Climate change impacts on livestock and implications for adaptation

Climate impacts on land use, food production and productivity Session

An Notenbaert, Juan Andres Cardoso, Jacobo Arango, Ngonidzashe Chirinda, Michael Peters
Anne Mottet

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Outline

- Importance of livestock
  - People
  - Planet
  - SDGs
- Livestock production systems
- Impact of CC on livestock
  - Direct
  - Indirect
- Implications for adaptation:
  - Vulnerability
  - Options
- Feed as a triple-win
- Conclusion



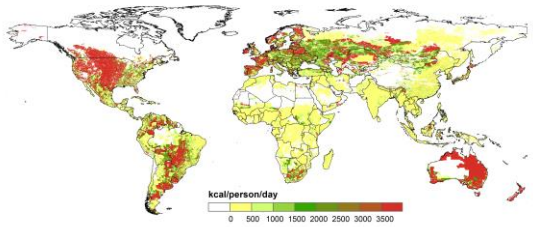
Importance of Livestock

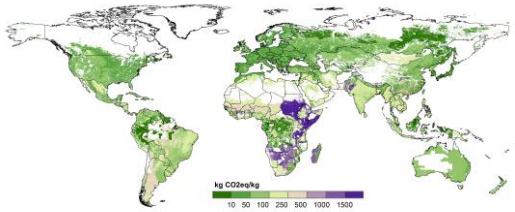
For PEOPLE

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

And the PLANET

- Biggest land user
- Natural resources:
  - Manure, SOC, biodiversity, energy, …
  - GHGe, water use and pollution, fishmeal





17 billion domestic animals
1.3 billion people employed in livestock VCs
600 million poor livestock keepers (2/3 women)
70% demand increase 2005-2030

Sector value >1.4 trillion USD; growth rate 2.5%
Constitutes about 40% of agricultural GDP

Food for at least 830 million food insecure people
17% of kilocalorie and 33% of protein consumption
Vitamin A, B-12, riboflavin, calcium, iron and zinc

26% = rangeland, 33% of cropland for fodder
32% of global water consumption

60% of cropping area receives manure application
14.5% of human-induced GHG emissions

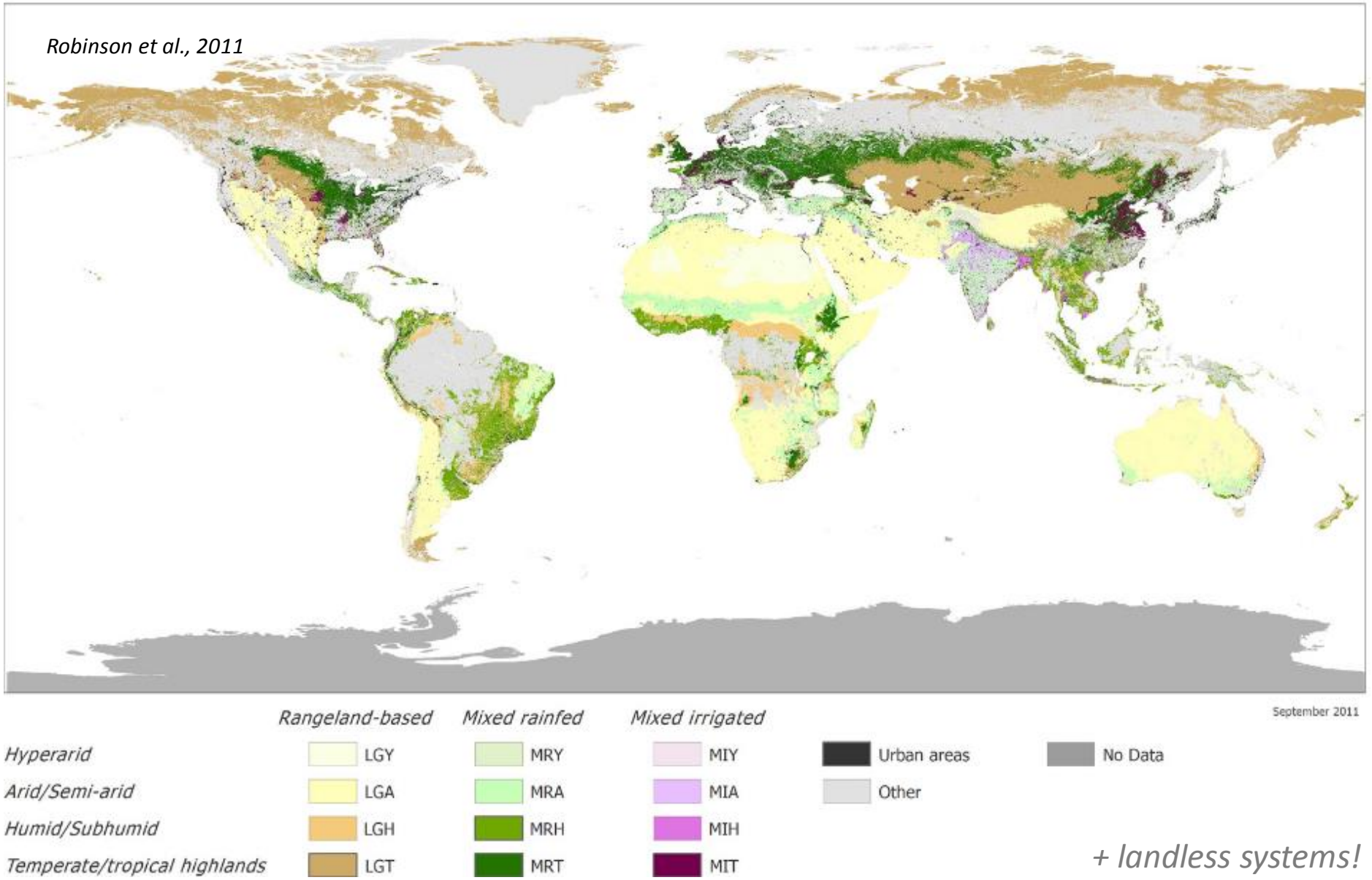
FAO 2016; Gerber et al. 2007; Herrero et al. 2008; Herrero et al. 2013; LID 1999; Thornton et al. 2002; Thornton and Herrero 2008; Rosegrant et al 2009; Worldbank 2009

Livestock -SDG linkages



FAO 2016 - http://www.livestockdialogue.org/fileadmin/templates/res_livestock/docs/2016/Panama/FAO-AGAL_synthesis_Panama_Livestock_and_SDGs.pdf

Livestock production systems



+ landless systems!

- Huge heterogeneity
  - Mixed crop-LS
    - Rainfed
    - irrigated
  - Rangeland-based
- Adaptability
- Dynamic
  - Growing demand
  - Globalisation
  - Consumer preferences

+ CC!

Impacts of CC on Livestock

- Hazards/stresses:
  - Δ CO_2, temperature, precipitation
  - Variability and extreme events

- Direct impact
  - Heat stress
- Indirect impact
  - Water
  - Diseases
  - Biodiversity, Soil
  - Feed and forages

  - Livelihoods and systems



Impacts of CC on Livestock

Heat stress

- Behavioral and metabolic changes, e.g. reduced feed intake, increased energy requirement, decreased conception rates, …
- Influenced by species, genetic potential, life stage and nutritional status

Water

- Rising temperature ~ higher water demand (feed production and drinking)
- Δ surface and groundwater supply

Diseases

- Δ development of pathogens, distribution of vectors, transmission rates
- Decreased resistance of livestock

Impacts of CC on Livestock

Biodiversity

- Risk of extinction (habitats, plants and animals)
- Loss of genes for disease-resistance, environmental adaptation, …

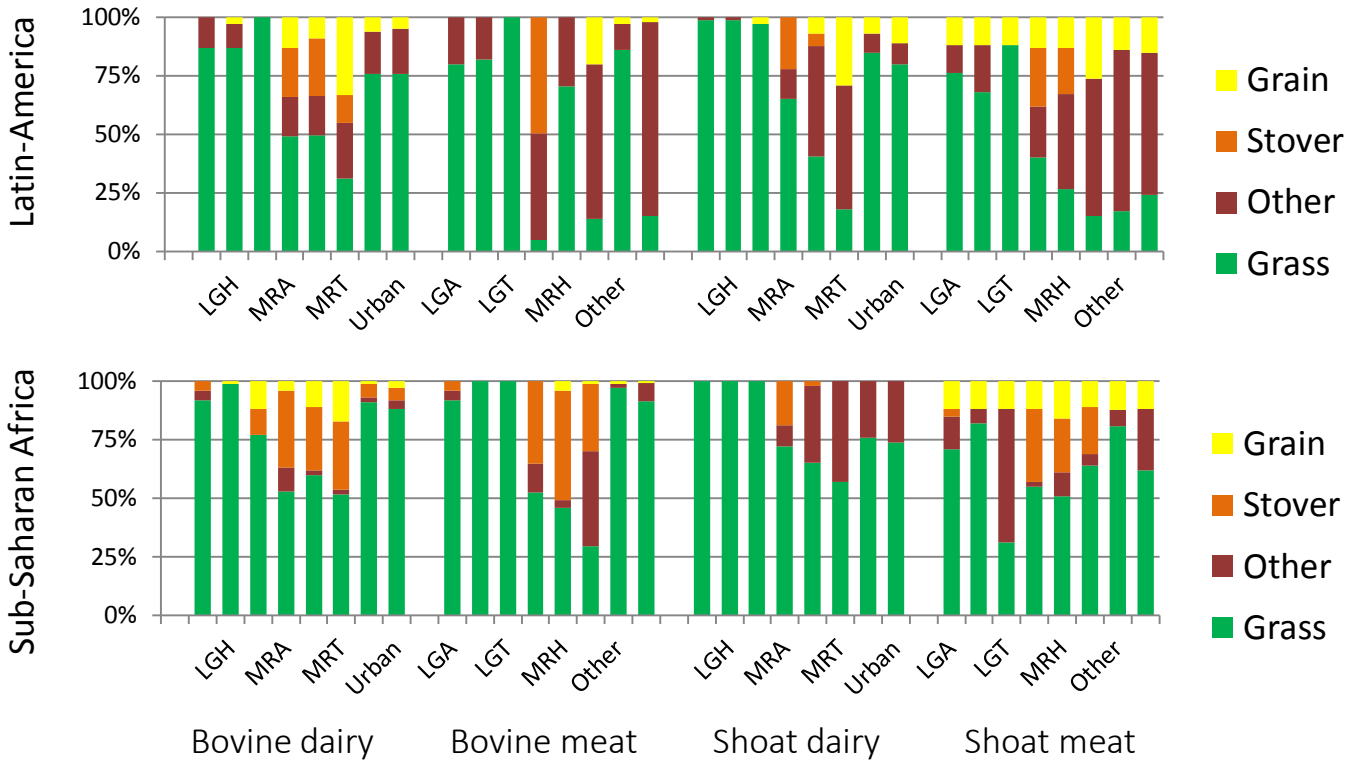
Systems and livelihoods

- Decreased productivity
- Altered resource allocation, human health, …
- Migration
- Conflict for resources
- Production system transitions

Impacts of CC on Livestock

Feeds and forages

- Crop residues
- Planted forages
- Grassland/Rangeland
- Grains
- Additives



Herrero et al, 2013

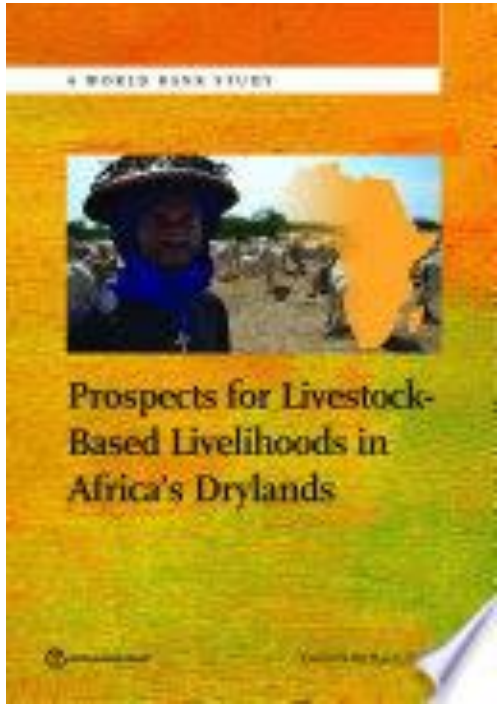
- Climate change and variability!
- Indirect effects e.g. pests

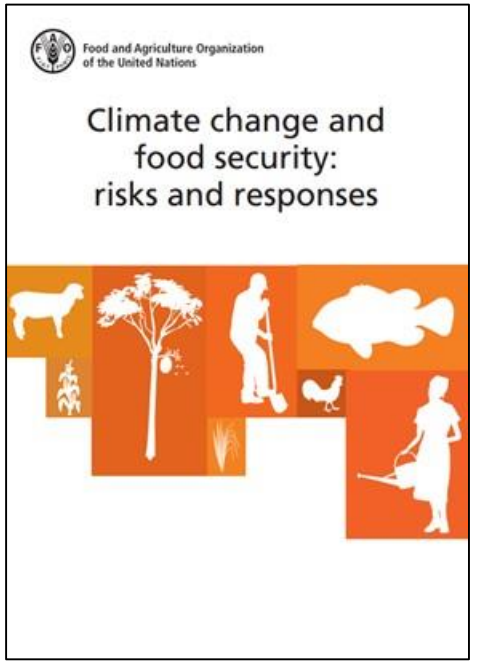
- Quantity
- Quality
- Composition



Need for more livestock specific assessments (IPCC AR5)

- Case studies and local/national observations exist but little consolidation in regional and global assessments
- Very little information available of CC impact on feed resources at regional level
- Climate models are not well suited for pastures and rangelands productivity
- Some first tentative analysis exist

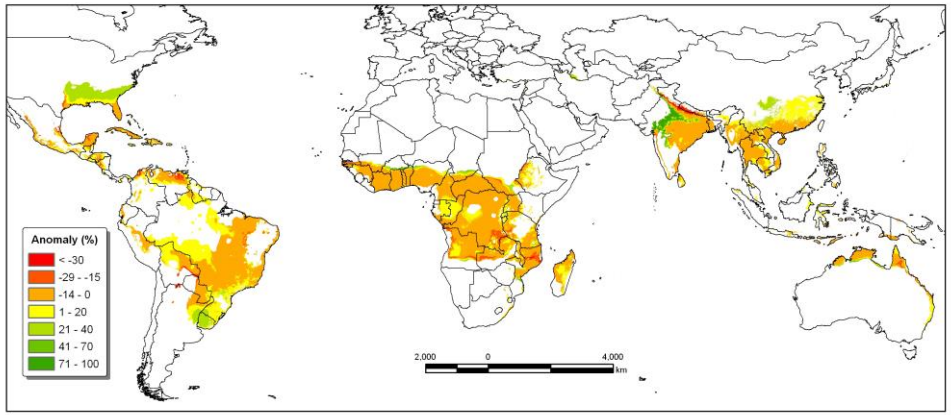




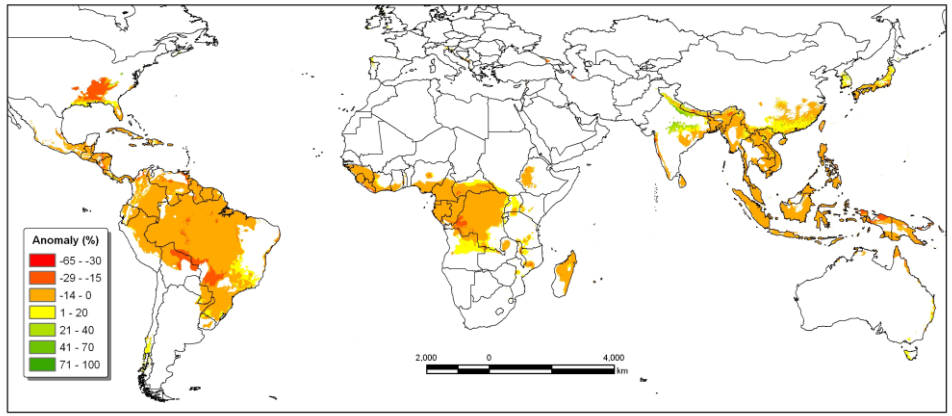
Impacts of CC on Livestock – feed and forages

- Suitability change – 2000-2020 (A2):

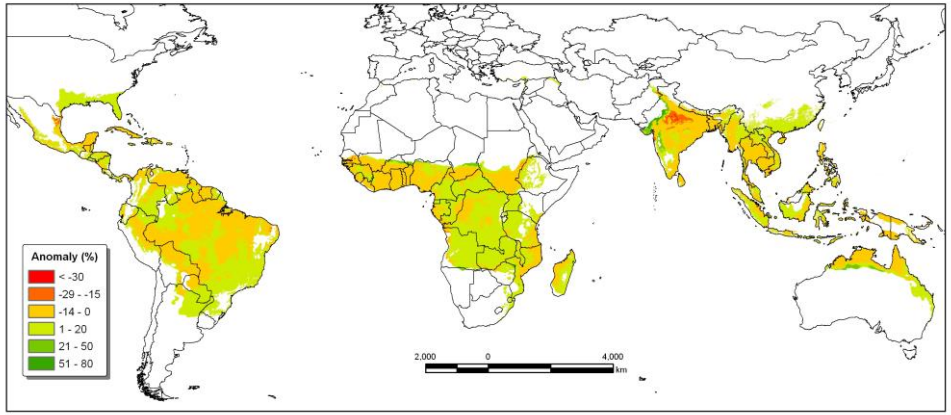
Pennisetum purpureum (Napier grass)



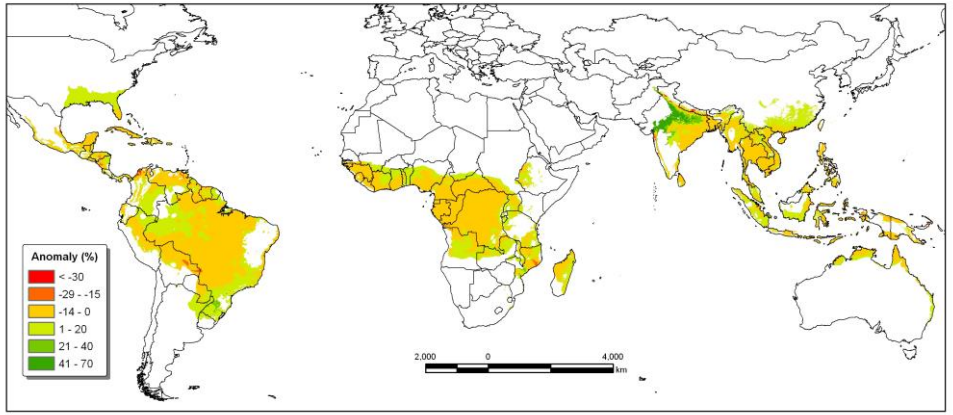
Desmodium ovalifolium

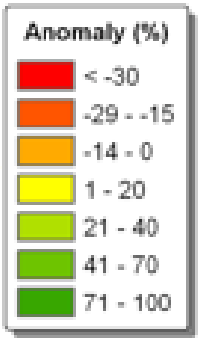


Brachiaria brizantha (Signal grass)



Gliricidia sepium





Ecocrop modeling based on LGP, Temperature and Rainfall parameters (Hymann et al.)



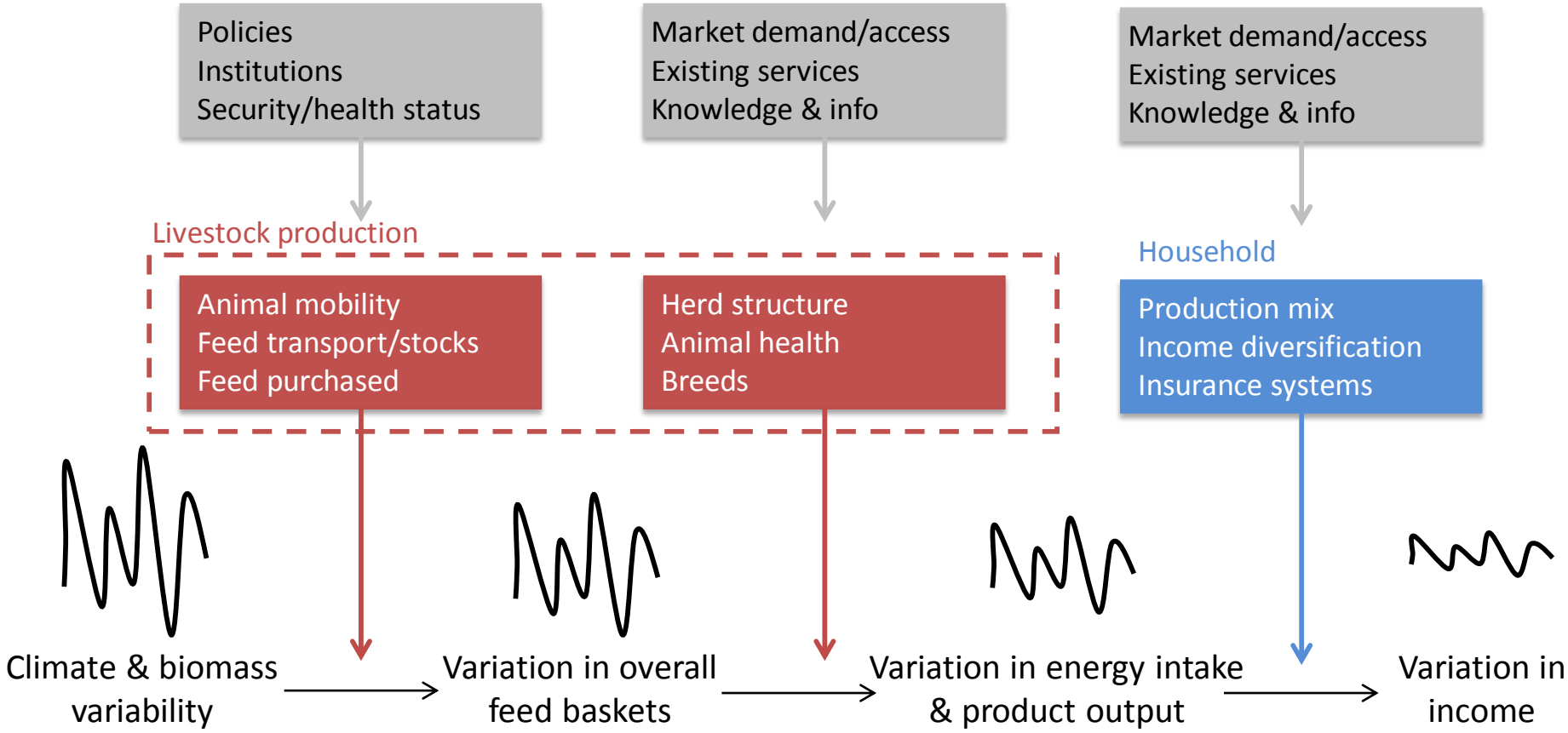








Attenuation of the effect of climate variability

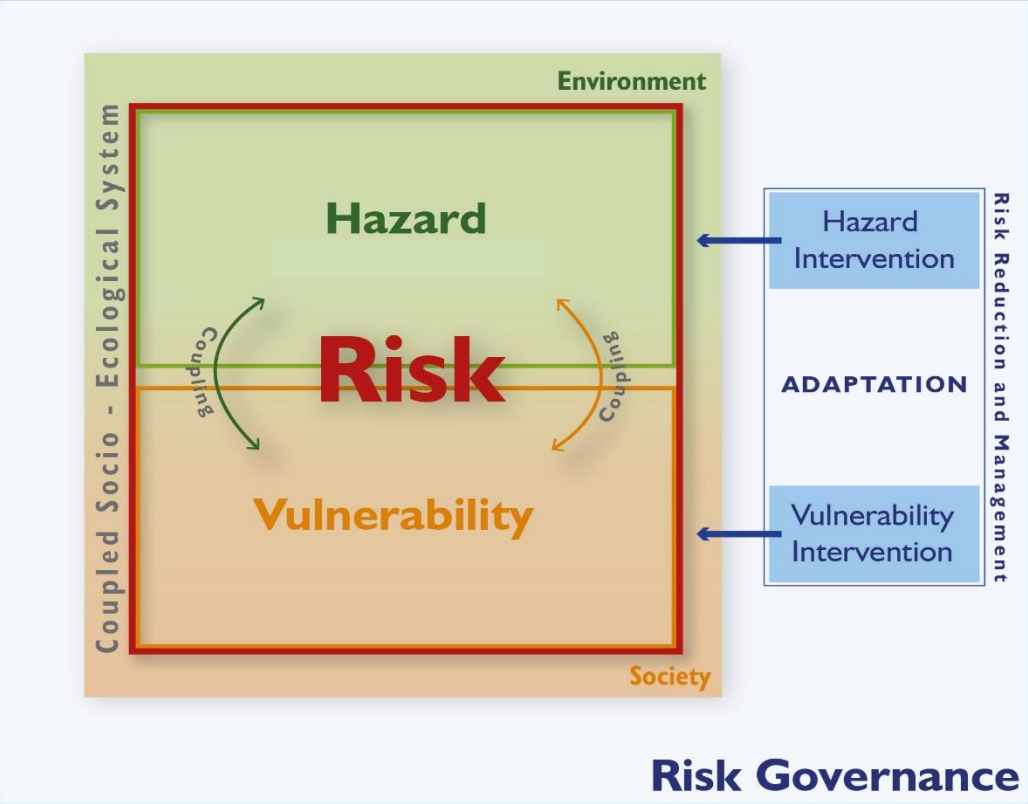


De Haan, 2016. Prospects for Livestock-Based Livelihoods in Africa's Drylands
FAO, 2016. Climate change and food security: risks and responses

Implications for adaptation

- Adaptation options will be needed if households are to cope with the multiple (inter-related) changes

- Risk and vulnerability:
  - We're living in coupled socio-ecological systems



Adapted from: Birkman et al, 2013 & Kienbergen and Notenbaert, 2013

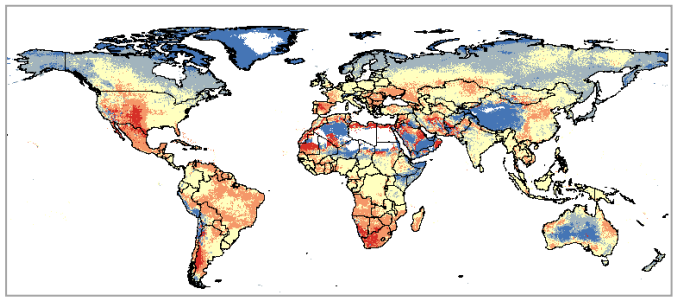
Vulnerability: the predisposition of the system to the burden of CC, considering spatial and temporal differences in exposure, susceptibility and lack of resilience.
Vulnerability largely rests within the condition and dynamics of the coupled socio-ecological system exposed to CC.

Risk: probability of being negatively affected by climate change. It is a function of the climate change and the SES's vulnerability to it. This is in turn influenced by the exposure, susceptibility and lack of resilience.

Climate change not the only "hazard"; also: increasing competition for resources, landuse change, …

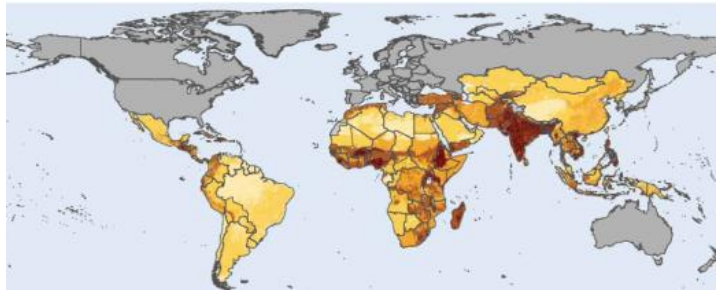
Impacts also influenced by social vulnerability

High vulnerability in SSA and SA



Projected LGP Change

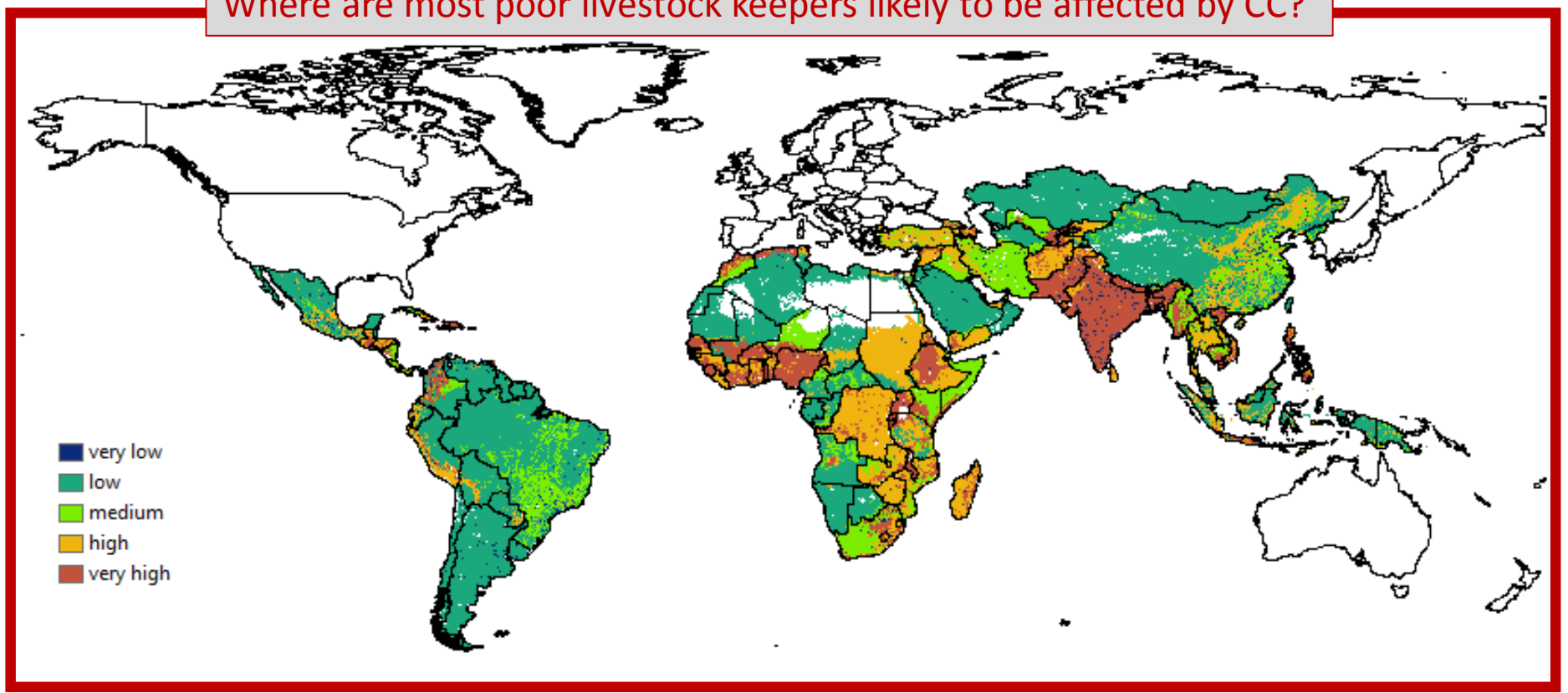
X



Poor Livestock Keepers

heavily reliant on natural resources

Where are most poor livestock keepers likely to be affected by CC?



Notenbaert et al, 2013

Adaptation

- It involves individuals' behaviour as well as collective behaviour and the interaction between them.
- It comprises activities which intervene either on the hazard or the vulnerability component of risk.
- Is successful if it reduces the risks without compromising economic, social and environmental sustainability.

- Context-specific:
  - Livestock production system
  - Farmers' circumstances (socio-economic, cultural, …)
  - Policy context

Adaptation 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

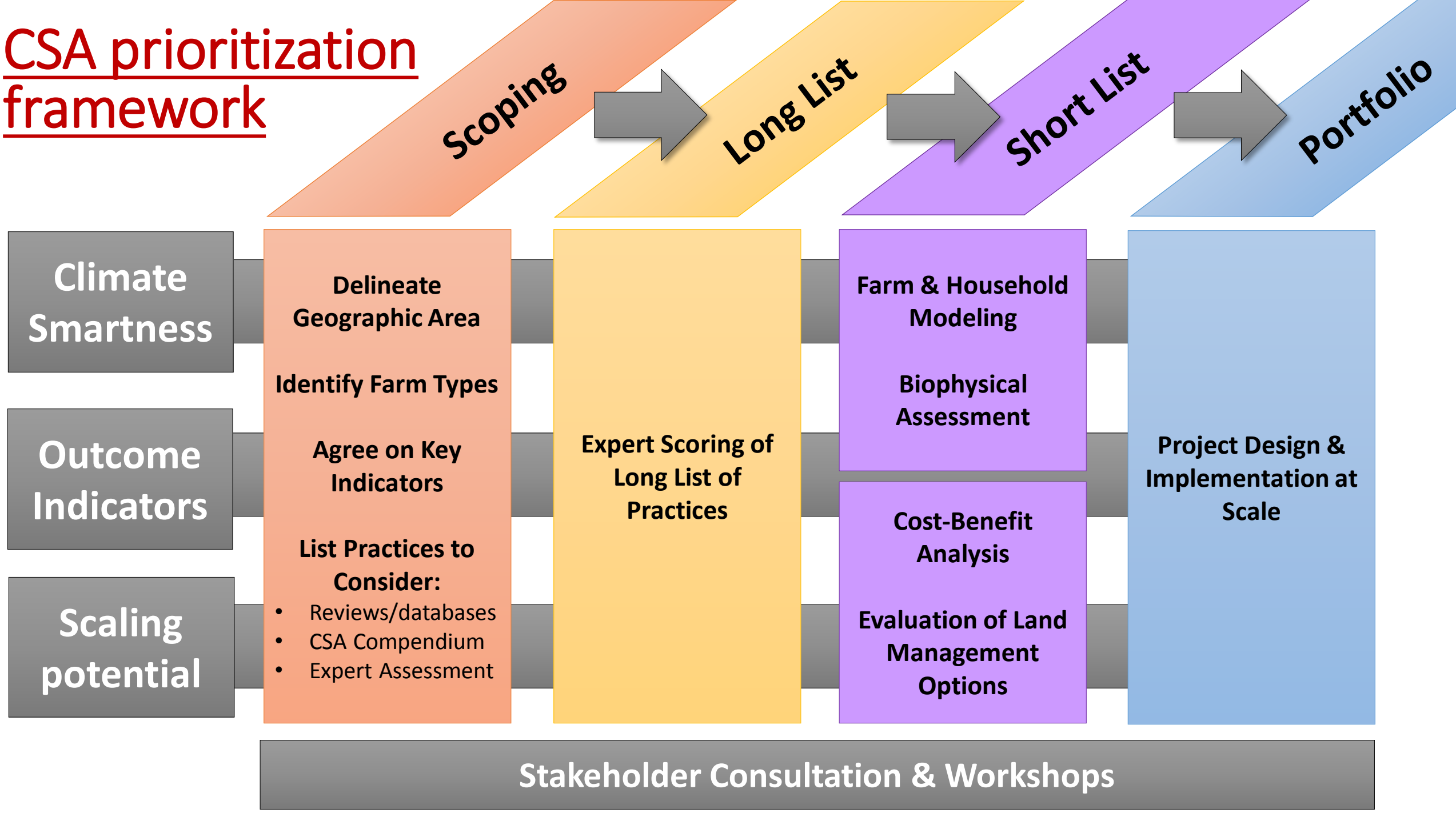
- Diversification
- Shifts in species and/or production systems
- Landuse planning and sustainable land mngt. (biodiversity, water, soils, …)
- Protection of ecosystems services (incl. carbon sequestration!)

Institutional and policy options

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



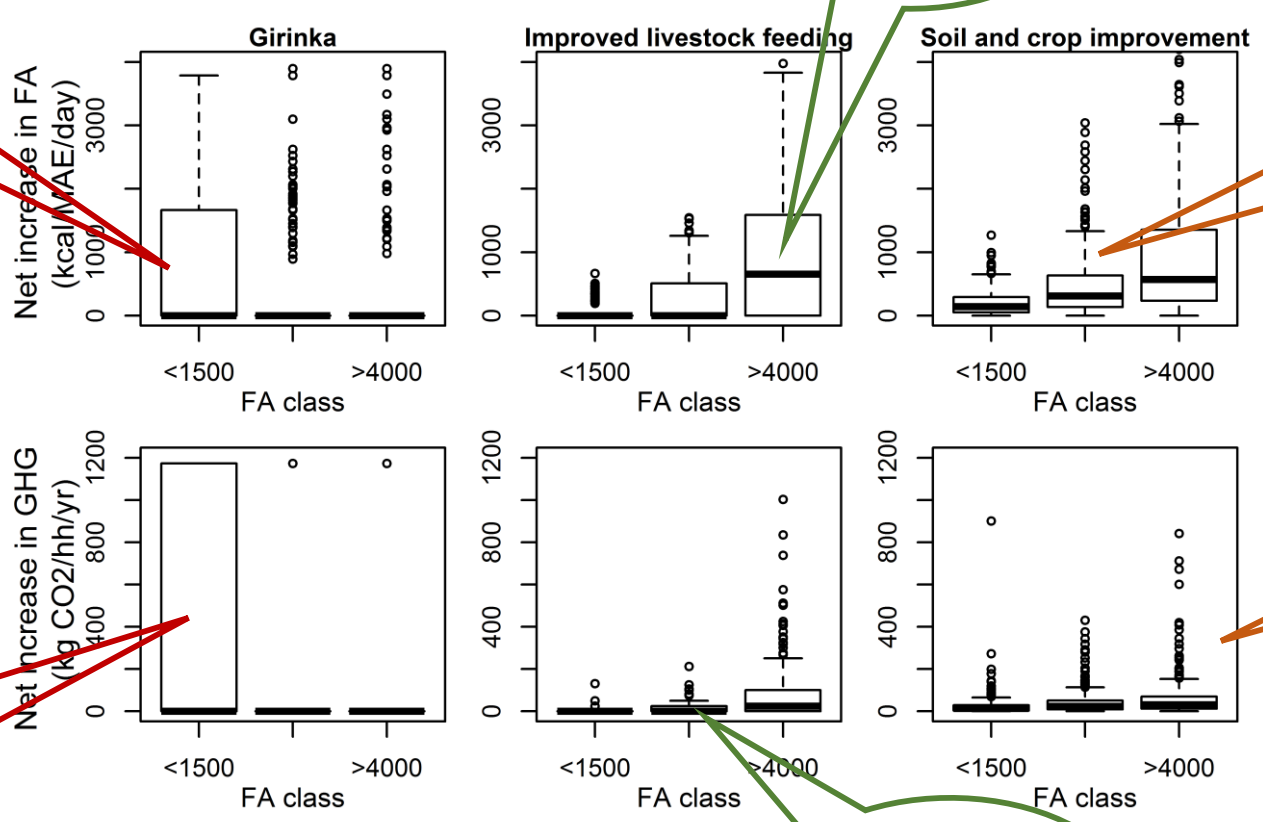
CSA prioritization framework



The impact of SI policies in Rwanda

3 HH "types" ~ FA

3 Scenarios:
- Girinka (cows 4 farmers)
- Feeding
- S-C improvement



Pro-poor

Benefits Better-off HHs

Moderate Benefits For all

Marginal GHGe increases

GHGe increase

Only small GHGe increases

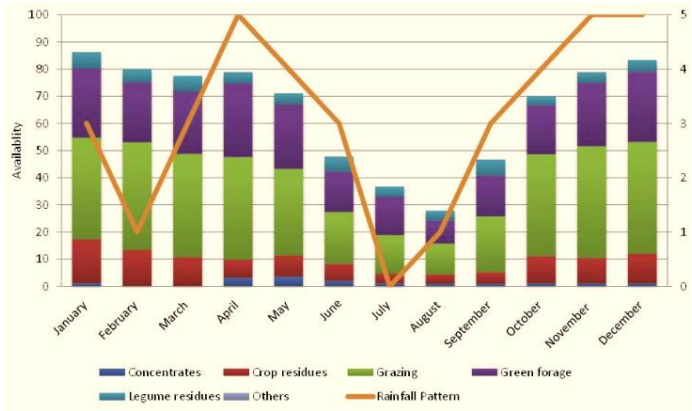
Different potential impacts (synergies and trade-offs) on different sections of the farm household population.

Paul et al., forthcoming

Feed as a true triple-win (CSA) intervention

Production

- 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

Adoption rate \ Increase in productivity	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%
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

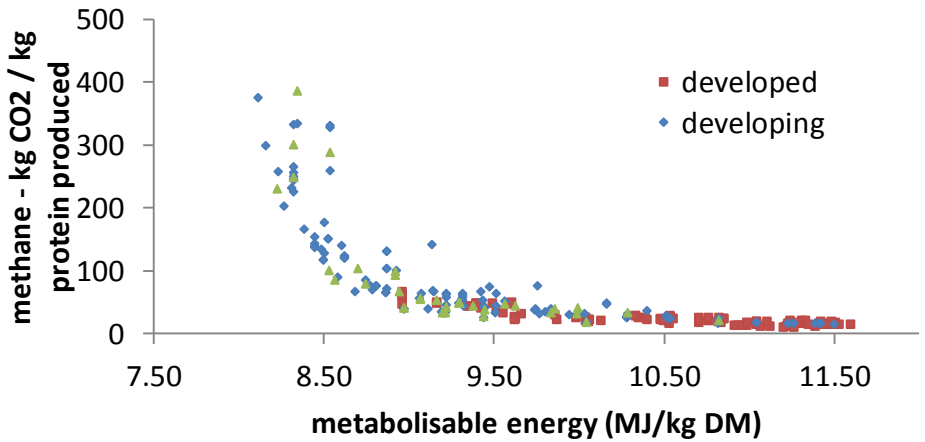
Gonzalez et al, 2016

Adaptation

- Feed availability generally cited as one of the biggest risks of climate change

Mitigation

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



Herrero et al. 2012

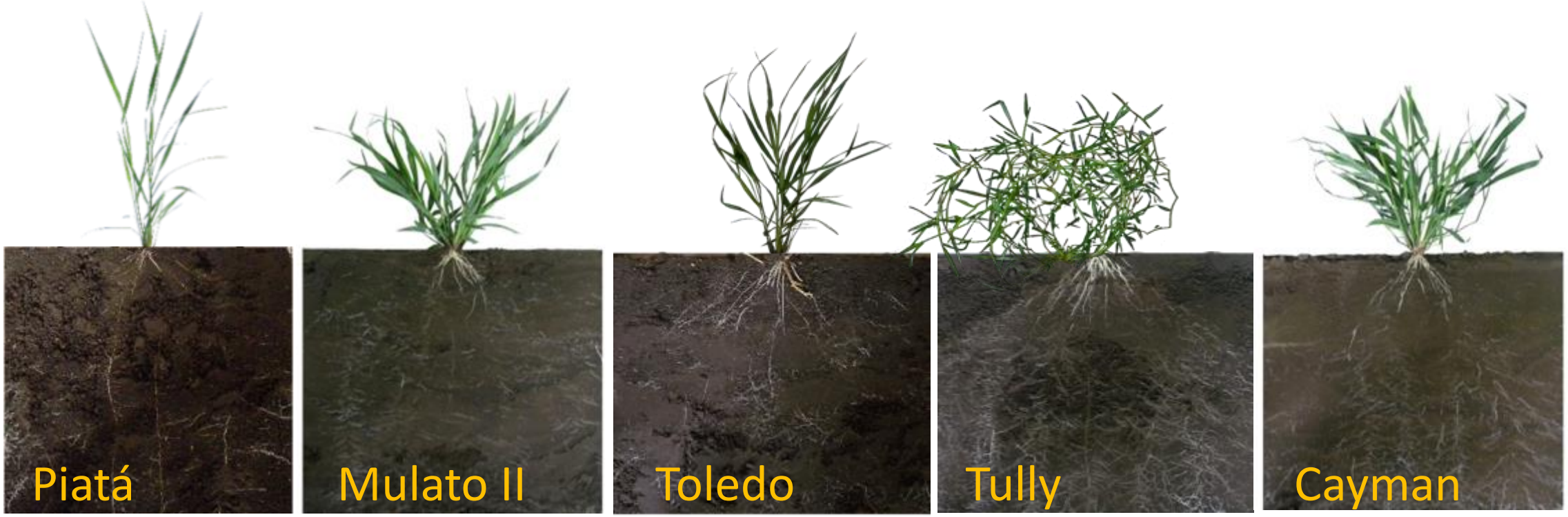
The Brachiaria example: Impact on animal production



Five top performing cultivars in participatory selection in Kenya and Rwanda

- On farms evaluation – Over 3,000 farmers in Kenya and 600 farmers in Rwanda
- Representative farms recorded milk production and body weight gains in different regions
- Increase of milk production from 4 to 7 liters per cow per day (Napier grass vs. *Brachiaria*).
- Live weight gain of 205 g/day/animal (an increase of 35%)
- Increase in on-farm forage availability during dry season
- Evaluation for seed production at different locations is in progress

Brachiaria grasses adapted to drought and low fertility



Background:

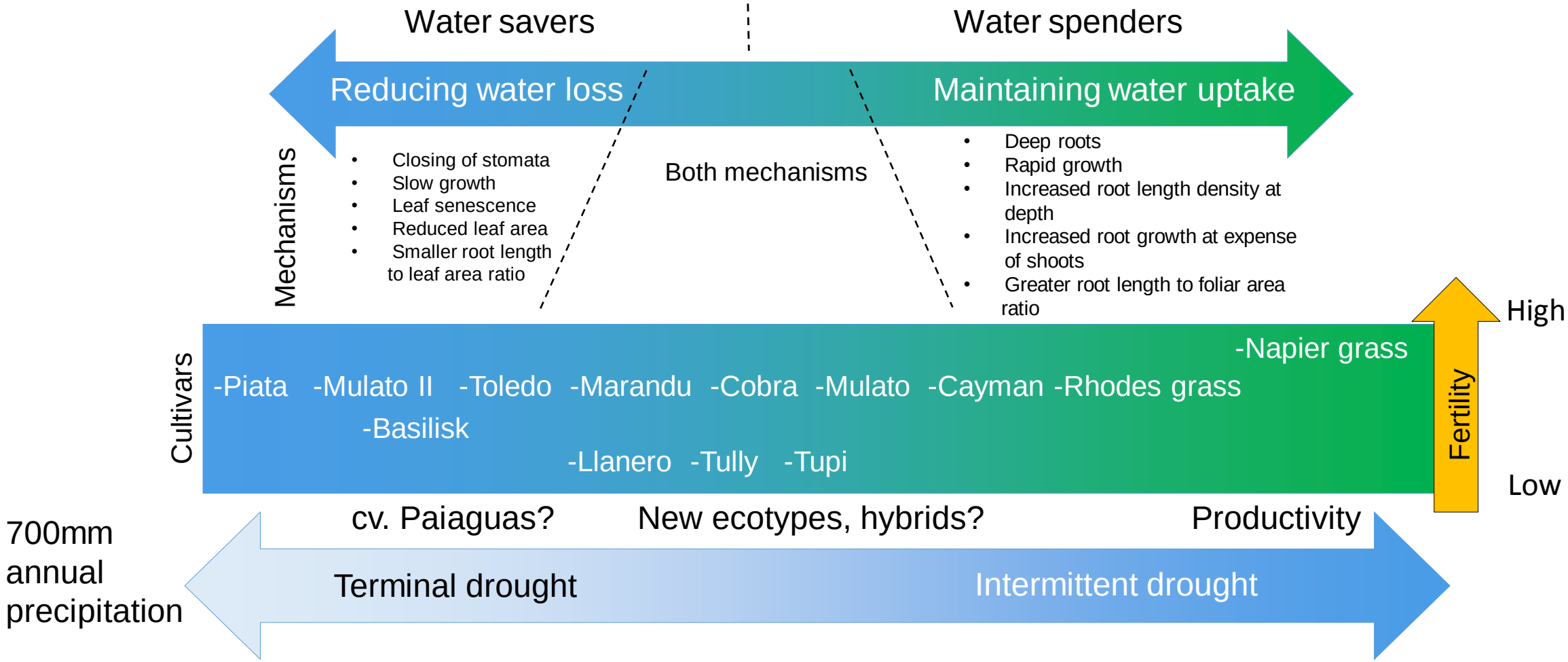
- *Brachiaria* grasses are well known for their adaptation to low soil fertility
- Great inter and intra-specific diversity in adaption to stresses, including drought

Assumptions

- *Brachiaria* grasses perform better under combined stress of drought and low fertility than Napier grass
- Adaptation to drought conditions is a achieved through increasing access to water by deep and large roots and or regulation of water loss at leaf level

Brachiaria grasses adapted to drought and low fertility

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



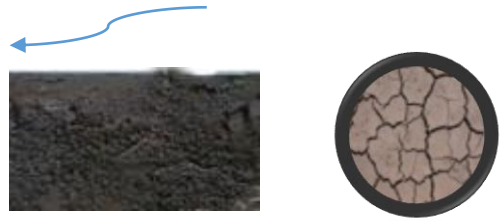
Contribution of *Brachiaria* grasses to soil quality improvement

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)

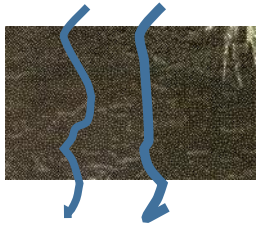
	Mean weight diameter (mm)	
	Greenhouse	Palmira
Bare soil	150	109
Napier	227	134
Rhodes	287	133
Brachiaria grasses		
Basilisk	316	128
Tully	354	125
Llanero	349	118
Tupi	378	127
Marandu	277	134
Toledo	279	138
Piata	260	136
Mulato	309	125
Mulato II	290	137
Caymán	319	131
Mean	304	131
LSD	20	15

runoff



Soil crusts after aggregates break down

Infiltration



Aggregated soil

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

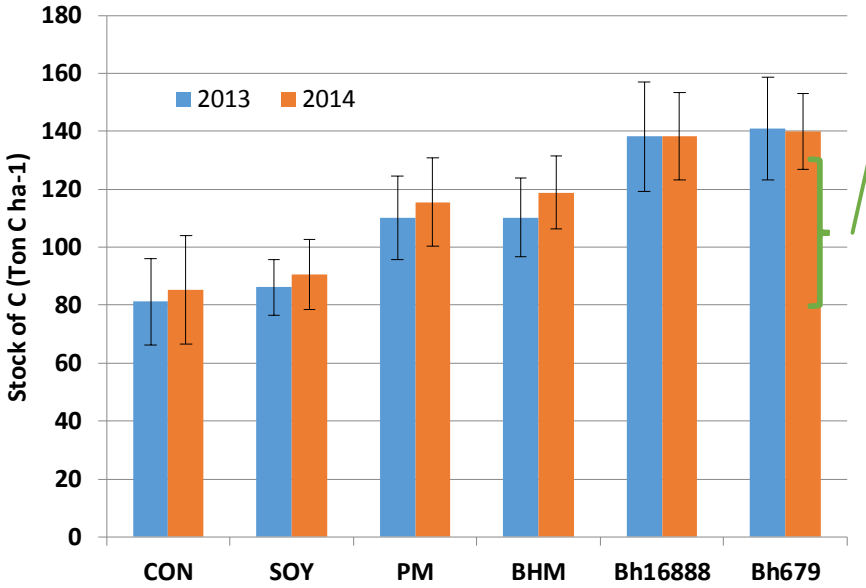
- Overall, a tendency for greater soil carbon accumulation from *Brachiaria* grasses
- Further statistical analysis is in progress

Contribution of *Brachiaria* grasses to soil carbon accumulation

Soil carbon sequestration – LAC – 10 years old experiment

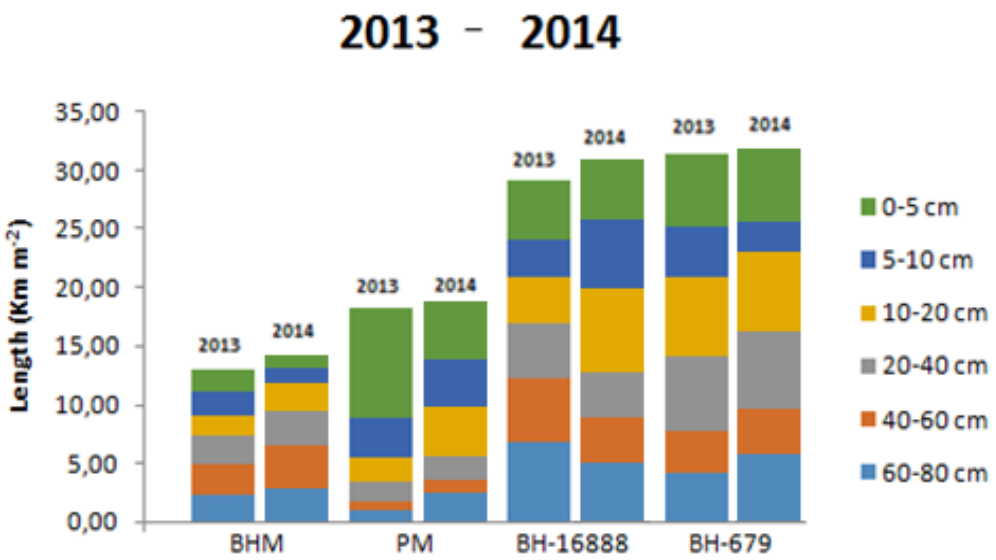


Soil carbon stocks



6 Ton C/ha/año

Root length





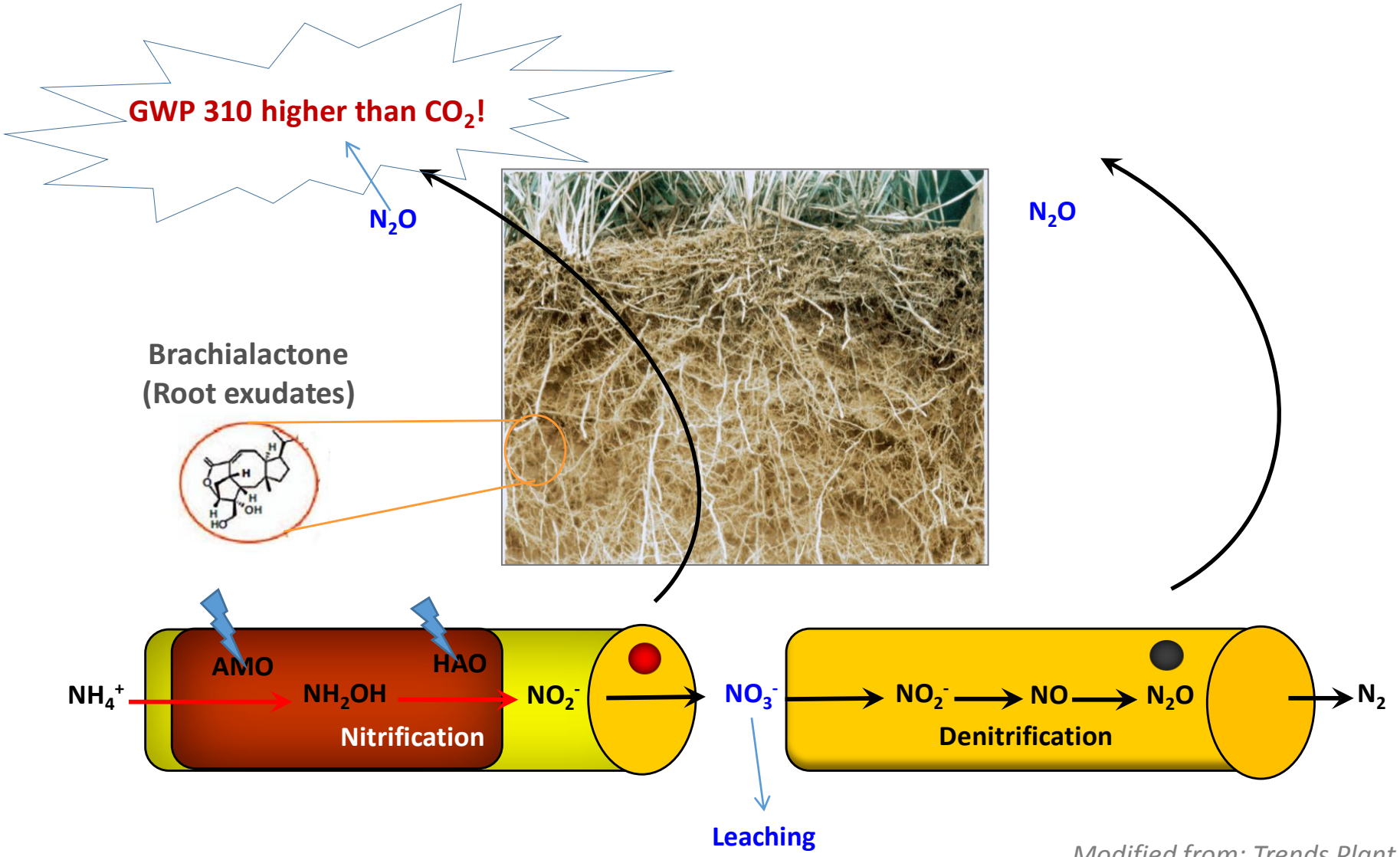
80cm depth

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

Arango et al. unpublished

Contribution of *Brachiaria* grasses to GHG emission reduction

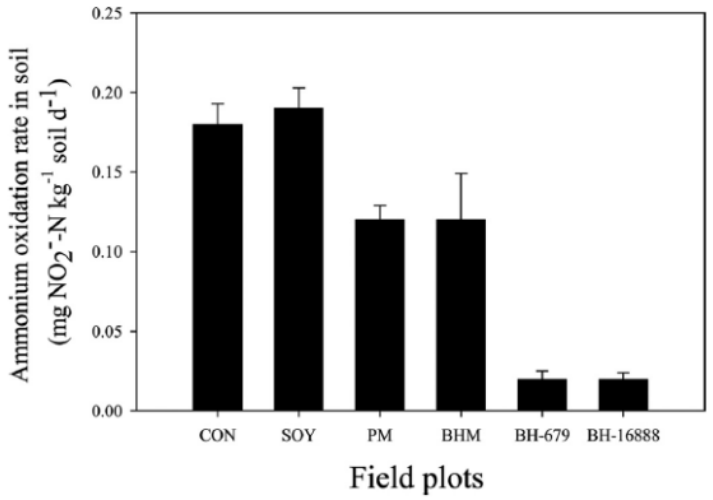
Biological Nitrification Inhibition: a process by plants



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

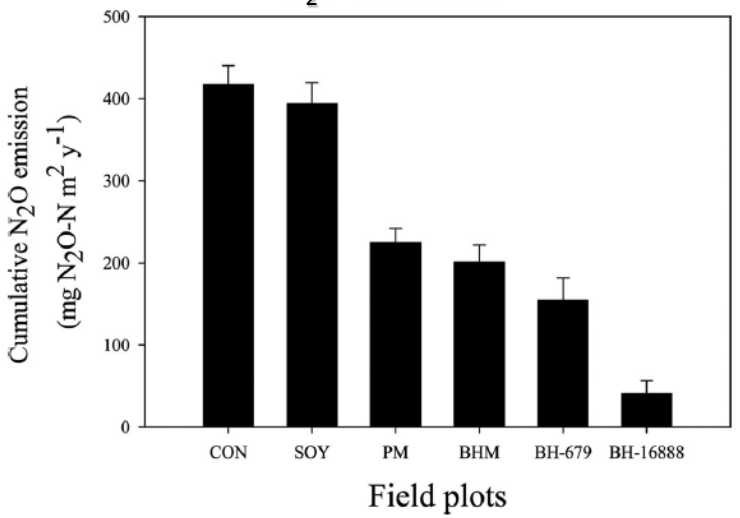
Evidence for Biological Nitrification Inhibition in Brachiaria pastures

Soil ammonium oxidation rate



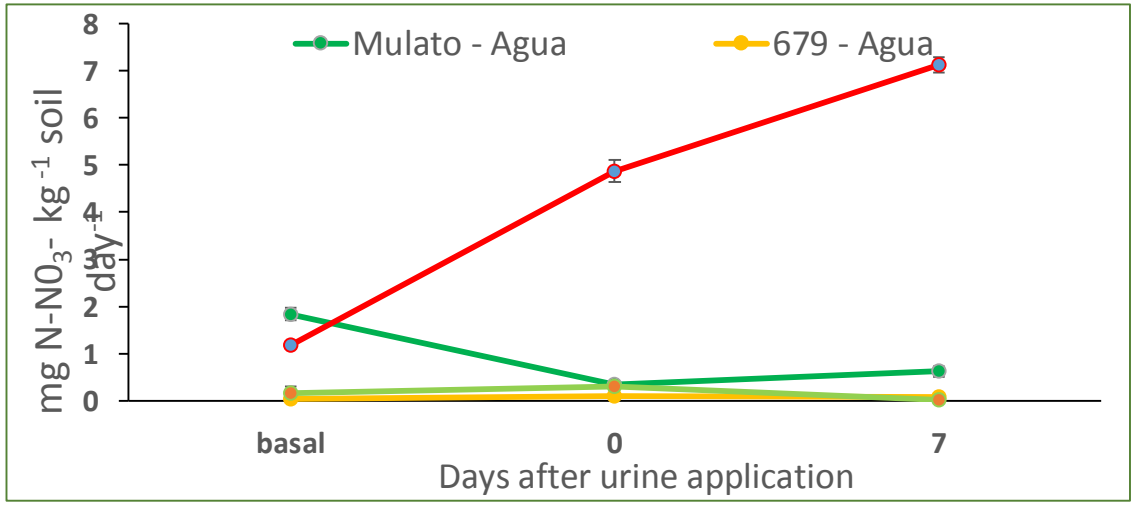
CON: Bare soil
SOY: Soybean
PM: *P. maximum*
BHM: *Brachiaria* Mulato hybrid
BH:679: *B. humidicola* 679
BH-16888: *B. humidicola* 16888

N_2O emissions

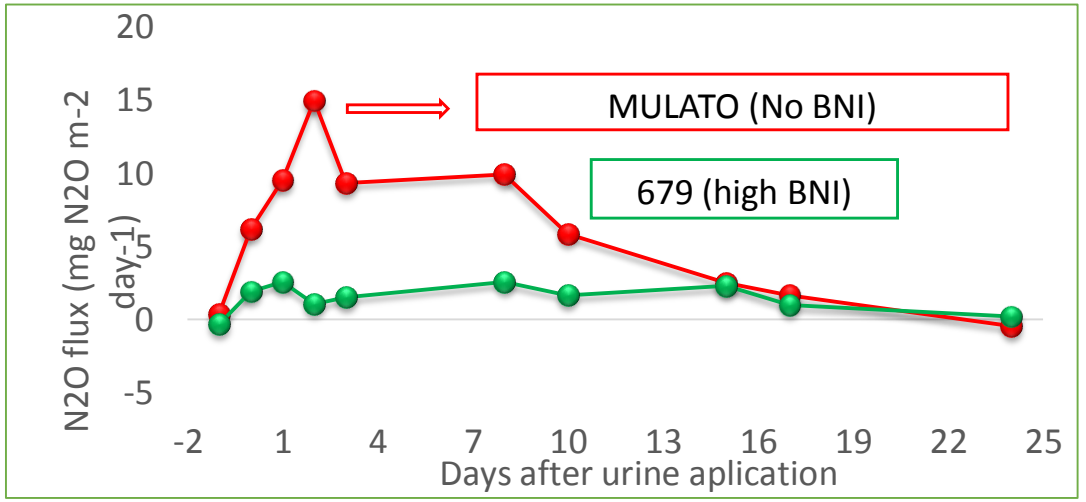


Subbarao et al., 2009

Nitrate production in soil



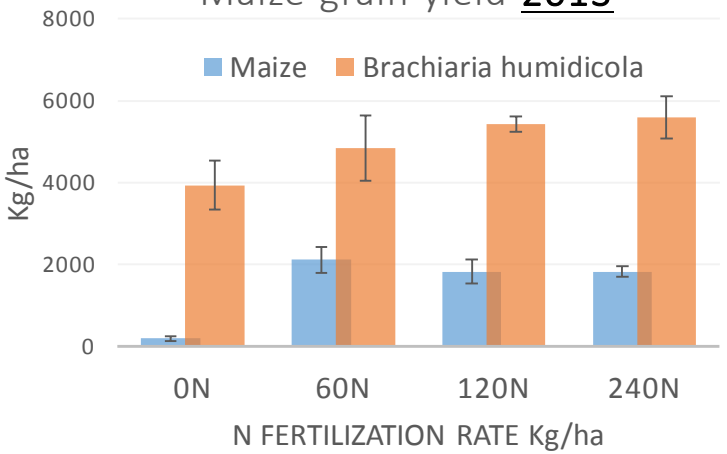
N_2O fluxes

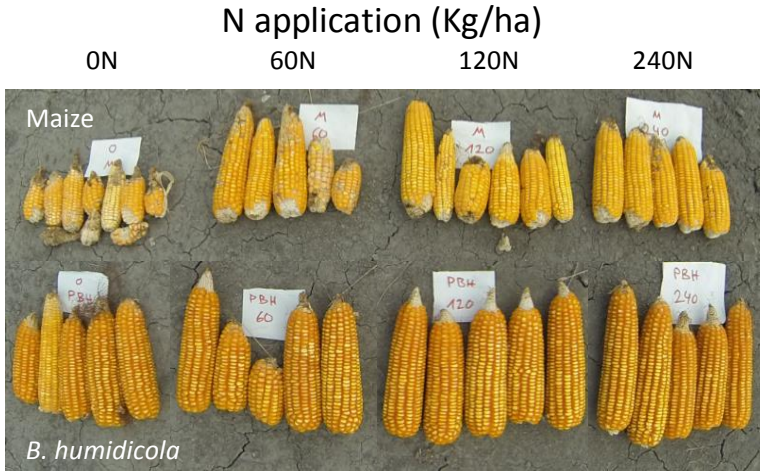


Byrnes et al., 2017

B. humidicola residual BNI effect on maize as subsequent crop in Andean foothills of Colombia

2013, 2014 and 2015

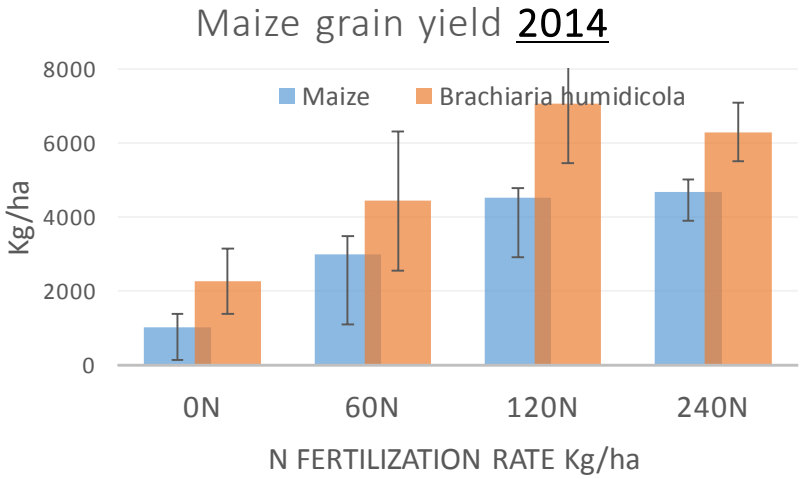


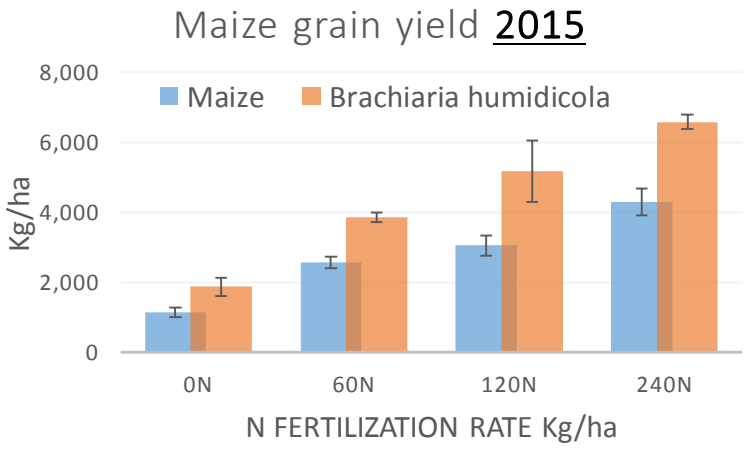


Agronomic N use efficiency

(Kg grain produced /Kg N applied (±SE)

	60N	120N	240N
Maize	34.4 (±2.1)	15.8(±1.0)	7.7(±0.2)
B. humidicola	80.7 (±5.4)	45.2(±0.6)	23.3(±0.9)

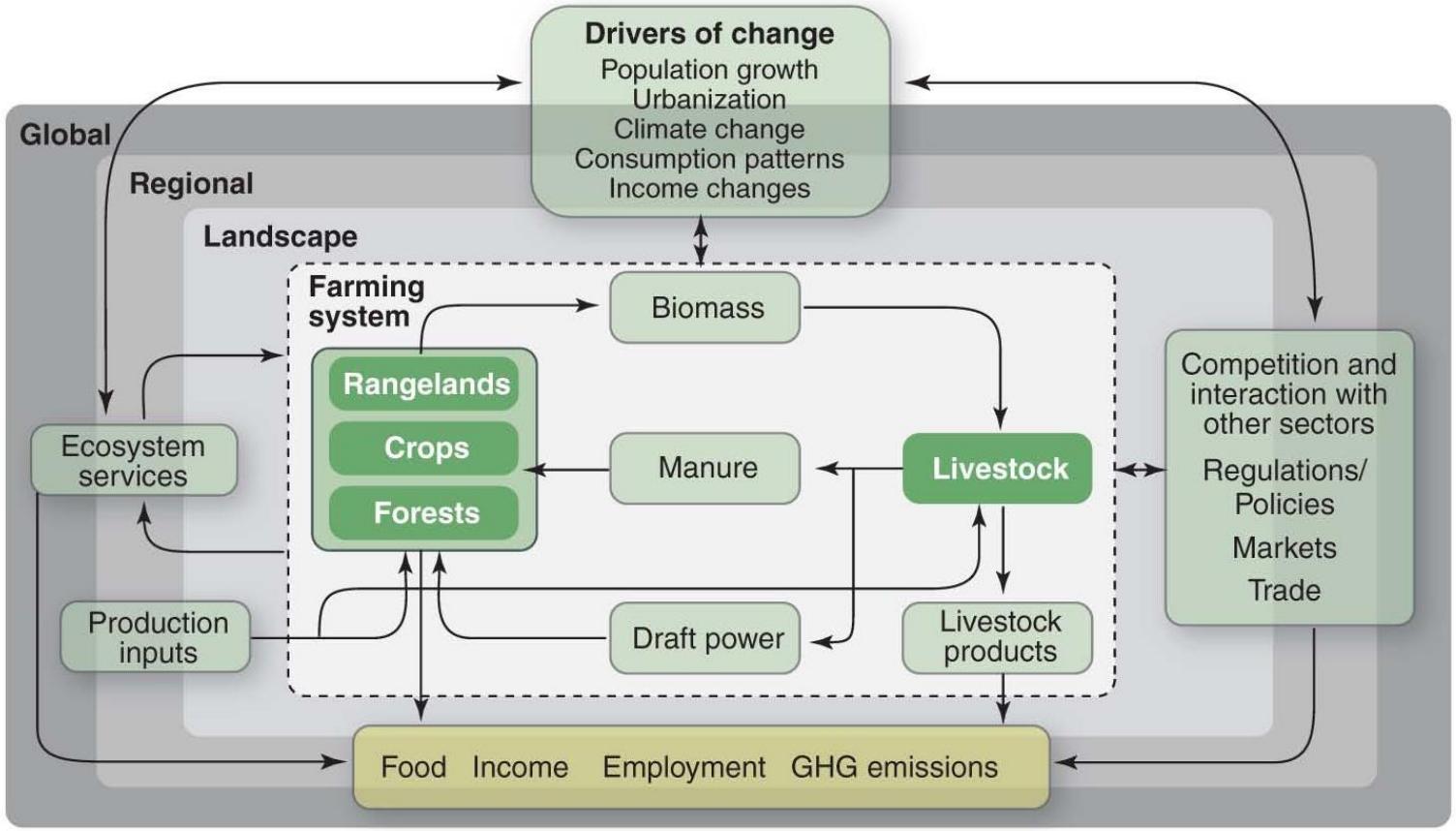




Consistent greater yields in the previously *B. humidicola planted* fields over three years

In conclusion

- Livestock production is well adapted to different climates
- Livestock are a tool for adaptation (e.g. in case of crop failure)
- CC**+** threatens productivity/ sustainability
- Triple-win opportunities exist
- High complexity and inter-linkages with crops, forests, …
- Need for further research



Herrero et al, 2012



Thank you!