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Tropical Forages

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RESEARCH PROGRAM ON Livestock

The role of science in developing low emitting livestock systems

Regional Awareness-Raising Workshop on Low Emissions Livestock: Supporting Policy Through Science in Southern Africa
24th July 2019 Pretoria, SA

An Notenbaert

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The importance of livestock

For PEOPLE

- Employment, income
- Economy
- Food and nutrition
- Cultural value
- Resilience and risk management

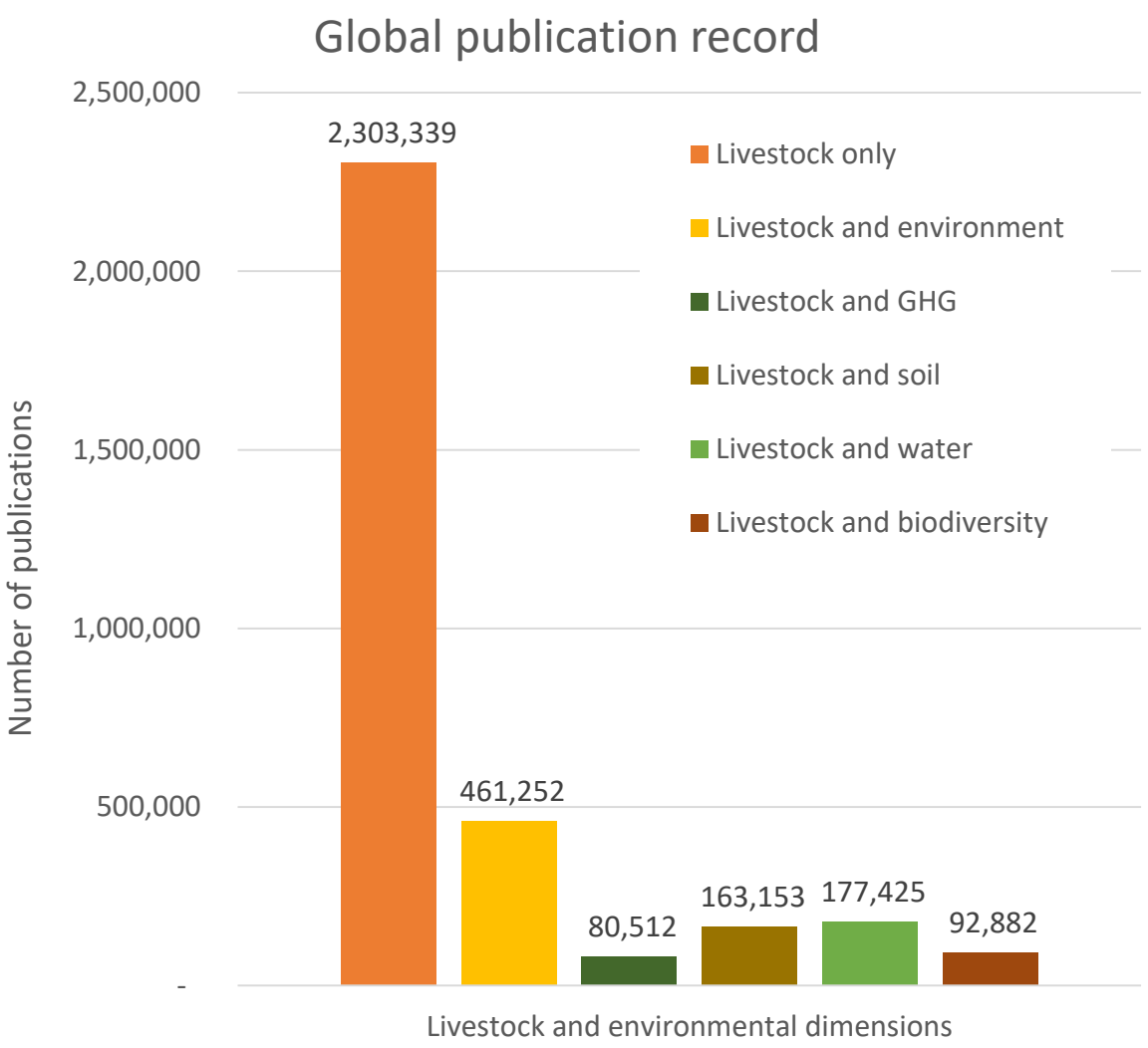
And the PLANET

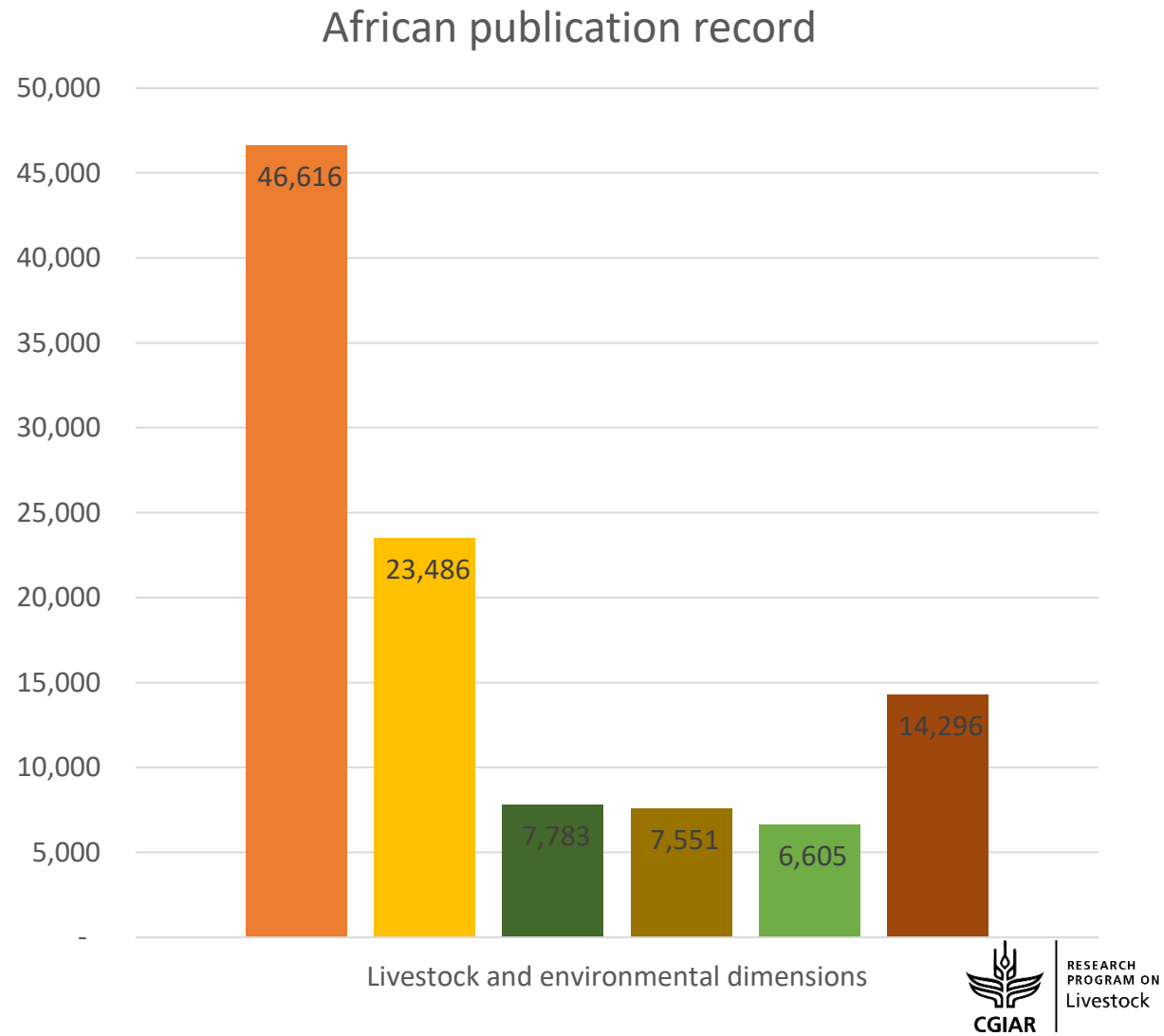
- Biggest land user
- Natural resources:
  - Manure, carbon in the soil, energy…
  - GHGe, water use/pollution, degradation,…

OECD narratives mostly negative
Not much evidence from Low-Middle Income Countries

Sustainability is a big issue and needs to be managed

Current livestock and environment research





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The aim of R&D at the livestock-environment nexus

Optimize the environmental footprint

i.e.

↑ “Goods” & “Bads“ ↓

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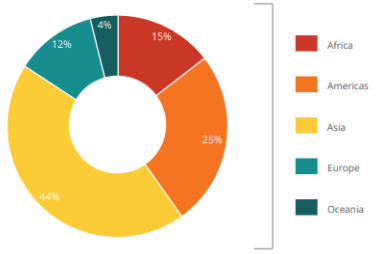
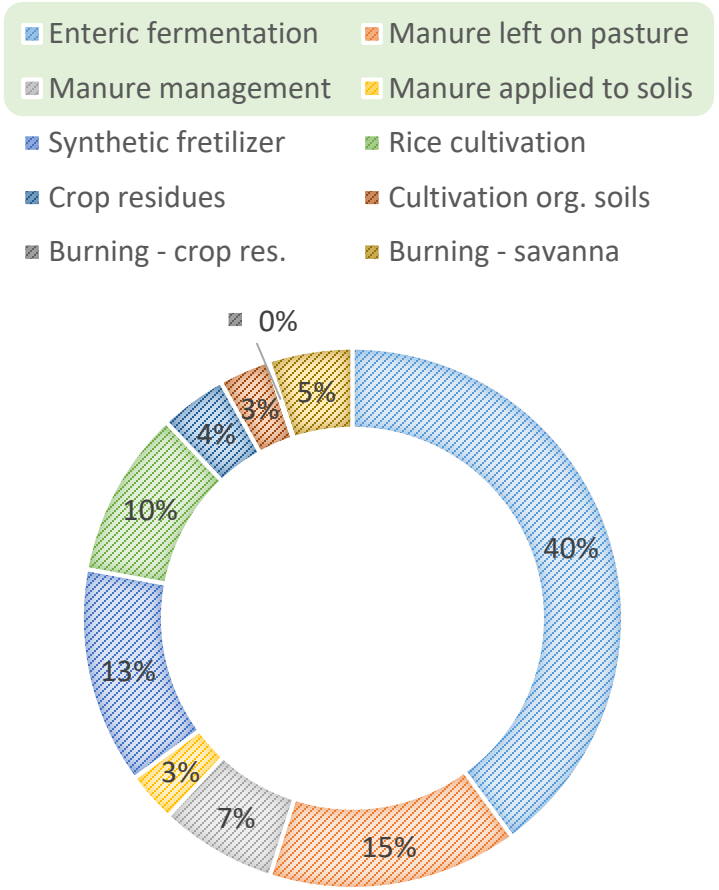
Zooming in on GHG emissions

Investing in LIVESTOCK offers big potential gains

(for people and the planet)

Agricultural GHG emissions





FAO, Tubiello et al. 2014

Current knowledge (Tier 1):

- Agriculture: 30% of anthropogenic GHG emissions in SSA
- about 70% of agricultural GHGs from livestock
- 25% of emissions in livestock sector are from manure

Paris Climate Agreement

- (Nationally Determined Contributions - NDCs)
- Tier 2 data: locally derived evidence
- Interventions to mitigate GHG emissions

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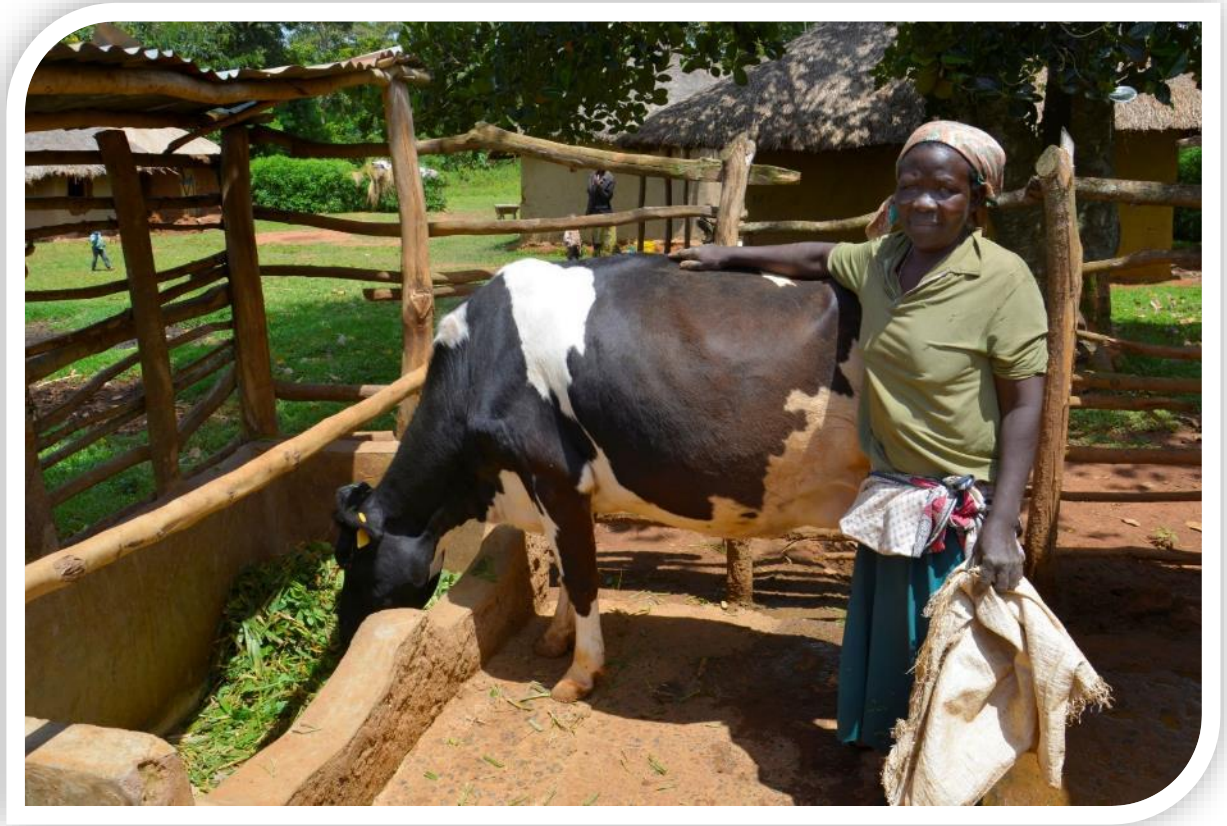
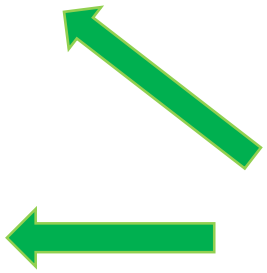
Low emissions livestock

- The global livestock sector contributes a significant share to anthropogenic GHG emissions.
- But it can also deliver a significant share of the necessary mitigation effort.



- **Low emissions livestock development offers countries an opportunity to achieve economic gains at the same time as responding to climate change.**

- Sustainable production to be complemented by Adaptation measures and Sustainable Consumption patterns.



SCIENCE

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CSA Priority Setting

Climate Smartness

Suitably Increase **Productivity**
Increase **Resilience** and **Adapt** to Climate Change
Climate **Mitigation** and **Low-Carbon** Development

What

Outcome Indicators

Impact on GDP, Employment
Contribution to SDGs, INDCs, LDN, CBD, among others

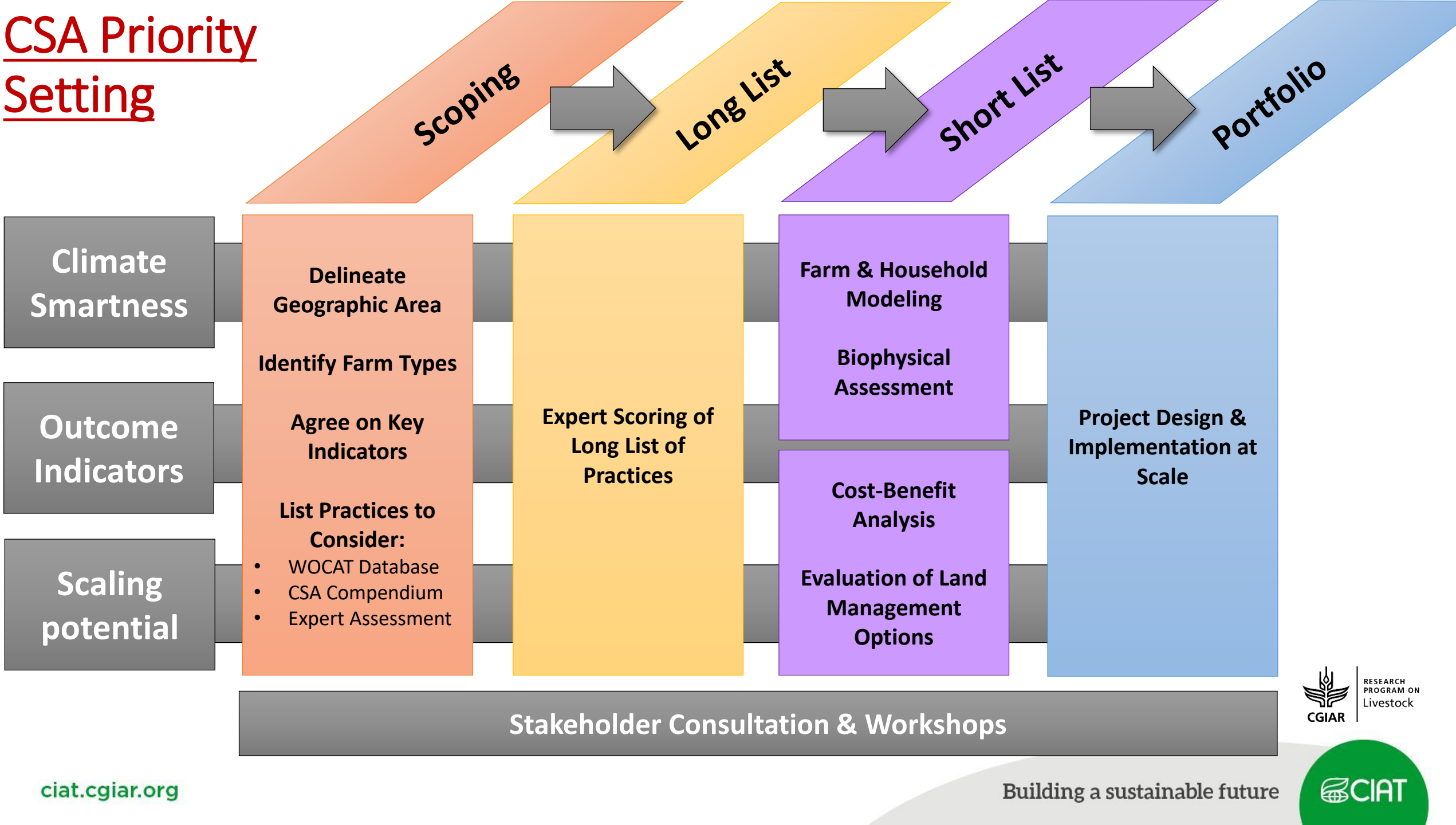
Why

Scaling potential

Adoption – Behavior and Economics
Delivery – Extension, Markets, ICTs, etc.
Sustainability – Maintenance of TIMP adoption & delivery

How

CSA Priority Setting



Research for evidence-based decision making - at farm and policy level

1. Function – support:

- ✓ Program and policy design
- ✓ Implementation
- ✓ Monitoring and Learning

2. Challenges

- ✘ Lack of reliable data: animal numbers, breeds, feed resources, management practices, context-specific emission factors…
- ✘ Low adoption and uptake: awareness, buy-in; relevant, timely and actionable information; human and financial capacity
- ✘ Long-term investment

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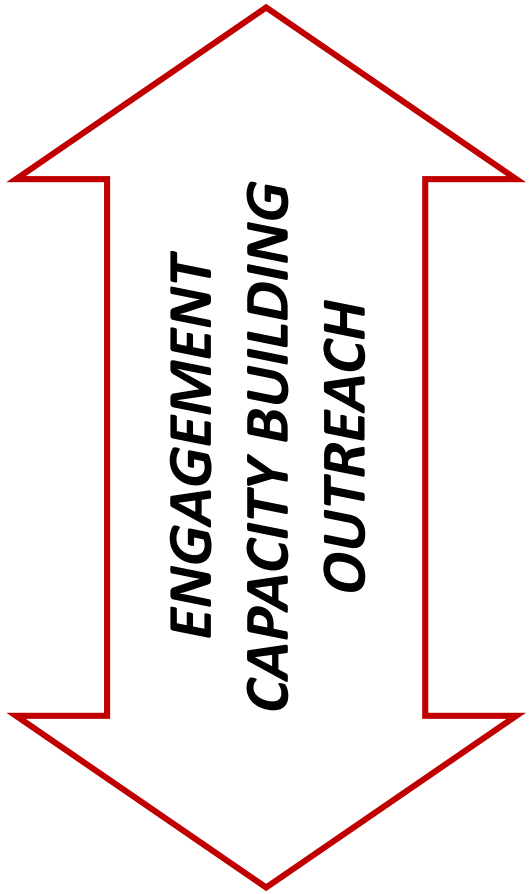
Research for evidence-based decision making - at farm and policy level

1. Improved ***foresight and assessments***
   a) 2-way CC-livestock interactions
   b) based on site-specific data
2. Identify ***solutions*** and provide stakeholders with knowledge and incentives to implement solutions
3. Foster an ***enabling*** policy and institutional environment



== Targeting & prioritising, supporting & monitoring ==

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Pillar 1: Assessments

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Impacts of CC on Livestock

Hazards/stresses:

- Δ CO2, temperature, precipitation
- Variability and extreme events

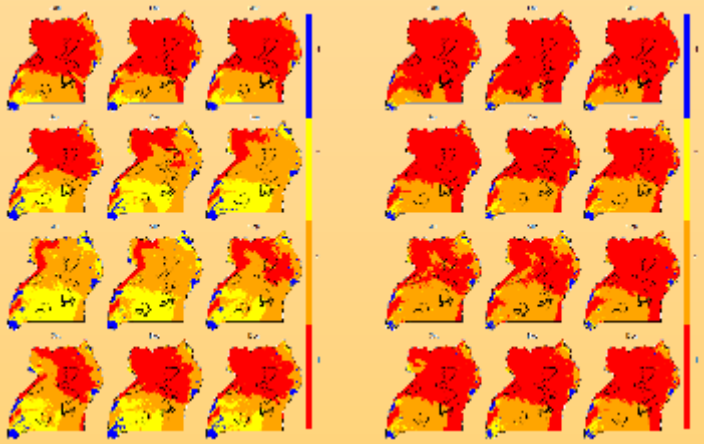
Direct impact

- Heat stress

Indirect impact

- Water
- Diseases
- Biodiversity, Soil
- Feed and forages
- Livelihoods and systems

Heat stress change – 2010-2035:



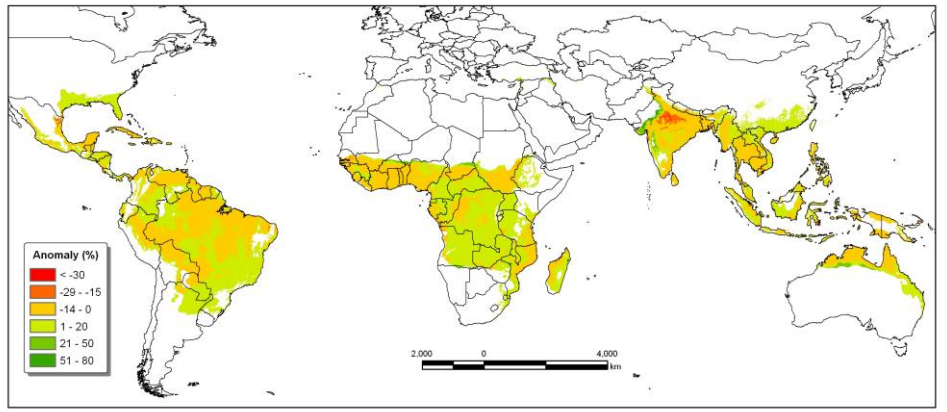
Heat stress is to likely increase in the future, with negative impacts (livelihoods and economy)

→ Quantification? Incl. knock-on effect on GHGe

→ How to adapt?

Suitability change – 2000-2020 (A2):

Brachiaria brizantha (Signal grass)

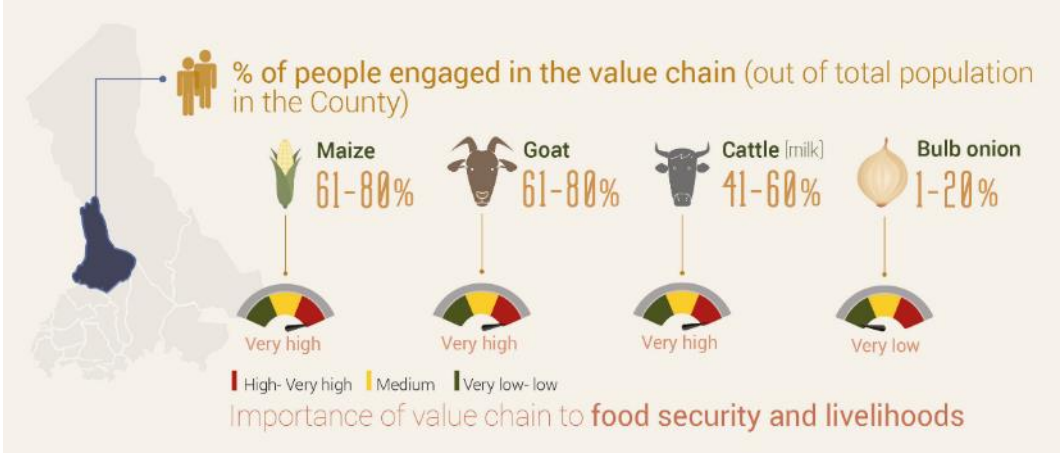


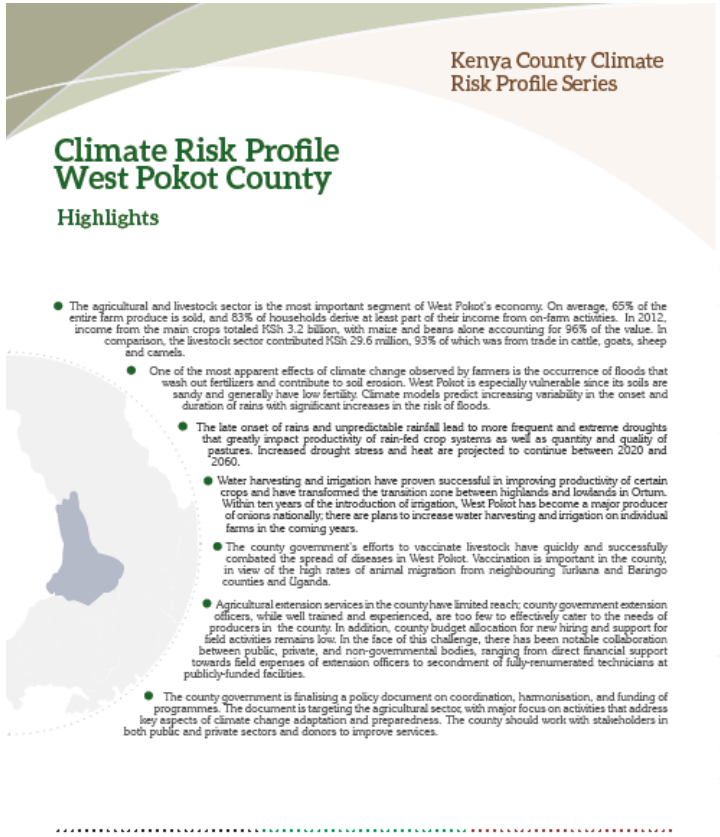
- "no-regret" forage choices
- Breeding for future conditions

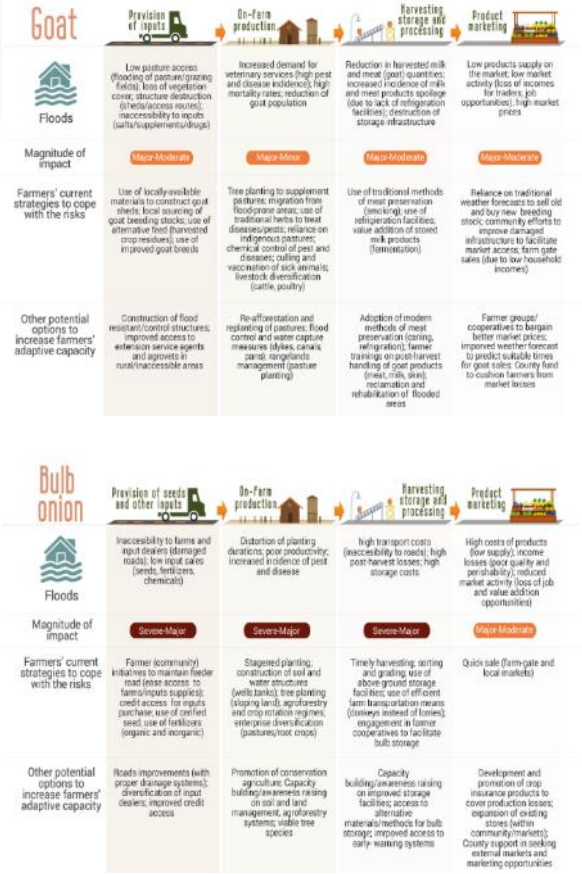
Ecocrop modeling (Hymann et al.)

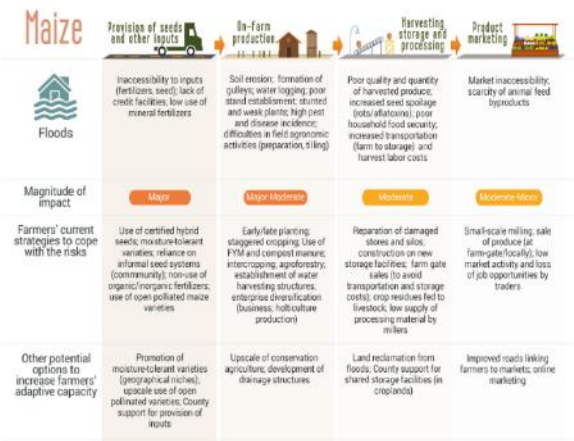
County Climate Risk Profiles:

- Four Key Value Chains in each County
- Key Risks and Adaptation Options Identified









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Impacts of Livestock on CC / GHG emissions

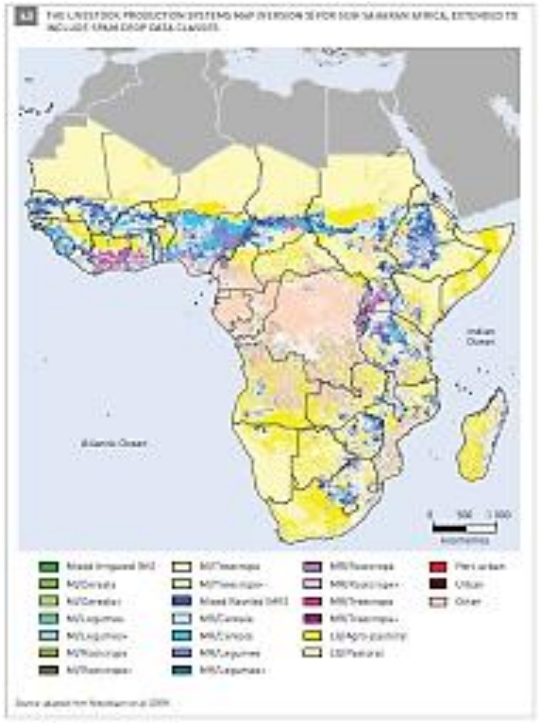
Ecocrop modeling (Hymann et al.)

GHG emissions in the developing

Spatial Targeting Agricultural Intensification Investments

Herrero et al., 2013

Livestock production systems



GIS

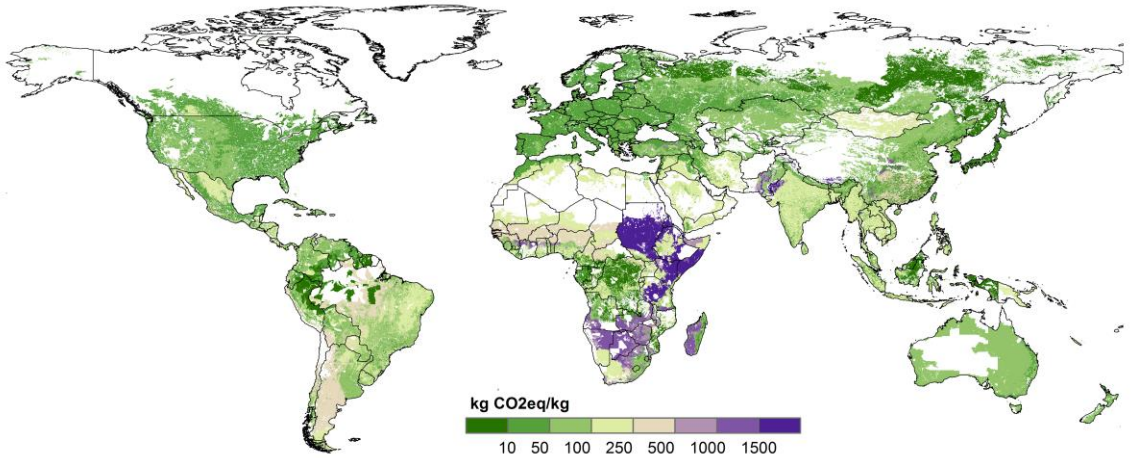
HH surveys / Expert opinion

Animal numbers

Animal characteristics
Feed baskets

Process-based modeling

Estimates of:
- Livestock productivity/production
- GHG emissions



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SSA-specific emission factors

- Tier 2 estimates of ruminant Emission Factors
- Difference due to assumptions about energy intake
  - Feed shortage/ seasonal LW loss
  - Caution: only one location
- Countries in stronger position for climate finance

Report	Region	Males	Females	Calves
		kg CH_4 yr^{-1}		
IPCC	Africa	49	41	17.3
Goopy et al. (2017)	Nyando, Kenya	34.4	24.6	16

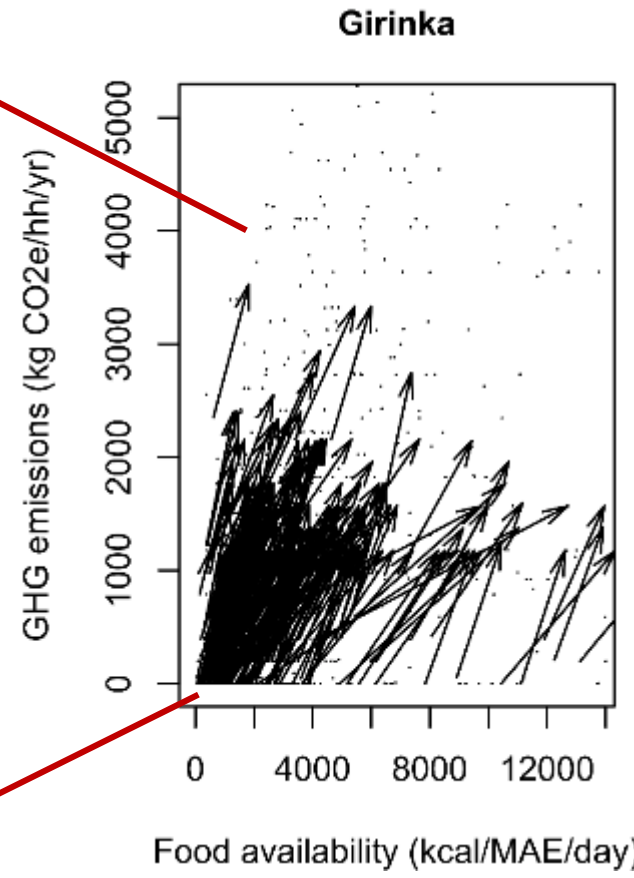
IPCC approach

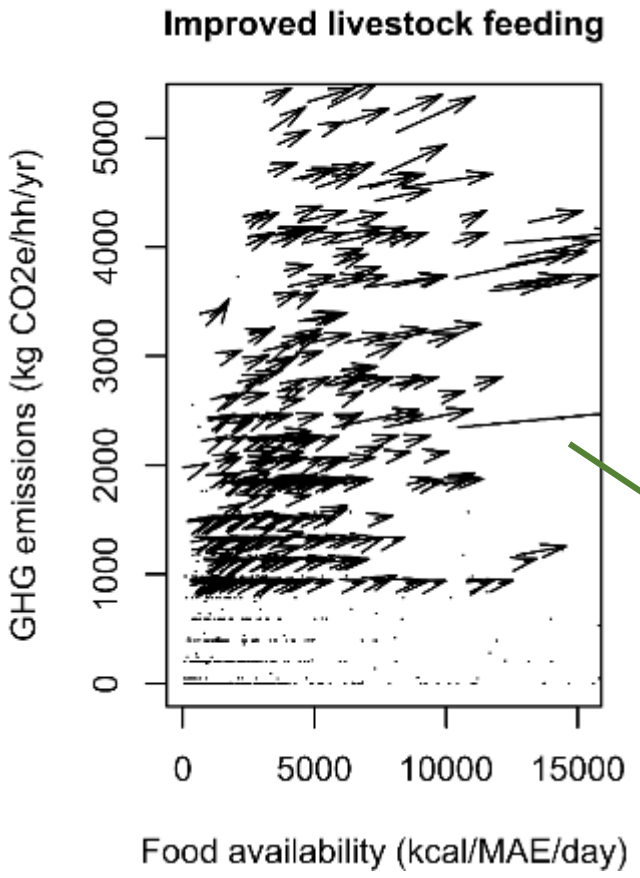
CH_4 = Energy intake* Y_m ("methane conversion factor")

Potential impacts of livestock policies in Rwanda

GHG vs. food security trade-offs

GHGe increase





Pro-poor

Only small GHG increase

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B.K. Paul, et al. 2018. Potential impact of crop and livestock intensification policies on household food availability and greenhouse gas emissions in different agro-ecological regions of Rwanda. Agricultural Systems. doi: 10.1016/j.agsy.2017.02.007

Impact of livestock on CC: *Ex-ante* environmental assessments (CLEANED)

-> Potential impact of intervention packages in different livestock production systems in the dairy VC of Tanga, Tanzania

		Productivity		Land requirements		Water use			GHG emissions		
		Total supply (FPCM)	Productivity (FPCM/ha)	Land used (ha)	Land used per product (ha/MT FPCM)	Total water use (m3)	Water use per area (m3/ha)	Water use per product (m3/MT FPCM)	Total emissions (kg CO2-eq)	Emissions per area (kg CO2-eq/ha)	Emissions per product (kg CO2-eq/MT FPCM)
Mixed crop-livestock enterprise	Baseline	*1,157*	*525*	*2.2*	*1.9*	*1,234*	*560*	*1.1*	*2,647*	*1,202*	*3.7*
	Genetics		-	-	-	-		-	-		-
	Feed	+++	+	---	+	---		+	---	-	++
	Health	+++	+	---	+	---		+	---		+
	Combined	+++	++	---	++	---		++	---	-	++
Agro-pastoral enterprise	Baseline	*10,862*	*195*	*55.7*	*5.1*	*28,570*	*513*	*2.6*	*36,271*	*652*	*7.7*
	Genetics	++	+++	++	++	++		++	+	-	++
	Feed	++	+++	++	+++	++	-	+++	--	---	+++
	Health	++	+++	++	+++	++	-	+++	--	---	+++
	Combined	+++	+++	-	++	-		++	--	-	+++
Tanga VC	Baseline	*135,372,101*	*235*	*576,462*	*4.3*	*299,119,461*	*519*	*2.2*	*413,748,868*	*718*	*6.6*
	Genetics		+		+			+			+
	Feed	++	+++	++	++	+		++		--	++
	Health	+++	+++	++	+++	+	-	+++	---	---	++
	Combined	+++	+++	+	+++		-	++	---	---	++

---: negative change of more than 50%, --: negative change of 20-50%, -: negative change of 5-20%, +: positive change of 5-20%, ++: positive change of 20-50%, +++: positive change of more than 50%

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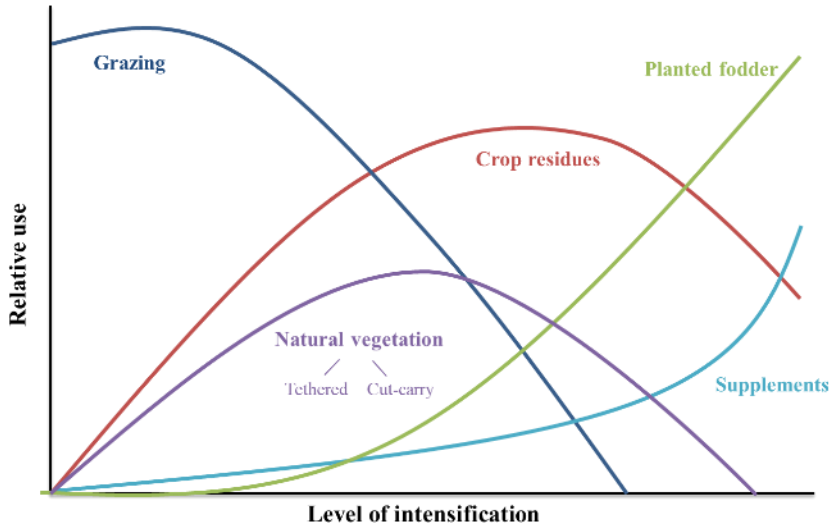
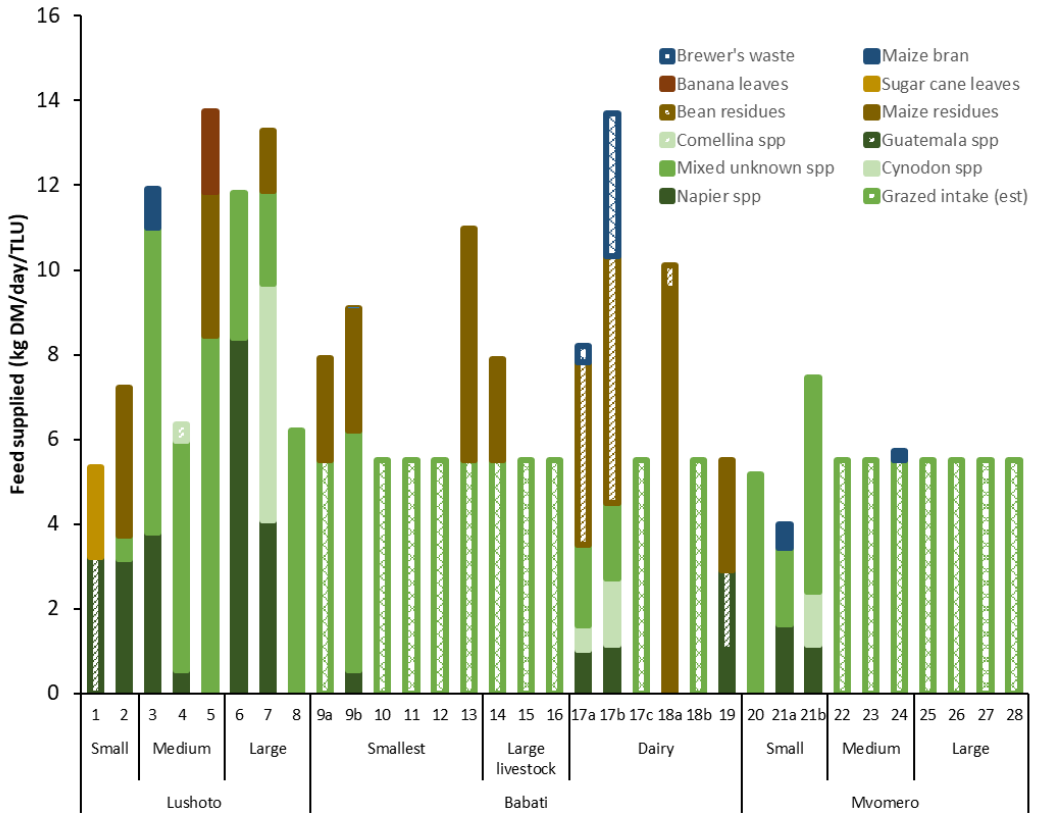
Notenbaert, An; Mukiri, Jessica; Van der Hoek, Rein; Paul, Birthe; Koge, Jessica; Birnholz, Celine, 2019, "CLEANED X - Version 2.0.1", https://doi.org/10.7910/DVN/G0G8IY, Harvard Dataverse, V1

CLEANED X: minimum-data environmental ex-ante assessment tool

Core of the model: feed basket descriptions (dry and wet season)





Triangulation between PGIS info, survey data and expert opinion

→ Large uncertainty!

Therefore: more detailed feed baskets being measured

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Pillar 2: Technologies

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Different options

Technical interventions

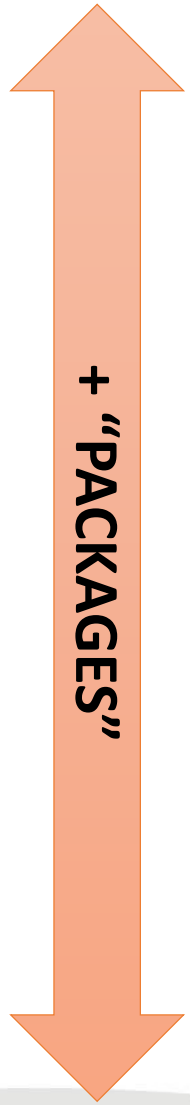
- Genetic improvement (productivity, heat-tolerance, disease-resistance, …)
- Animal health
- Feeds and forages:
  - Improved forages, conservation, fodder banks, supplementation, land restoration, re-seeding of pastures

Changes at system or landscape level

- Diversification
- Shifts in species and/or production systems
- Landuse planning and sustainable land mngt. (biodiversity, water, soils, …)
- Protection of ecosystems services (incl. carbon sequestration!)

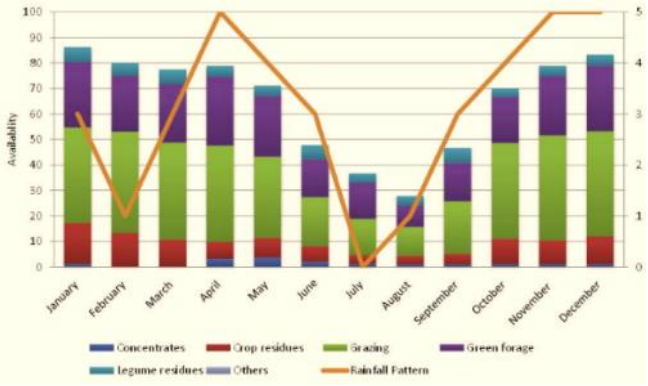
Institutional and policy options

- Markets and Trade
- Early warning, contingency planning, insurance, …
- Climate finance mechanisms, PES, …



The example of feeds and forages – a true triple win

- Current potential of mixed crop-livestock systems in e.g. SSA remains largely underexploited

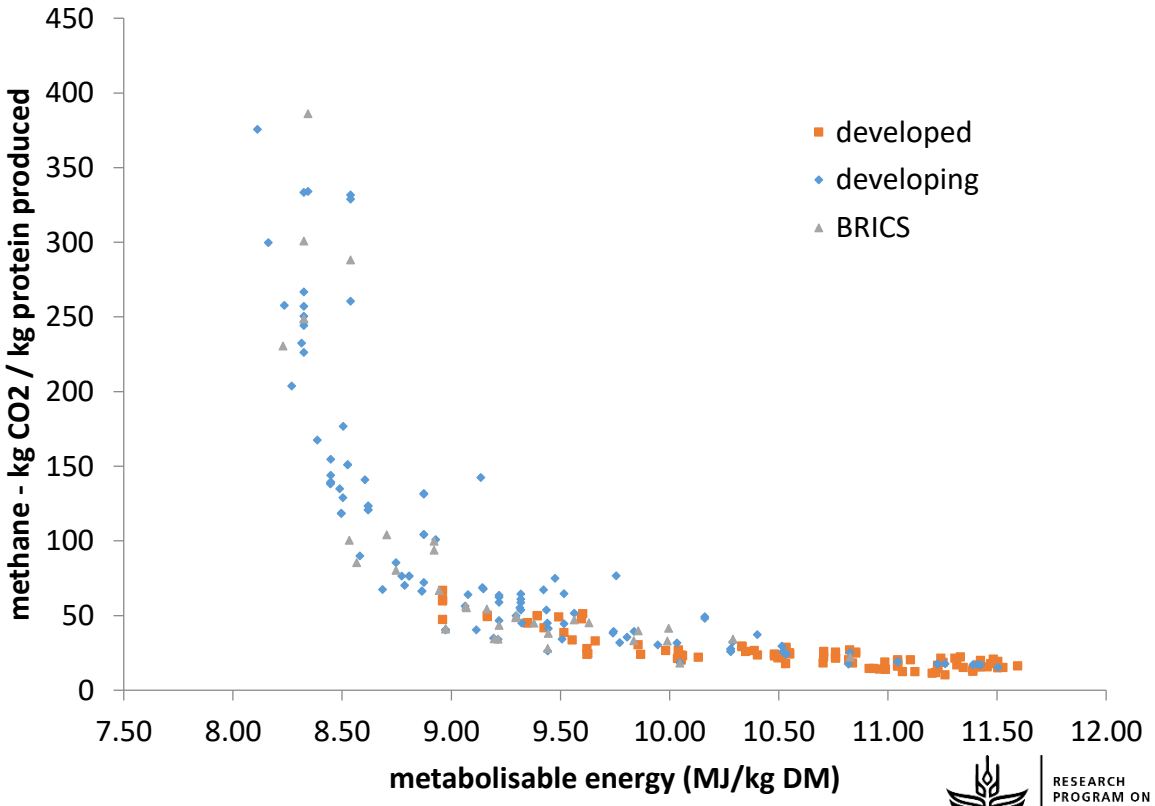


Main production constraint: sufficient quantity and quality of feeds all year round *(Maass et al, 2013)*

Program level (all countries, includes research cost)												
NPV Scenario Heatmap (USD $,000), Total Surplus basis												
		Increase in productivity										
		5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%
Adoption rate	5%	-3,169	4,837	12,848	20,864	28,885	36,911	44,942	52,979	61,021	69,067	77,119	85,177
	10%	4,837	20,864	36,911	52,979	69,067	85,177	101,306	117,457	133,628	149,820	166,032	182,265
	15%	12,848	36,911	61,021	85,177	109,379	133,628	157,923	182,265	206,653	231,088	255,569	280,096
	20%	20,864	52,979	85,177	117,457	149,820	182,265	214,793	247,403	280,096	312,871	345,729	378,669
	25%	28,885	69,067	109,379	149,820	190,389	231,088	271,915	312,871	353,956	395,170	436,513	477,985
	30%	36,911	85,177	133,628	182,265	231,088	280,096	329,290	378,669	428,234	477,985	527,922	578,044
	35%	44,942	101,306	157,923	214,793	271,915	329,290	386,917	444,797	502,930	561,316	619,954	678,845
	40%	52,979	117,457	182,265	247,403	312,871	378,669	444,797	511,255	578,044	645,162	712,610	780,388
	45%	61,021	133,628	206,653	280,096	353,956	428,234	502,930	578,044	653,575	729,523	805,890	882,674
	50%	69,067	149,820	231,088	312,871	395,170	477,985	561,316	645,162	729,523	814,401	899,794	985,702
	55%	77,119	166,032	255,569	345,729	436,513	527,922	619,954	712,610	805,890	899,794	994,322	1,089,474
	60%	85,177	182,265	280,096	378,669	477,985	578,044	678,845	780,388	882,674	985,702	1,089,474	1,193,987
	65%	93,239	198,519	304,670	411,692	519,586	628,351	737,988	848,496	959,876	1,072,127	1,185,249	1,299,243
	70%	101,306	214,793	329,290	444,797	561,316	678,845	797,384	916,934	1,037,495	1,159,067	1,281,649	1,405,242
	75%	109,379	231,088	353,956	477,985	603,174	729,523	857,033	985,702	1,115,532	1,246,522	1,378,672	1,511,983
	80%	117,457	247,403	378,669	511,255	645,162	780,388	916,934	1,054,801	1,193,987	1,334,493	1,476,320	1,619,466
	85%	125,540	263,739	403,429	544,608	687,278	831,438	977,088	1,124,229	1,272,859	1,422,980	1,574,591	1,727,693
	90%	133,628	280,096	428,234	578,044	729,523	882,674	1,037,495	1,193,987	1,352,150	1,511,983	1,673,487	1,836,661
	95%	141,721	296,473	453,087	611,561	771,898	934,095	1,098,155	1,264,075	1,431,857	1,601,501	1,773,006	1,946,373
	100%	149,820	312,871	477,985	645,162	814,401	985,702	1,159,067	1,334,493	1,511,983	1,691,535	1,873,149	2,056,826

Gonzalez et al, 2016

- Improved feeding offers the potential to improve productivity & reduce GHG emissions



Herrero et al, 2012

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Brachiaria example – improved livestock productivity

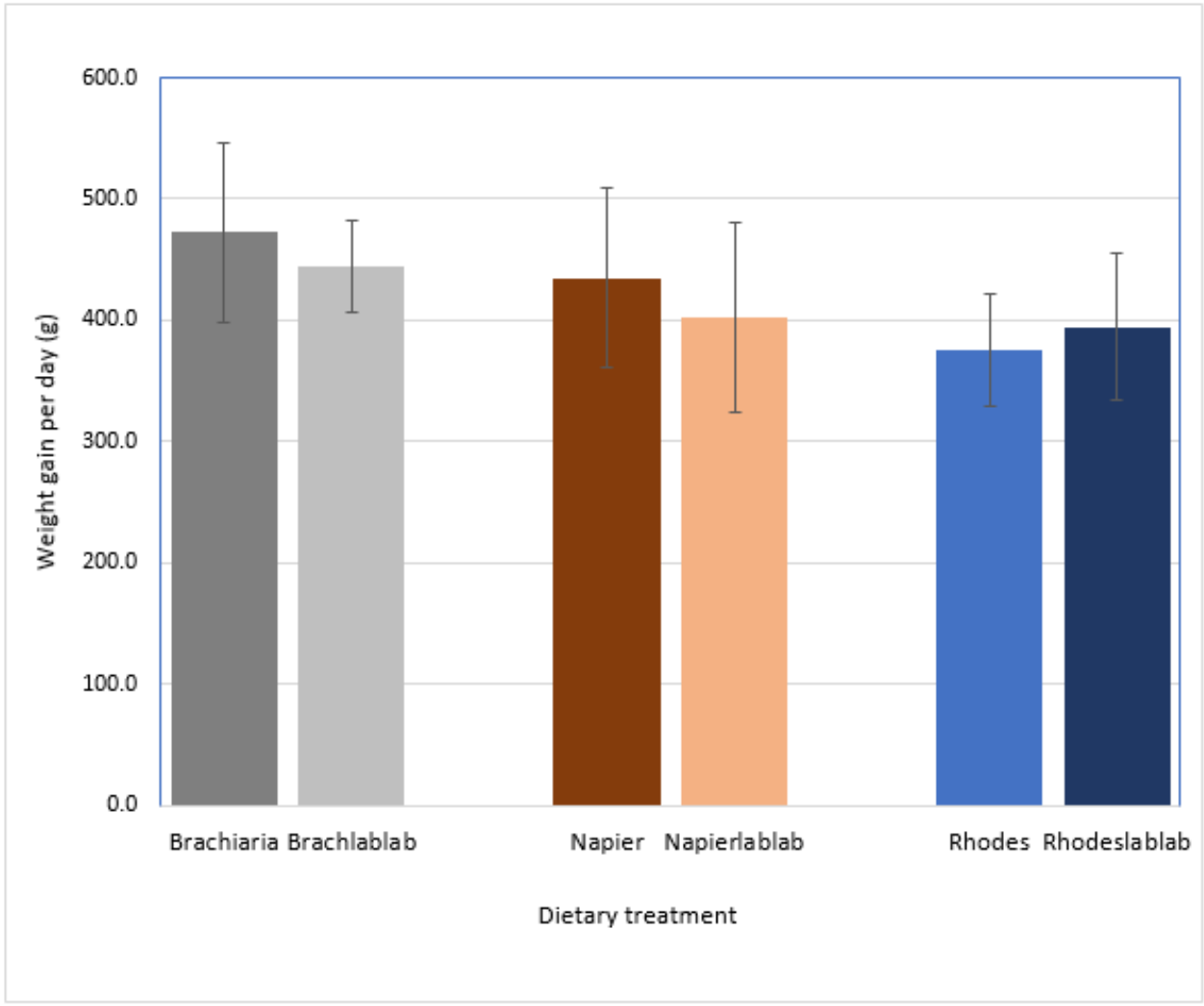

Figure 1: Average daily weight gain (g) of growing Boran steers fed on Brachiaria, Napier and Rhodes grass grown either alone or intercropped with *Dolichos lablab* over a 65-day feeding period.

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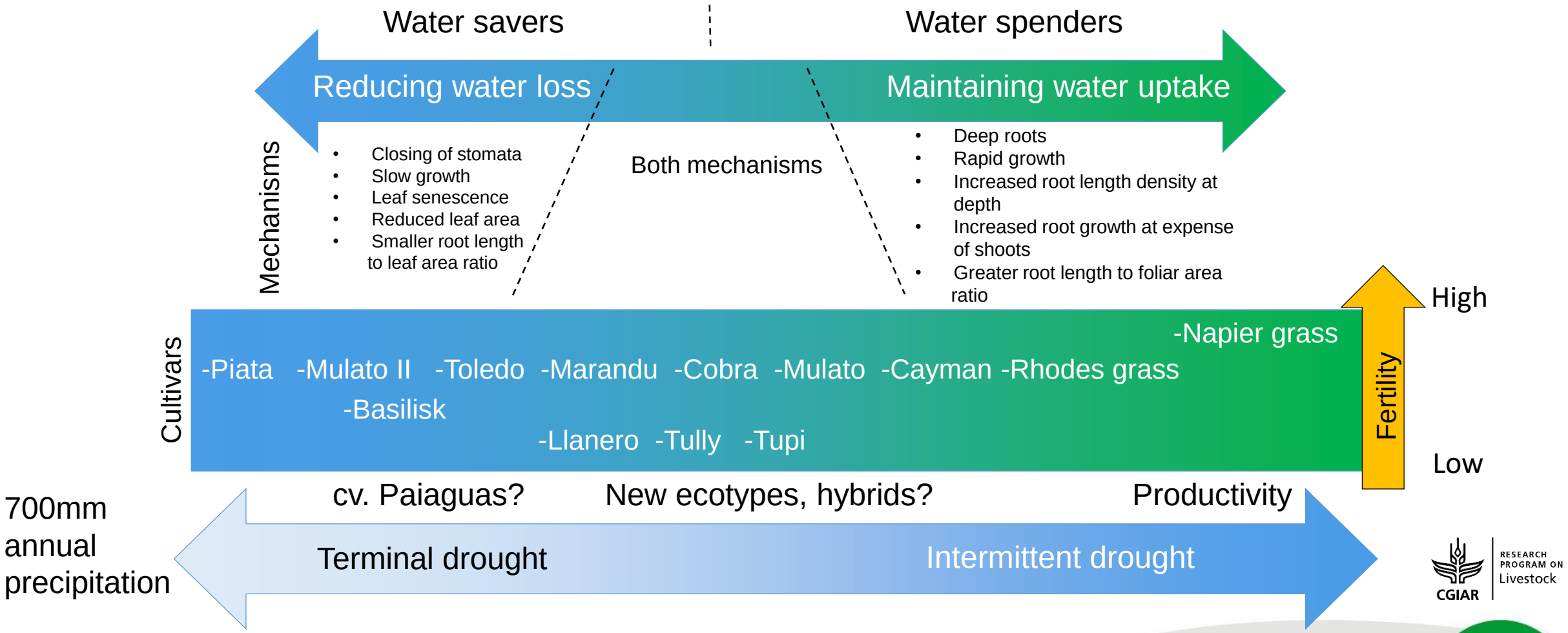
Brachiaria grasses adapted to drought and low fertility

Targeting of *Brachiaria* grasses to areas with different patterns of drought



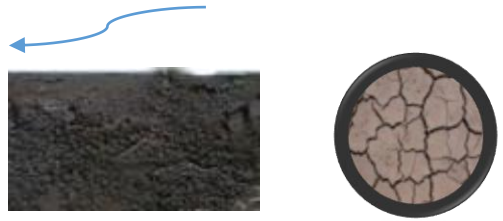
Contribution of *Brachiaria* grasses to soil quality improvement

Improving soil aggregation

- Soil aggregates are groups of soil particles that bind to each other more strongly than to adjacent particles.
- Aggregate stability refers to the ability of soil aggregates to resist disintegration when disruptive forces associated with tillage and water or wind erosion are applied.
- Aggregate stability (e.g., MWD) is an indicator of organic matter content, biological activity, and nutrient cycling in soil.
- Increase of mean aggregate size under *Brachiaria* grasses relative to bare soil (>2 years)

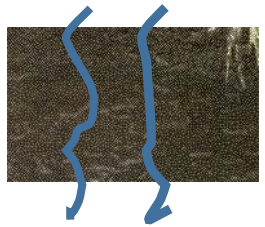
	Mean weight diameter (mm)	
	Greenhouse	Palmira
Bare soil	150	109
Napier	227	134
Rhodes	287	133
Brachiaria grasses		
Basilisk	316	128
Tully	354	125
Llanero	349	118
Tupi	378	127
Marandu	277	134
Toledo	279	138
Piata	260	136
Mulato	309	125
Mulato II	290	137
Caymán	319	131
Mean	304	131
LSD	20	15

runoff



Soil crusts after aggregates break down

Infiltration



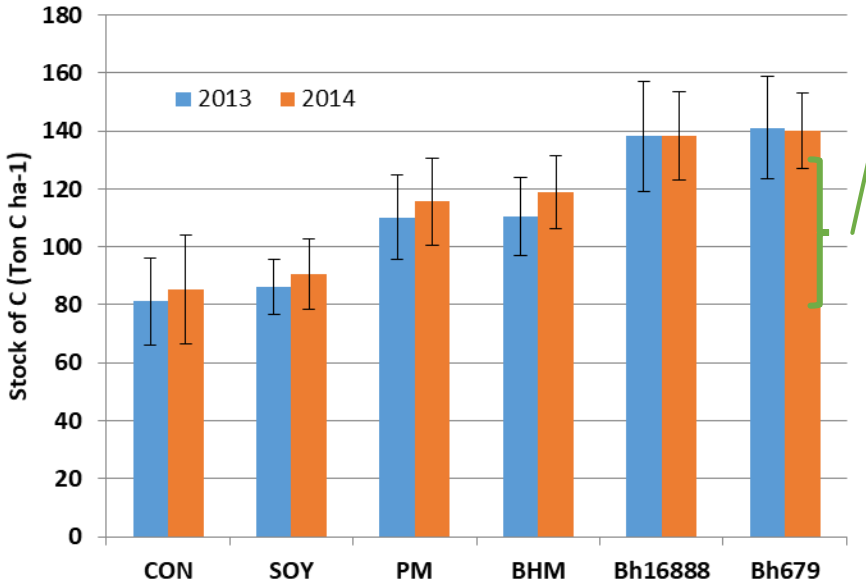
Aggregated soil

RESEARCH PROGRAM ON Livestock

Contribution of *Brachiaria* grasses to soil carbon accumulation

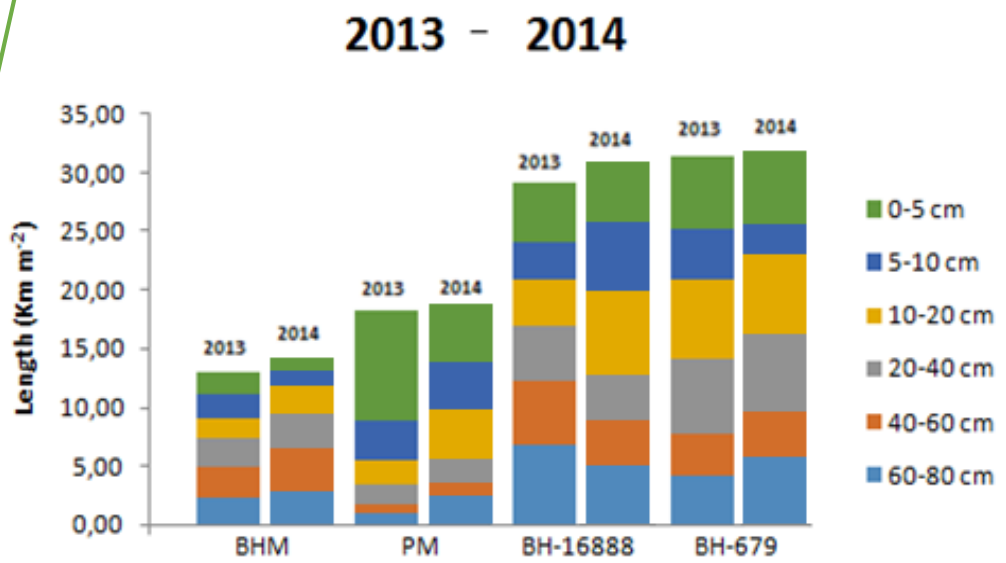
Soil carbon sequestration – LAC – 10 years old experiment

Soil carbon stocks



6 Ton C/ha/year

Root length



80cm depth

CON: Bare soil, PM: *P. maximum,* BHM: *Brachiaria* Mulato hybrid, BH:679: *B. humidicola* 679 and BH-16888: *B. humidicola* 16888

CGIAR RESEARCH PROGRAM ON Livestock

Contribution of *Brachiaria* grasses to soil carbon accumulation

Soil organic carbon (SOC) – East Africa

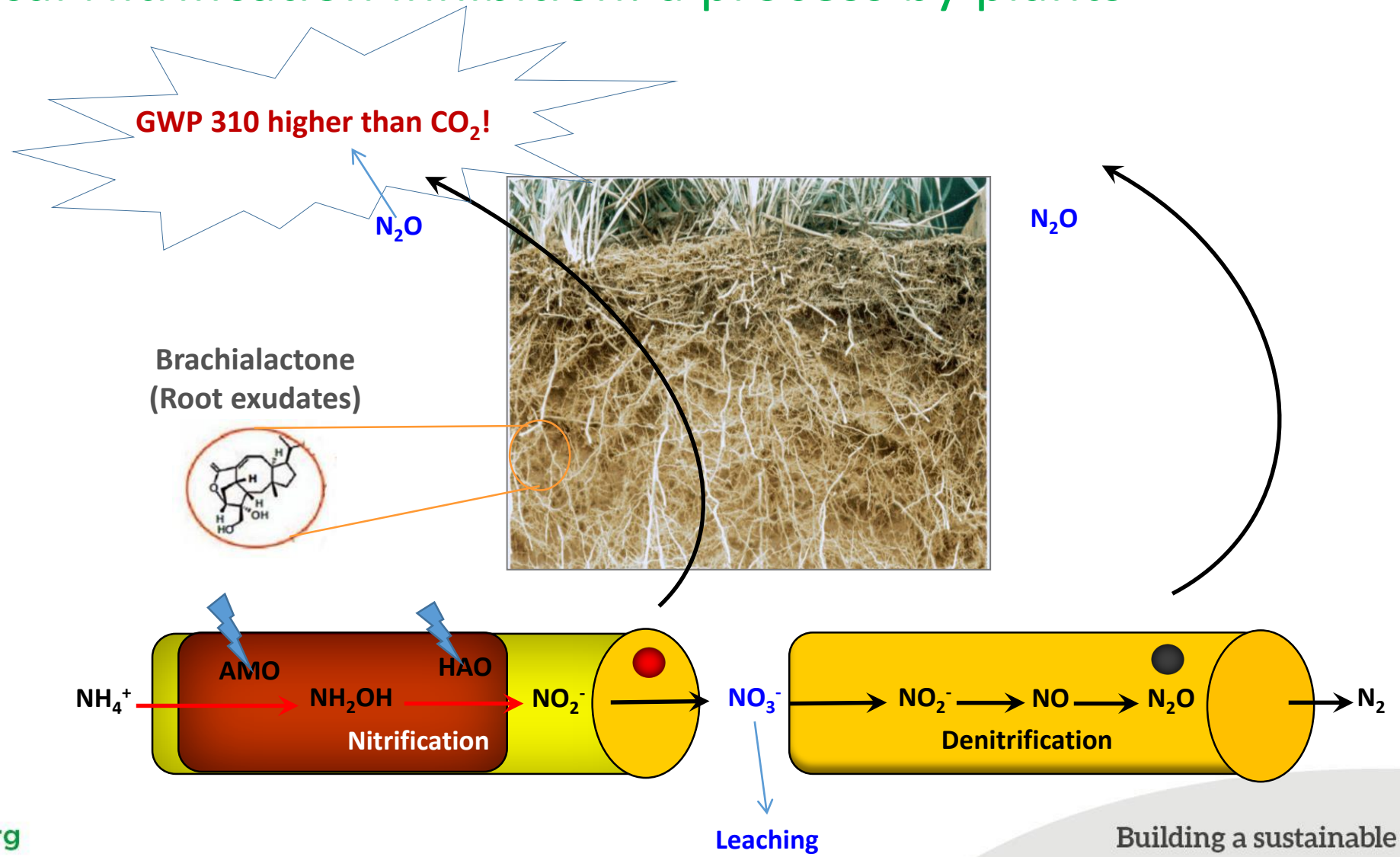
	SOC (g/kg)						
	Greenhouse study (2.5years)	Rwanda (2.5 year)		Kenya (1 year)			ILRI campus (2.5 years)
	Santander de Quilichao	Karama Research station	On farm	Katumani			ILRI campus
				+P	+N	No fertilizer	
Bare soil	20	29	24	26	28	24	22
Napier	21	30	23	27	29	26	22
Rhodes	22						
Basilisk	24	28	24	26	28	25	23
Tully	26	33		25	30	24	23
Llanero	26	34					
Tupi	26						
Marandu	23	28	23	28	28	26	24
Toledo	25	28	23	28	28	28	24
Piata	22	32	26	29	31	28	24
Mulato	24	28	23	27	28	26	
Mulato II	21	25	25	25	25	24	23
Caymán	25						
Mean	23	29	24	27	28	26	23

- Overall, a tendency for greater soil carbon accumulation from *Brachiaria* grasses
- Further statistical analysis is in progress

Modified from: Trends Plant Sci. 2011 Sep;16(9):476-80

Contribution of *Brachiaria* grasses to GHG emission reduction

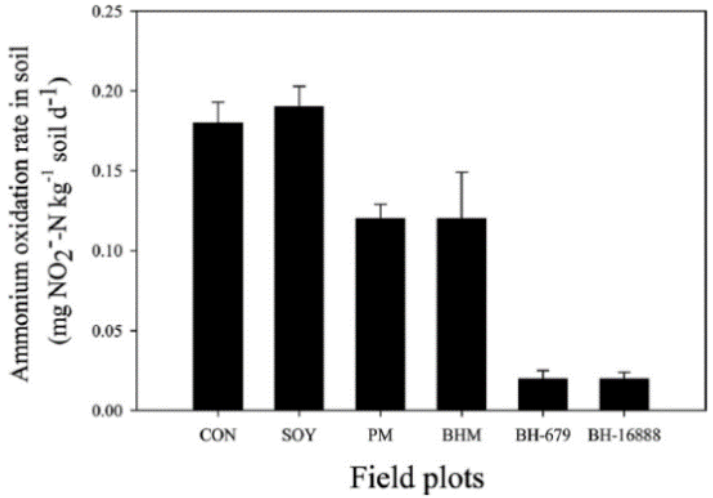
Biological Nitrification Inhibition: a process by plants



Subbarao et al., 2009

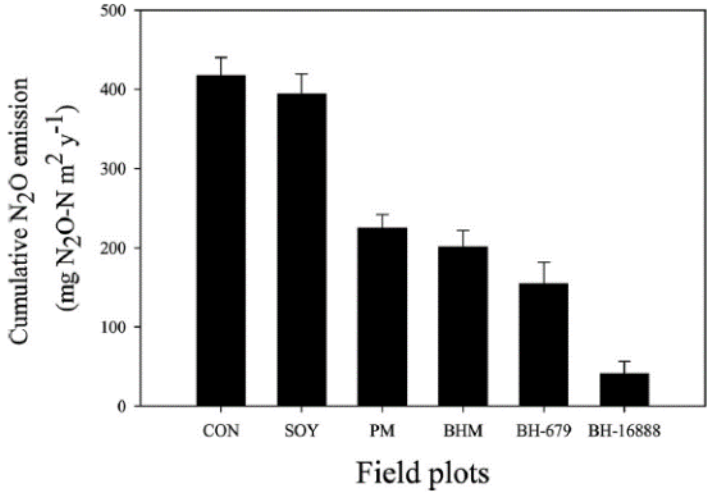
Evidence for Biological Nitrification Inhibition in *Brachiaria* pastures

Soil ammonium oxidation rate

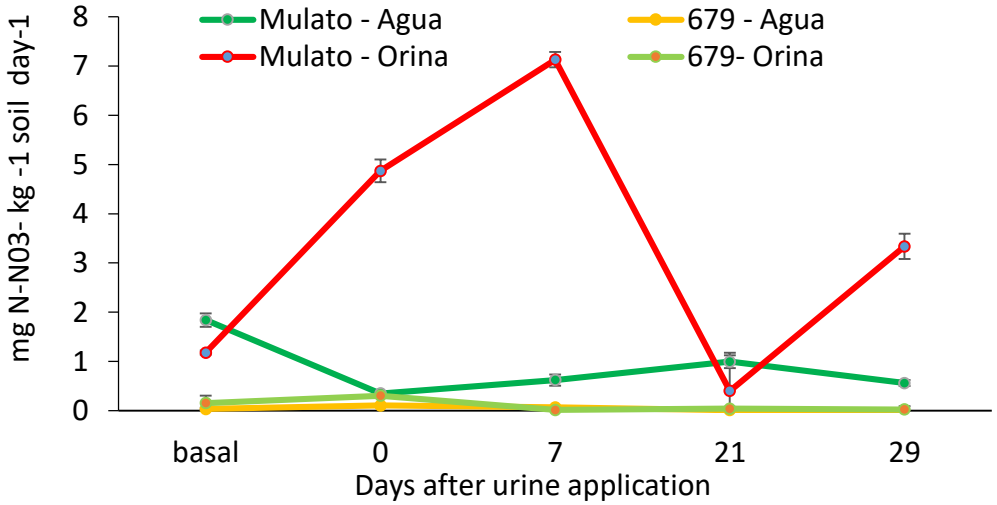


- **CON:** Bare soil
- **SOY:** Soybean
- **PM:** *P. maximum*
- **BHM:** *Brachiaria* hybrid cv. Mulato
- **BH-679:** *Brachiaria humidicola* 679
- **BH-16888:** *B. humidicola* 16888

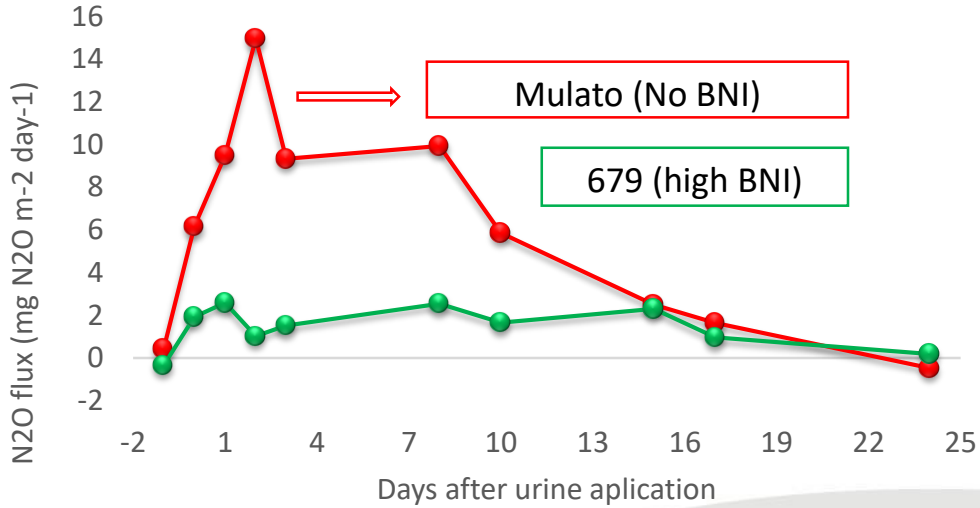
N_2O emissions



Nitrate production in soil



N_2O fluxes



Byrnes et al., 2017

Pillar 3: Institutions and Policies

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CGIAR

Building a sustainable future

CIAT

Scaling of Tropical Forages

East Africa

- Demo plots
- Field days
- ‘Trade fairs’
- Fact sheets
- Close interaction with private sector e.g. seed suppliers and dairy cooperatives

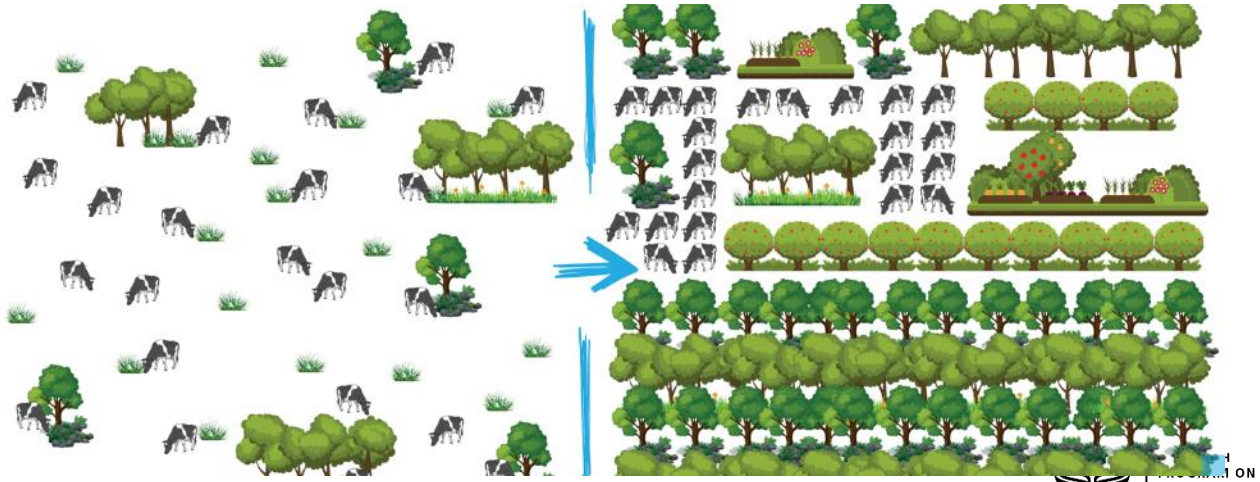
ciat.cgiar.org

Colombia

ganso.com.co

GANSO‘s farm level business model

- Support farms with extensive cattle operations to transition to an intensified system with improved pasture management boosting productivity and reducing land use
- a) Intensification of cattle operations; b) Diversification of production; c) Restoration and conservation



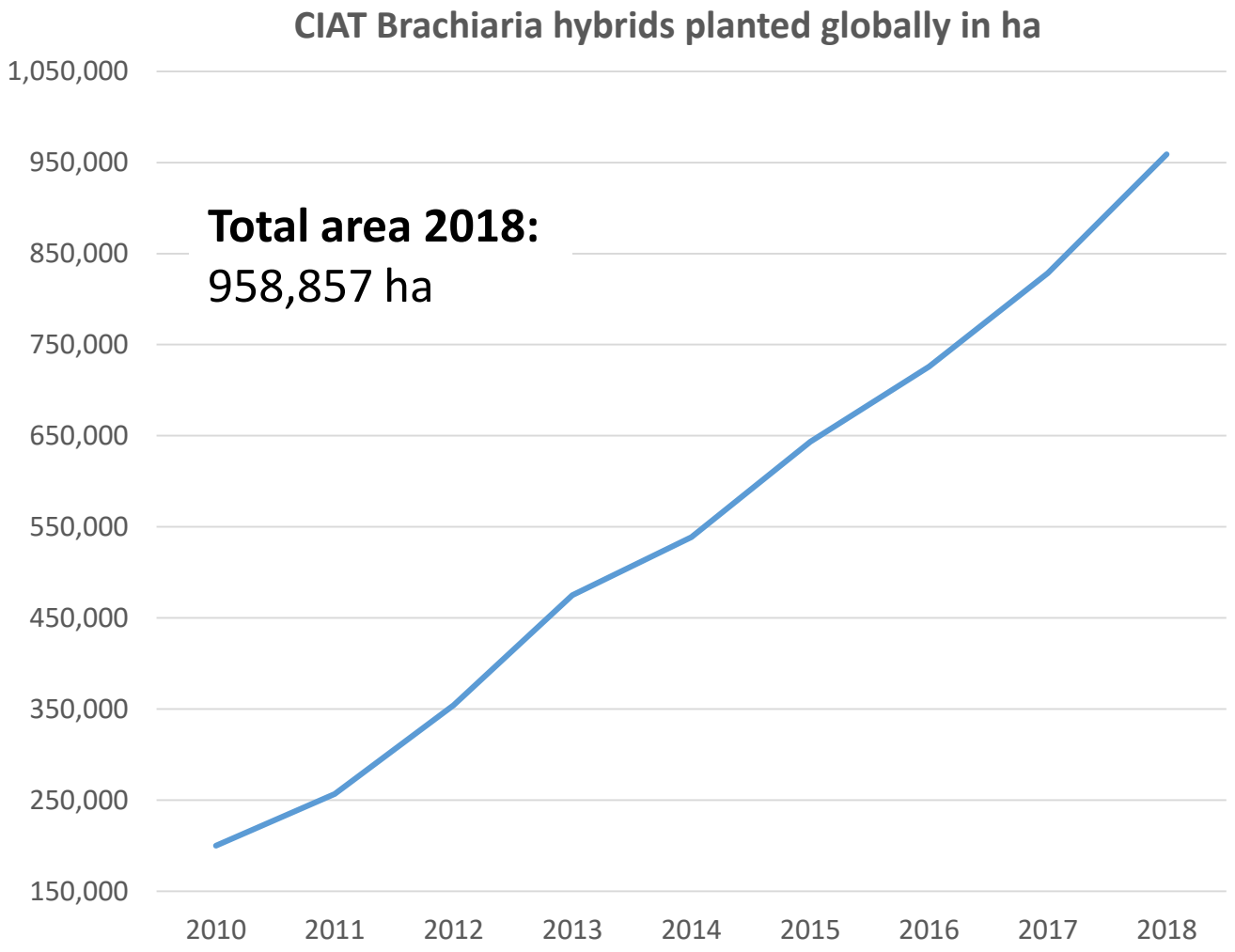
CGIAR Livestock

Building a sustainable future

CIAT

Collaboration with the private sector for boosting hybrid dissemination

- CIAT is collaborating with the private forage seed sector on *Brachiaria* hybrids since 2001
- Since 2001, CIAT's Brachiaria hybrids have been planted on over **950,000 hectares** in more than **30 countries** of the global tropics
- Since 2018 a **new agreement is in place** between CIAT and Papalotla, a Mexican forage seed company specialized on hybrids
- The main market is in Latin America but a **constant growth is being observed** for Africa and Southeast Asia



Colombian Roundtable for Sustainable Cattle and Dairy (MGS)

48 permanent members from the public and private sector in Colombia, including donors and scientific institutions.

The MGS works through 3 thematic commissions:

INSTITUTIONS COMMUNICATIONS MARKETS

13 regional roundtables were created and cover all main cattle and dairy regions of Colombia. Principal tasks:

- Capacity building of primary producers
- Knowledge and information Exchange
- Development of innovations
- Influencers for regional policy making

Idea: 2014

Formalization: 2015/16

Operational with annual work plan: since 2016

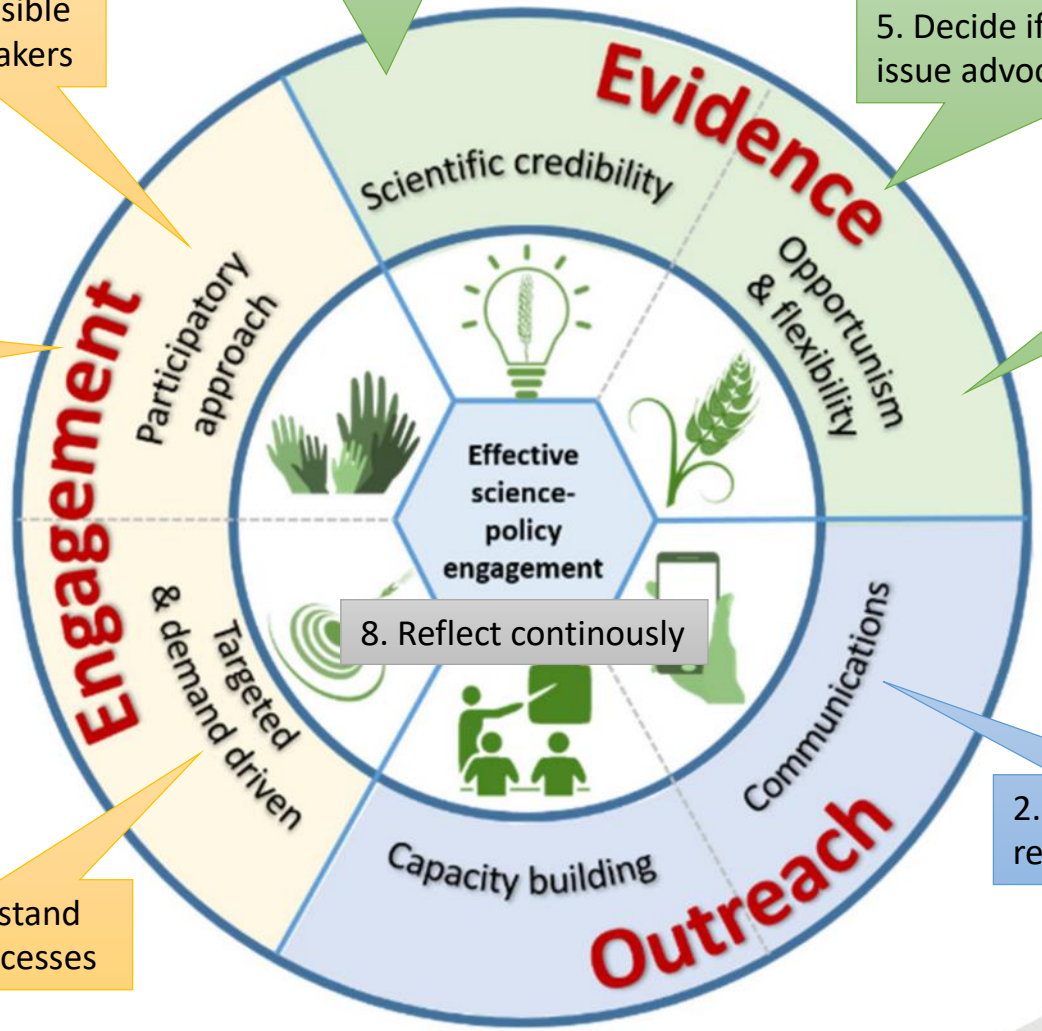
Main objectives of the MGS:

- 2018-20: Establish technical guidelines for a national level public sector policy on Sustainable Cattle/Dairy
- Constant knowledge exchange and dialogue among the members of the roundtable
- Fund raising for national level projects on Sustainable Cattle/Dairy
- Capacity building for primary producers and value chain actors both at regional and national level
- Integrating the MGS into the Global Roundtable for Sustainable Beef (GRSB) and exchange with other roundtables from Latin America (e.g. Brazil, Costa Rica, Mexico)

Dinesh et al. 2018; Oliver and Cairney 2019
From Lamanna et al., 2019

The process of influencing decision-making

Engagement + Evidence + Outreach = Outcomes



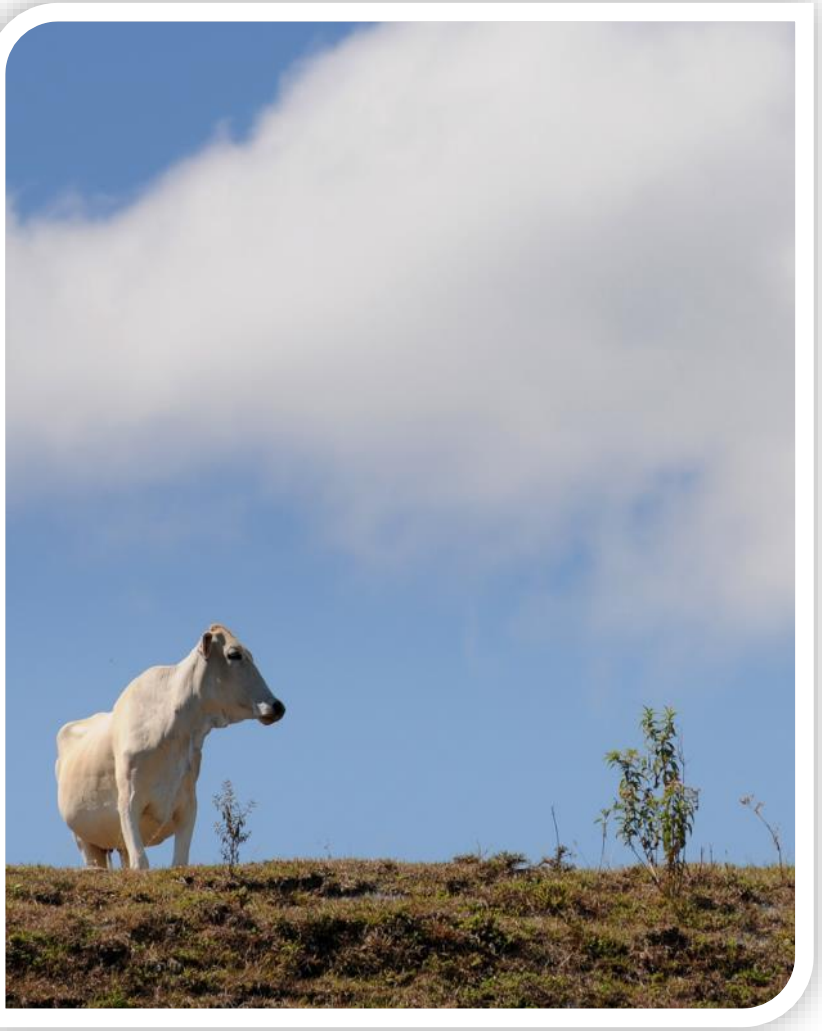
1. Do high quality research
2. Make your research relevant and readable
3. Understand policy processes
4. Be accessible to policymakers
5. Decide if you want to be an issue advocate or honest broker
6. Build relationships with policymakers
7. Be 'entrepreneurial
8. Reflect continously

In conclusion

- Livestock is important for economies and livelihoods
- Livestock is affected by and contributes to CC
- Livestock productivity in SA is relatively low

- Real opportunities for triple wins
- Co-benefits and trade-offs need to be quantified

- Science has a role to play:
  - Development of solutions (technical and institutional)
  - Targeting and prioritization
  - Monitoring and Learning
- Research process is as important as results
  - Engagement, Evidence, Outreach



Thank you!

CIAT 50
1967-2017

WE'RE PROUD TO
HAVE CELEBRATED 50 YEARS
OF AGRICULTURAL RESEARCH
FOR DEVELOPMENT

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CGIAR

El CIAT es un Centro de Investigación de CGIAR

GHG monitoring for program and policy support

- Rwanda's national strategy on Green Growth and Climate Resilience
- Rwanda's National Strategy for Climate Change and Low Carbon Development Strategy
- NDC for Rwanda -> improved quantitative reporting to IPCC
- Many organizations/investors interested in climate impact of their programs – including IFAD, Send a Cow
- Assist in arguing for increased investment from Green Climate Fund
- Carbon trading?

CLEANED: minimum-data environmental ex-ante assessment tool

The quantification of

1. Production (absolute and per ha)
2. Land requirement for feed production (ha, ha/kg product)
3. GHG emissions (absolute, per ha, per kg product, per protein)
4. Soil health (Erosion, NUE, % area leached, % area mined)
5. Water use (absolute, per ha, per kg product, per protein)

+ simple Cost/Benefit calculations for intervention scenarios

In different livestock production systems; under different scenarios

ILRI
INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

CIAT
Centro Internacional de Agricultura Tropical
Desde 1967 Ciencia para cultivar el cambio

SEI STOCKHOLM ENVIRONMENT INSTITUTE

CSIRO

CGIAR RESEARCH PROGRAM ON Livestock

Evaluating Land Management Options (ELMO)

Participatory tool for assessing farmers' land management (LM) decisions, preferences & trade-offs

1. Identify techniques & attributes to be discussed
2. Record respondent characteristics
3. Define LM techniques & baseline
4. Rank & Score LM costs & input requirements
5. Rank & Score LM benefits & desired outcomes
6. Rank LM advantages & positive attributes
7. Rank LM disadvantages & negative attributes
8. Rank and weight LM alternatives overall

Individual discussions with farmers

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Building a sustainable future

CIAT