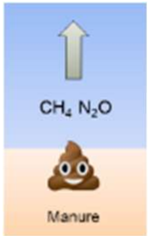
Wolz et al, Theoretical and Applied Climatology, 2021

GHG emissions from manure: bomas



- Livestock kept in bomas for protection
- ~50% of cattle manure deposited in bomas, seldom cleaned
- Measurement of boma CH_4 and N_2O emissions using static chambers in Kapiti ranch, Kenya
- Farm-scale GHG budget:

GHG emissions from manure: bomas



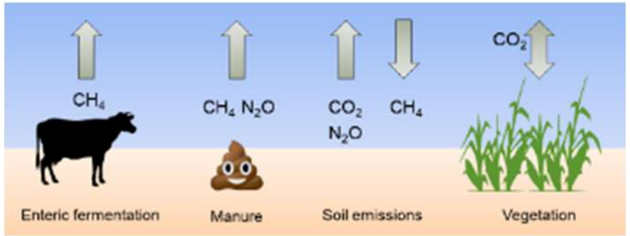
- Livestock kept in bomas for protection
- ~50% of cattle manure deposited in bomas, seldom cleaned
- Measurement of boma CH_4 and N_2O emissions using static chambers in Kapiti ranch, Kenya
-

	Methane (t CO_2eq yr^{-1})		Nitrous oxide (t CO_2eq yr^{-1})	
Grassland	4	0.0%	1906	62.8%
Enteric CH_4	8023	97.6%	-	-
Manure deposited on pasture	13	0.2%	140	4.6%
Cattle bomas	183	2.2%	990	32.6%
Total	8059	100%	289	100%

Bomas = overlooked hotspots for N_2O emissions!

Leitner et al., Agriculture, Ecosystems & Environment, 2024

Ecosystem-scale GHG measurements



Eddy tower at Kapiti Research Station

- **Ecosystem CO_2, CH_4 and H_2O exchange** in savanna
- Eddy tower "sees" incoming and outgoing C and H_2O fluxes
  → Is the ecosystem a carbon sink or carbon source?
  → Effects of climate & management?
  → Water balance, drought resistance
- **Link to vegetation activity** (photosynthetic activity, ecosystem productivity)

Odongo et al. 2025 Journal of Geophysical Research: Biogeosciences

Agroscope

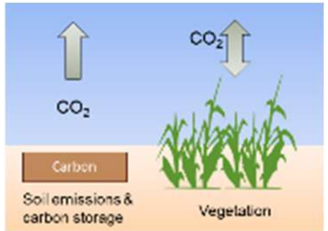
UNIVERSITÀ DEGLI STUDI DI MILANO BICOCCA

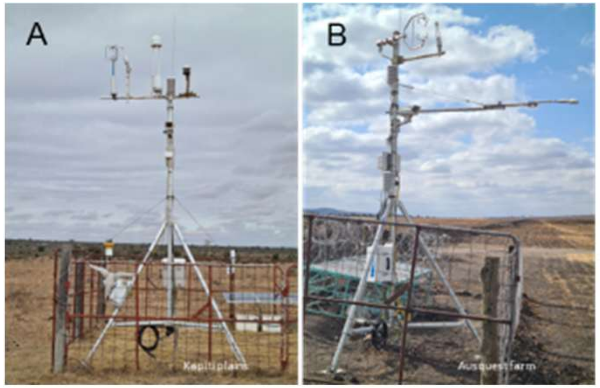
UNIVERSITÀ DEGLI STUDI DI MILANO

ILRI

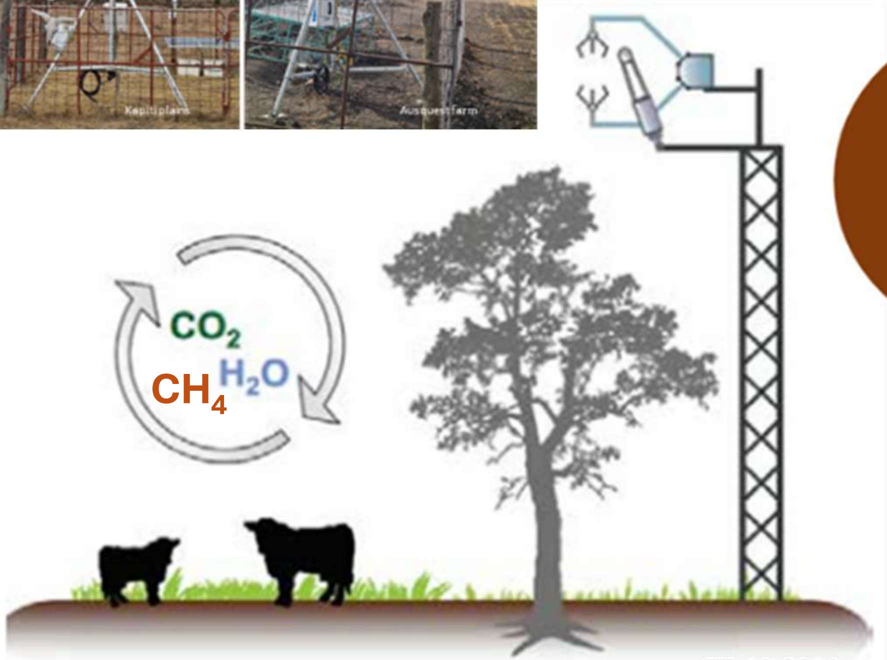
CGIAR

Rangeland carbon footprint – Ecosystem-scale GHGs





2 Eddy Covariance towers	
A	Kapiti Ranch (savanna, 2018-2020; 2022-Present)
B	Ausquest farm (precision ag., 2019; 2022-Present)



Wolf, 2010

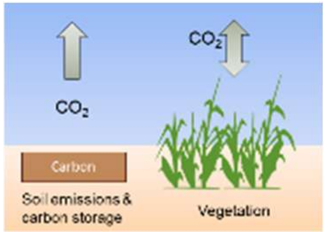
Eddy covariance system

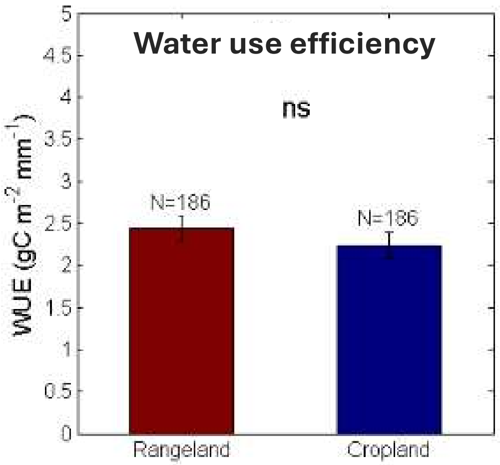
- **Ecosystem CO_2, CH_4 and H_2O exchange**
- EC tower "sees" incoming and outgoing C and H_2O fluxes
- Is the ecosystem a carbon sink or carbon source?
- Effects of climate & management?
- Water balance, drought resilience
- **Link to vegetation activity** (photosynthetic activity, ecosystem productivity)

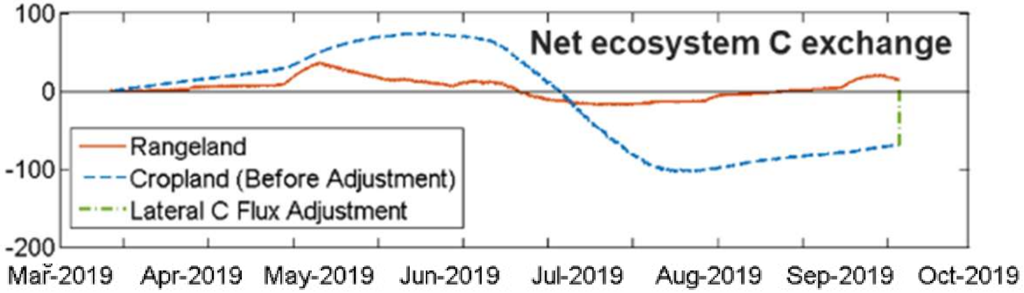
Odongo et al, submitted

Agroscope UNIVERSITY OF HELSINKI ILRI CGIAR

Ecosystem-scale GHG measurements (EC)







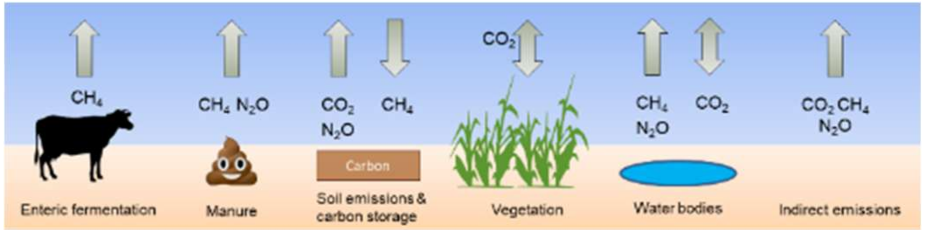
Odongo et al, submitted

Comparison of savanna and cropland CO_2 & H_2O

- **Rangeland (Kapiti)**: livestock & wildlife grazing, natural grassland vegetation
- **Cropland**: dryland agriculture, precision farming, no tillage, fertilizer & herbicide inputs
- **High carbon dynamics in cropland**
  → higher biomass productivity due to fertilizer addition
- **Similar water-use efficiency in the savanna and cropland**
  → drought tolerant vegetation & crops
- When accounting for carbon removal through crop harvest, **both systems were close to carbon neutral** over the observation period
- **Not a full GHG balance** (did not consider livestock and fertilizer emissions)!

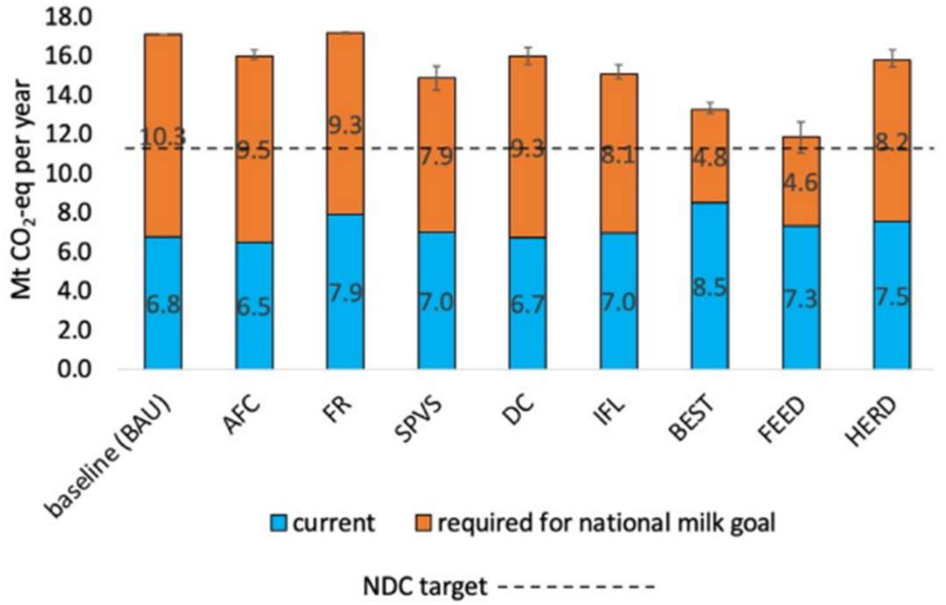
Agroscope
UNIVERSITY OF HELSINKI
ILRI
CGIAR

Intervention testing & upscaling

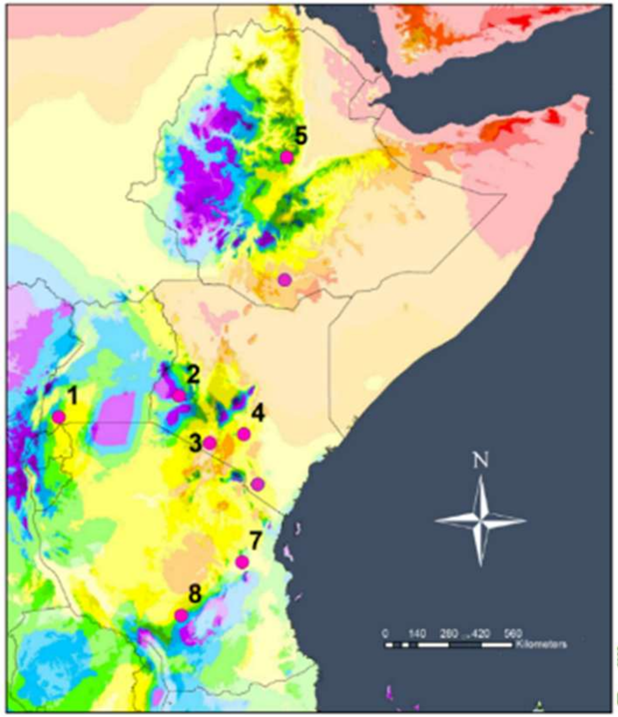


What do we do with all these data?

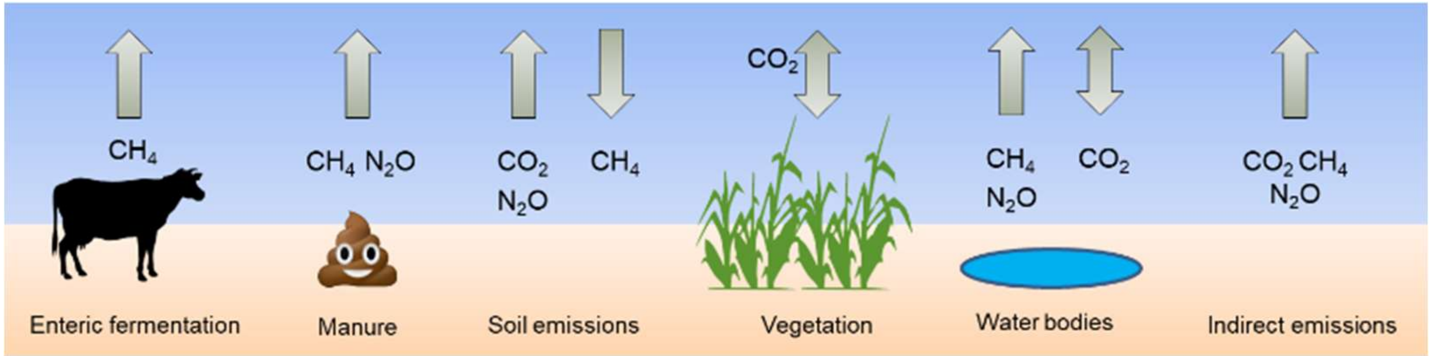
- Model effects of interventions under different scenarios
- Test potential to reduce GHG emissions and increase productivity
- Scale to areas with similar systems



Graham et al, Agricultural Systems, 2024



Summary: Mitigation & food security



- To understand **full GHG budget of rangelands**, individual emission sources (animals, soils, manure, vegetation, …) must be taken into account
- Meaningful **interventions must consider full ecosystem perspective** and be feasible for pastoralist communities
- *Goal is to find solutions for low-emissions development that **increase livestock productivity with mitigation co-benefits***

ILRI CGIAR

Better lives, better planet
through livestock

Moving to a systems perspective: landscapes and beyond

Anthony Whitbread, K. Mekonnen, M. Gebreyes, J. Hammond, M. van Wijk, N. Worou, E.J., Joseph, S. Kumar, K. Garg, A. Van Rooyen, T. Amede

rainier climate

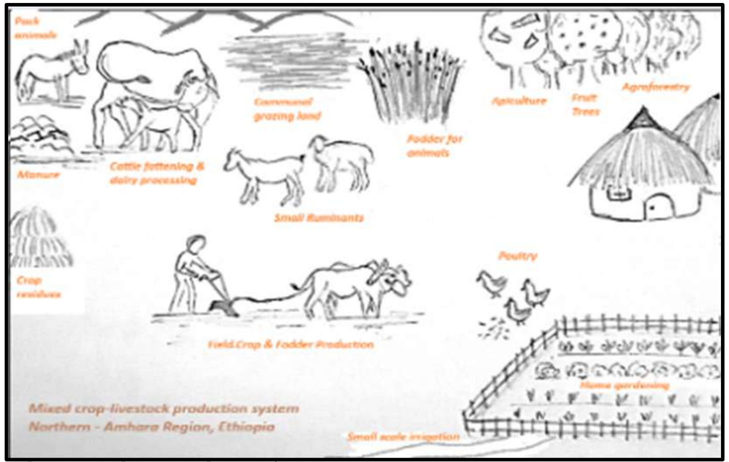
ILRI
INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

CGIAR

Better lives, better planet through livestock

Overview of the Africa RISING Project – a remarkable example of diversification and intensification as pathways to development

- Africa RISING was a multidisciplinary and integrated research USAID project that focused on the Sustainable Intensification (SI) of mixed farming systems.
- Focus areas: Climate smart development, gender integration, improved nutrition, inclusive agricultural sector growth, private sector growth, research and capacity building.
- The project used a variety of approaches to improve smallholder farming systems, including:
  - Farm systems analysis
  - on-farm research to develop and test new technologies
  - innovation platforms
  - policy advocacy
  - capacity development.



- The project reached over 455,000 beneficiaries with validated technologies
- >600 project outputs since 2012, including 51 journal articles.

Africa RISING innovations: Examples

a) Feed and forage innovations

Fodder tree

Forage grass

Herbaceous legumes /grass mixture

Feed trough

Introduced and validated different feed and forage technologies to improve livestock productivity.

Generated biophysical and socioeconomic data under on-farm environment - example

- – Biomass yields from forage crops fill feed gaps (oat/ vetch- 12 t DM ha-1; fodder beet- > 20 t DM ha-1; tree lucerne, 4-7 t DM ha-1).
- – Supplementation of oat/vetch mixture and fodder beet increased milk yield from 30–50%.
- – Feeding trough and storage shed have reduced feed wastage by 30- 50%.

b) Improved crop varieties and management practices

Introduced and evaluated over 127 improved crop varieties (cereal, pulse, oil, potato and enset varieties) through PVS and crowdsourcing approaches.

Yield increase c/w national crop yield: bread and durum wheat (52- 89%), faba bean (90%), malt and food barley (120-132%), field pea and lentil (83-111%), check pea and linseed (36-83%) and potato (171%).

C) High value fruit trees

Varieties

Introduced and validated 5 avocado and 2 apple (Anna and Princissa) varieties.

Fruiting

Avocado varieties provide fruit <2 years

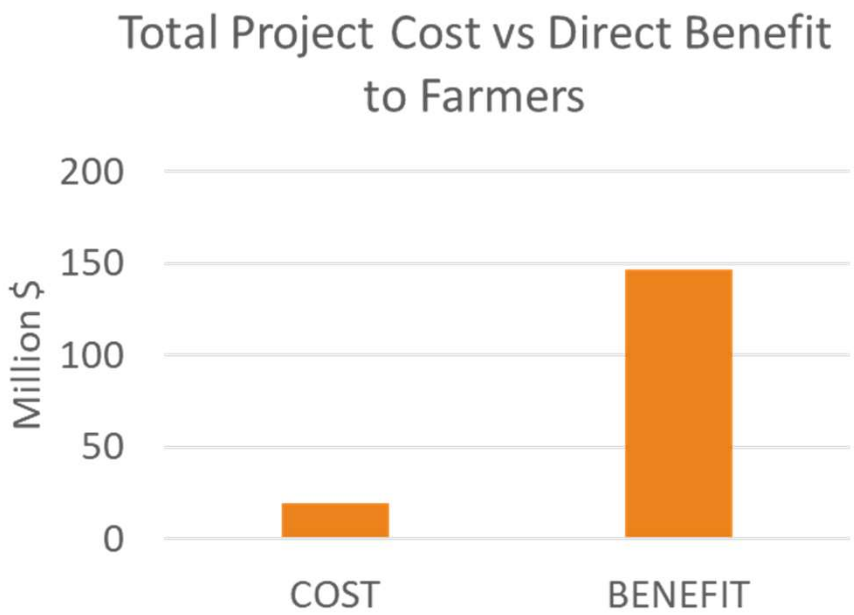
Yield

Fruit yield per avocado tree ranges from 50 kg for Ettinger to 181 kg for Nabal.

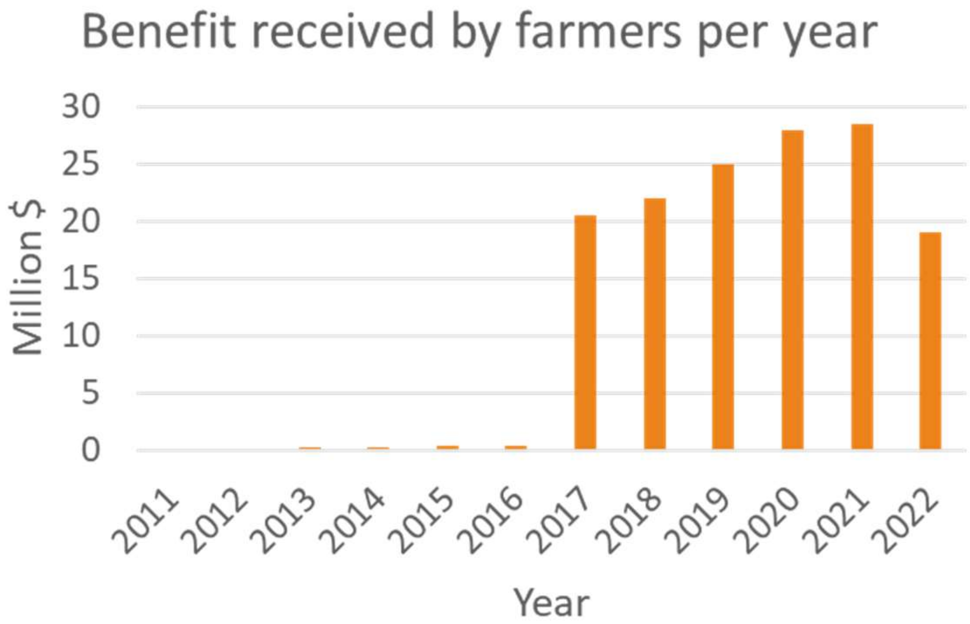
Quality Test

Quality (test, shelf life, oil content) for avocado var.: Hass > Ettinger > Fuerte > Reed > Nabal.

Financial Return on Investment – <u>cost benefit ratio of 7.8</u>



A 10-15% increase in annual household income, over the 455,000 households engaged.
Total cost $19M, direct benefit $146M
Some practices were more financially valuable (e.g. wheat), some more synergistic (e.g. feed troughs), or environmental (e.g. watershed restoration).

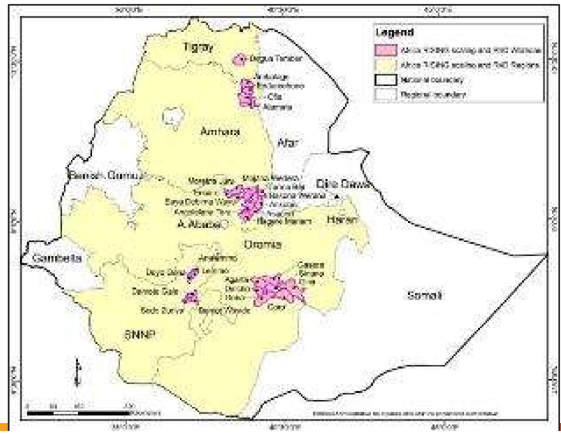


The scaling phase (post 2016) achieved the big returns in terms of impact. This underlines the importance of continuing to scale these validated technologies.

Method: The impact and adoption of promoted technologies was established using household surveys in 2018 and 2022, in reference to program records, and productivity impacts cross-checked with experimental data where available. The value of production gains was converted to USD$ in purchasing power parity (PPP) taking 2021 as the reference year. Mean increases in farm income were then extrapolated to the project and scaling kebeles according to adoption rates. No indirect or future benefits are included.

Diversification and intensification as pathways to development

1. **Markets** (esp. livestock) can drive on farm investments into technologies, inputs, management.
2. **Integration** of dual-purpose germplasm (cereals and legumes) and forages can provide multiple product options and tactical decisions.
3. **A farming systems perspective** helps to identify the potential for layered-multi-livelihood approaches which bring real systems change.
4. **Climate adaptation, livelihood resilience, circularity (incl. GHG) and nutrition** are linked and the 4x wins.
5. Scaling requires longer term layered investments by donors and governments



Conclusions

- **Soil Science** remains fundamental in building resilient livelihoods
- **Urgent transformation** of pastoral and agro-pastoral systems to address livelihood, nutrition, climate and environmental challenges.
- Shift narrative towards integrated science solutions with an **adaptation-mitigation-livelihoods** co-benefits approach.
- **Systems approaches**; multi-, trans-disciplinary work and participatory approaches are key to resilient and sustainable livelihood systems.