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Low Emissions Development

Evidence for reducing emissions from food value chains of smallholders in Africa

15 March 2016

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Low Emissions Development Flagship, CCAFS

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Gund Institute for Ecological Economics — The University of Vermont

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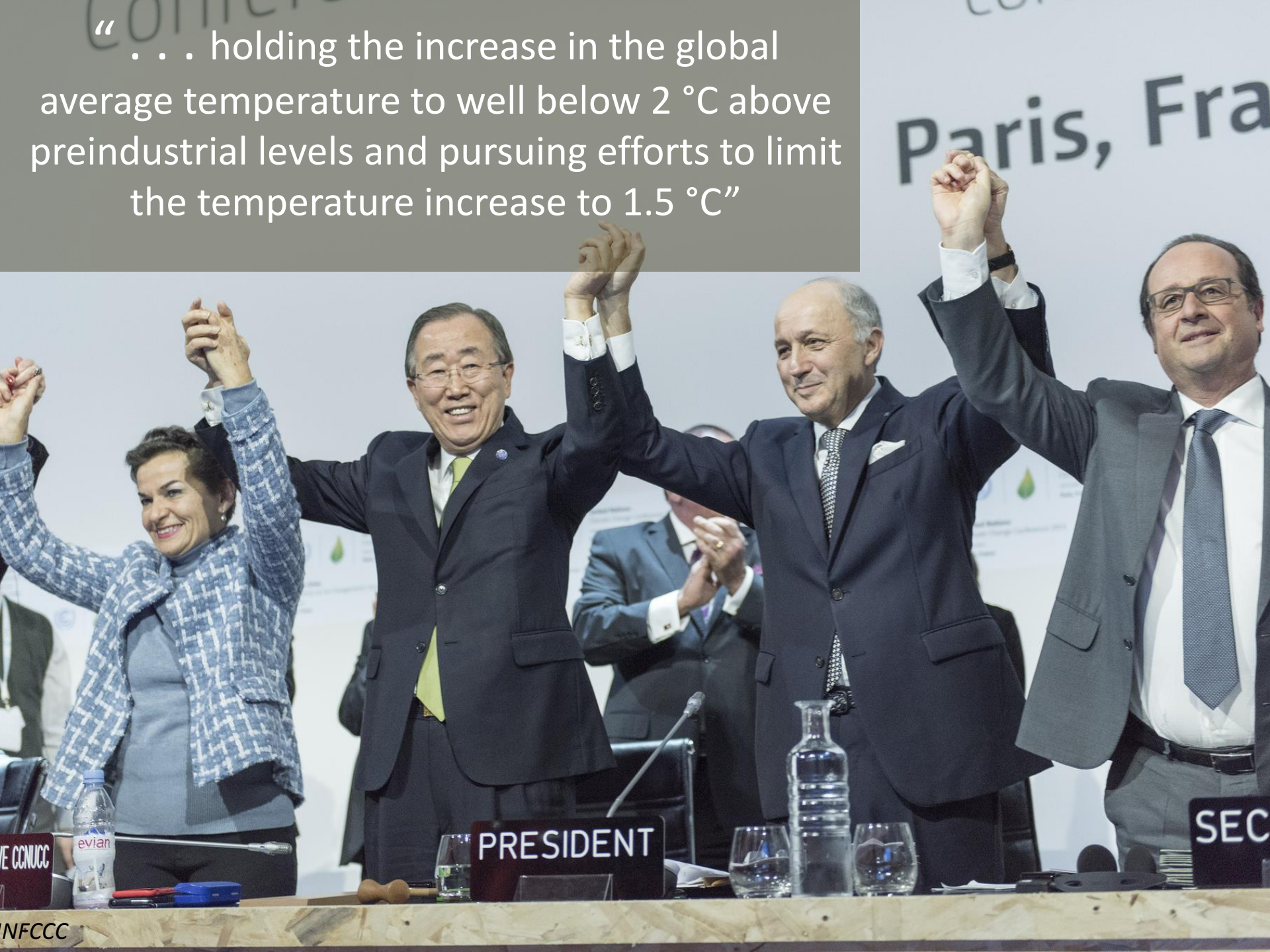
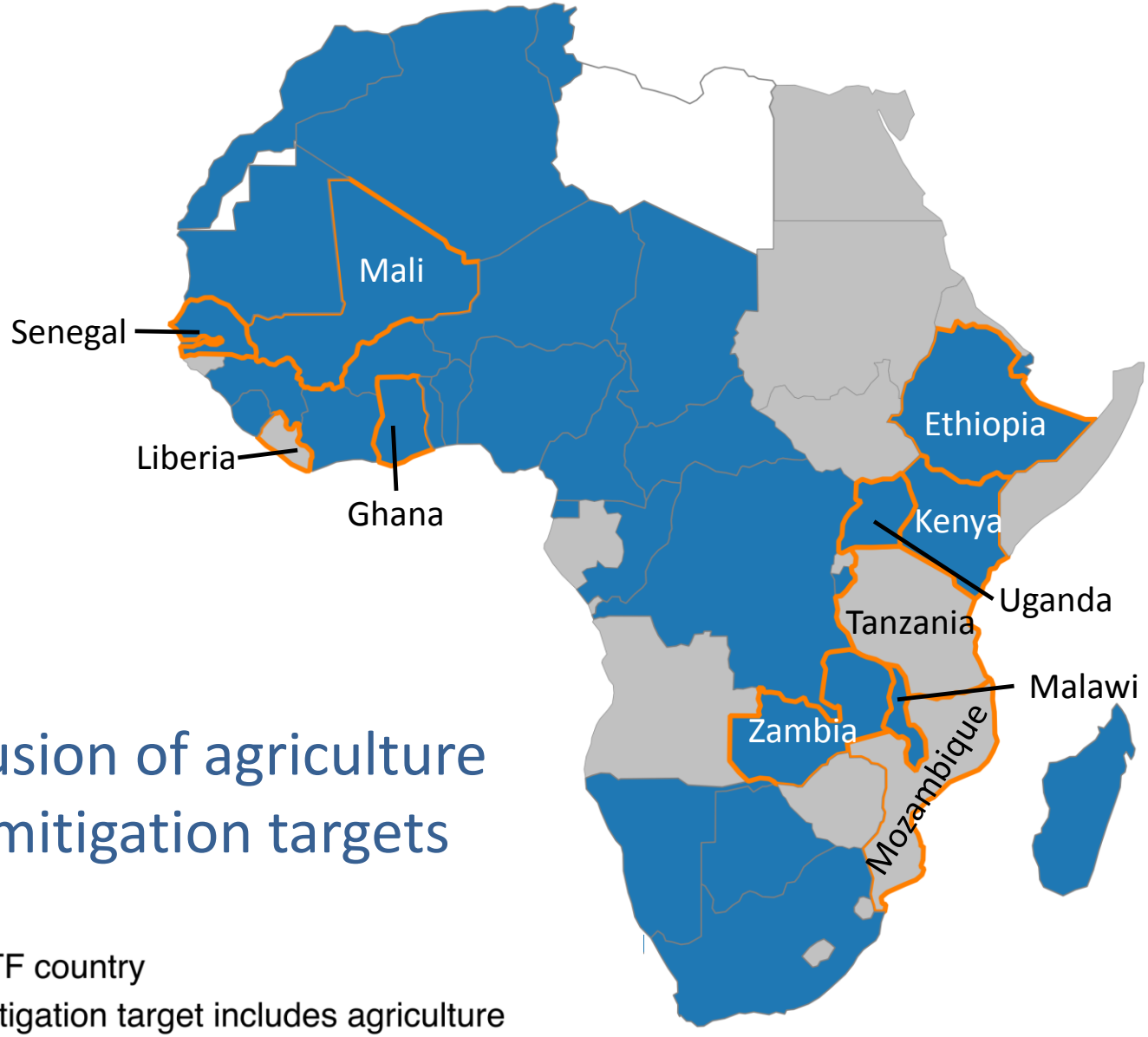
“. . . holding the increase in the global average temperature to well below 2 °C above preindustrial levels and pursuing efforts to limit the temperature increase to 1.5 °C”





Inclusion of agriculture in mitigation targets

FTF country
Mitigation target includes agriculture
Mitigation target does not include agriculture
No INDC

Slide courtesy of M. Richards

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Future food needs will increase emissions

- To meet food demands of the 9 billion: emissions must increase.
- But emissions don't need to increase proportionally: use LED to bend the curve
- **Priority #1: Reduce GHG / unit product (emissions intensity)**

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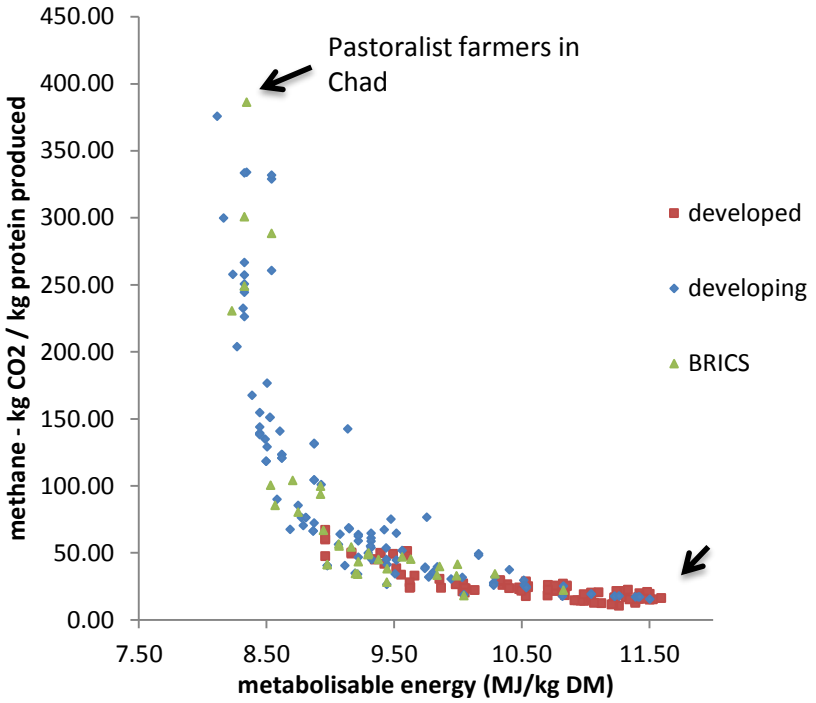
Livestock GHG efficiency

- Livestock intensification reduces emissions intensity up to 20X for beef, 300X for dairy

  (without considering LUC, feed)
- Improve digestibility of feed
- Reduce numbers of animals



Herrero et al. 2013, PNAS

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Nitrogen Use Efficiency

- Increase efficiency of N fertilizer uptake by plants, e.g. timing, rates, deep placement, microdosing
- Increasing NUE from 19 to 75%, decreases emissions intensity by 56% (12.7 to 7.1 g N2O-N/kg N uptake)

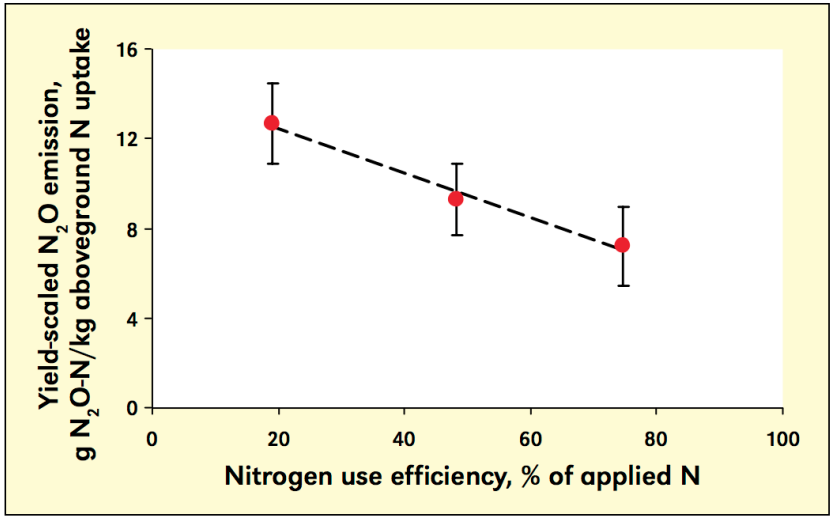

Figure 2. Meta-analysis results of the relationship between N use efficiency and yield-scaled N_2O emissions. NUE is expressed as apparent recovery efficiency (in %) of applied N.

Groenigen et al. n.d.

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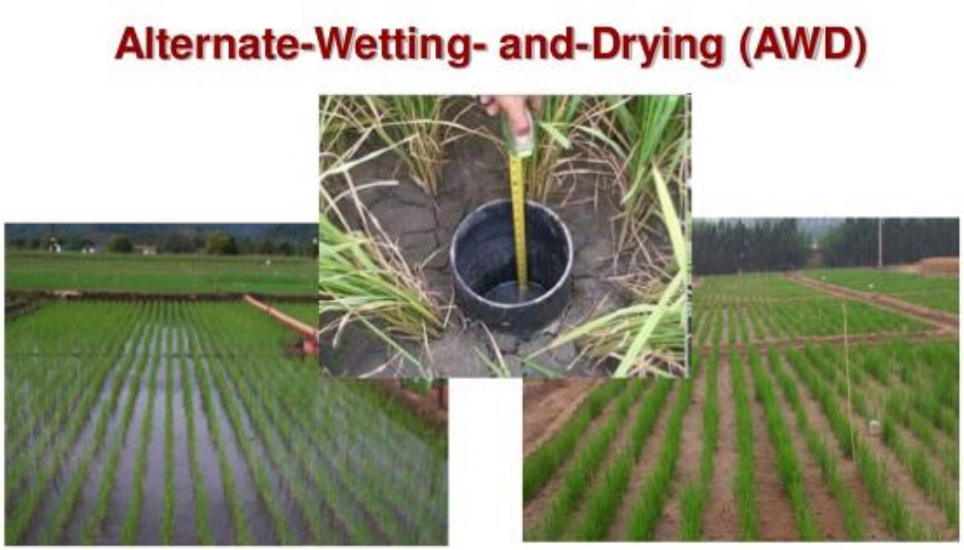
Water use efficiency

- Alternate wetting and drying can reduce CH_4 emissions up to 38% and reduce fossil fuel use
- Unless irrigation introduced



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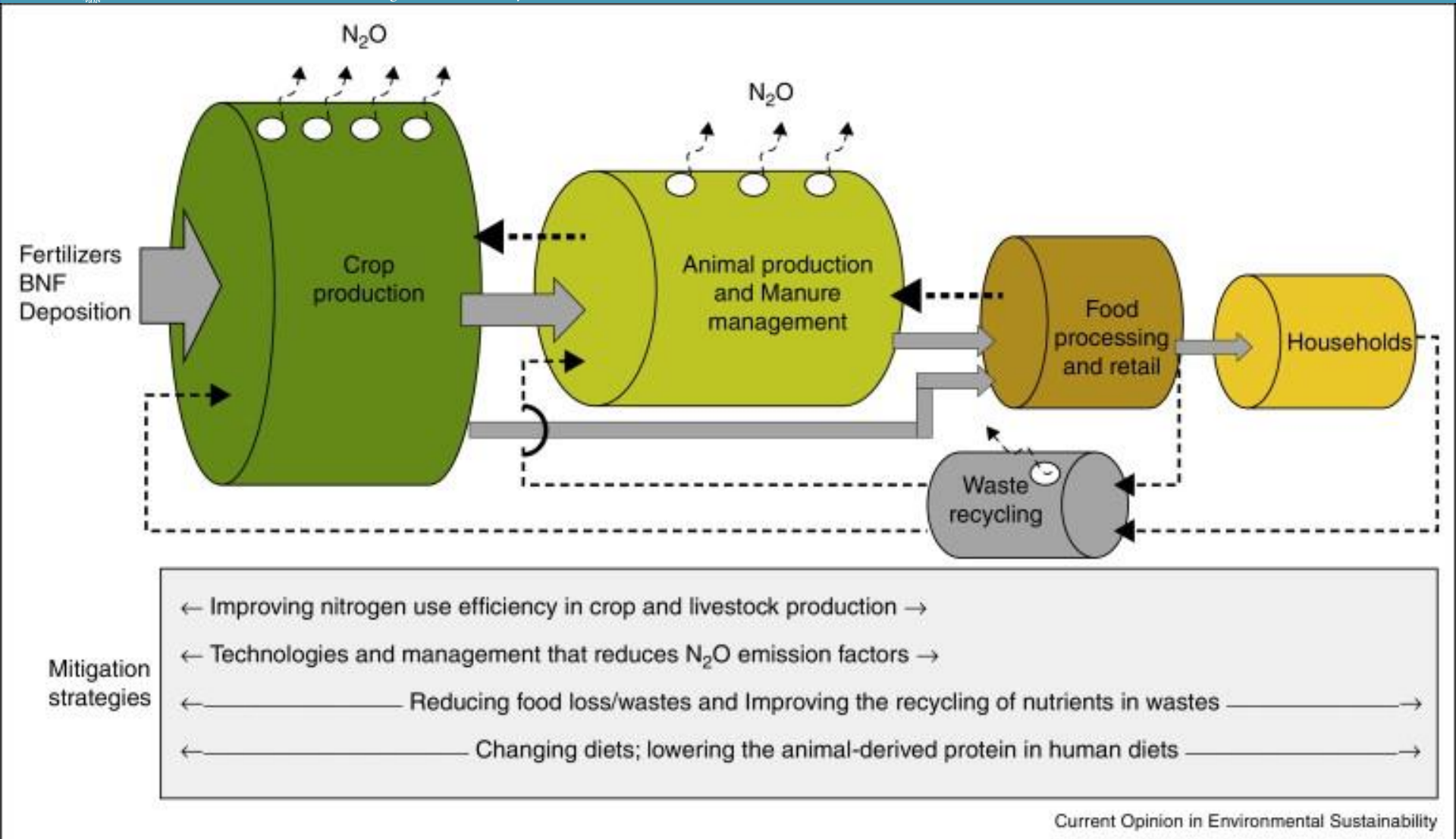
Value chain efficiency



Current Opinion in Environmental Sustainability

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Oenema et al. 2014

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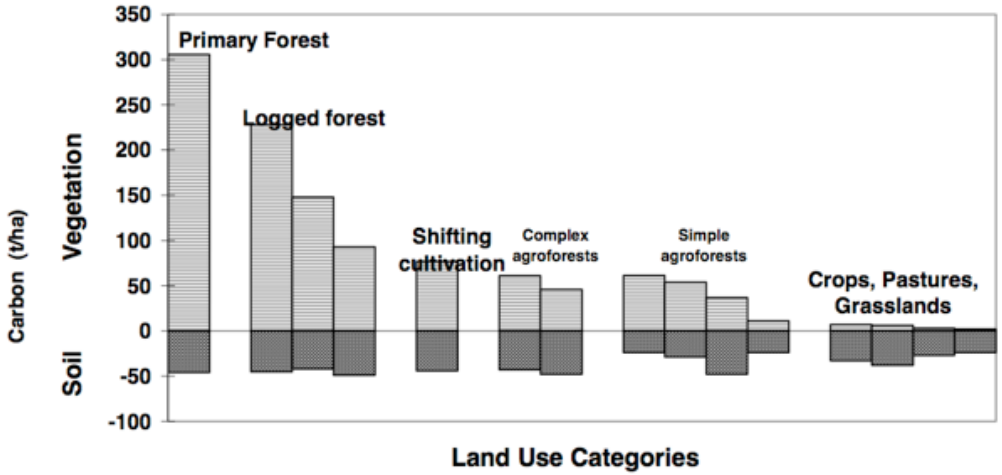
Sequestering carbon

- ***Priority #2: Sequester carbon in soil and biomass to offset emissions****; includes reduced burning and avoided conversion of high carbon landscapes*
- Most synergistic way to help meet countries' NDCs or 2°C target

Figure 3. Above-ground time-averaged and total soil carbon (0-20 cm) for all benchmark sites



Palm 2000: 14

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FtF already produces mitigation co-benefits

2015 CCAFS-USAID GCC-FtF survey shows potential

- **Livestock systems -** improving feeding, animal and herd management; pastureland management
- **Perennial crops-** transitioning annual crops or degraded land; avoided conversion of high carbon landscapes
- **Cereal crops-** building soils through ISFM or CA; nutrient efficiencies through technologies such as fertilizer deep placement; BNI in crops
- **Rice systems-** alternate wetting and drying (AWD) or shorter duration rice
- **Post harvest loss reduction**

LIVESTOCK- REGAL- KENYA

Feed and herd management improvement

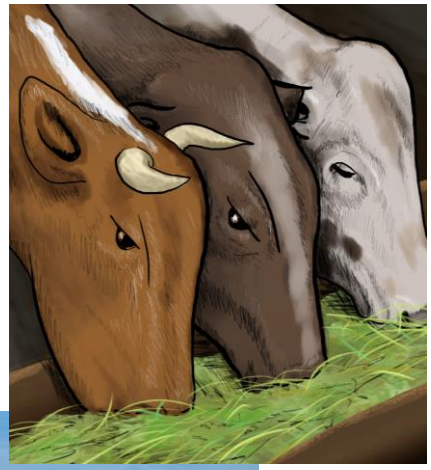
- Yield increase 50%

- Emissions reduction mostly from reducing numbers of animals (10% reduction)
- Some from improved feed (minor)

Emissions intensity decreased

- Cattle 34%
- Sheep 40%
- Goats 40%
- Camels 33%

EI = GHG Emissions / unit product



LIVESTOCK

The opportunity

- Largest source of emissions in Africa

Huge scope for further action, e.g.

- Increase feed quality
- Improve breeds

Constraints

- Social and economic constraints to new practices, especially for extensive systems

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CEREALS - ADVANCE II GHANA

Reduced tillage, crop residue burning reduction, nutrient management, AWD

- Yield increases of 51% - 149%
- AWD in rice - reduced emissions 43%
- Reduced burning and residue increased SOM
- Post-harvest losses reduced from 30 to 10%

Emissions intensity decreased

- Maize 117%
- Soybean 267%
- Irrigated rice 66%

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CEREAL ANALYSIS

The opportunity

- Soil carbon offsets emissions from N fertilizer
- Irrigated rice offers permanent reductions

Further action possible

- Manure management
- Increase NUE
- Short duration irrigated rice

Constraints

- Soil carbon is reversible, takes time to accumulate, variable

LANDSCAPE- BLA ZAMBIA

Better Life Alliance –landscape-level GHG mitigation benefits

Preventing shrubland burning (on roughly 395,000 ha) and shrubland conversion (on roughly 15,500 ha).

Newly established Gliricidia agroforestry (6,500 hectares)

Organic maize: residue management, manure inputs, reduced fertilizer

- Maize yields increased 13% (1.7 to 1.9t/ha)
- Post-harvest losses reduced from 5 to 3%
- Emissions intensity decreased for maize by 213%

PERENNIALS ANALYSIS

The opportunity

- Highest mitigation impact, especially in short-term
- Combining FtF and GCC initiatives
  - Wild certification: Shrubland protection tied to agricultural activities

Further action possible

- More NUE

Constraints

- Disadoption of Gliricidia
- Trade-offs in land available for other food production?
- Carbon sequestration is reversible
- Risk of creating burden on farmers for maintaining carbon

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Conclusion

- USAID programs have mitigation co-benefits: emissions intensities *and* absolute emissions

- Identify LED outcomes and communicate to countries
- What more can be done?
  - Further reduce emissions efficiencies relative to yields
  - Seek absolute reductions to meet climate targets, including carbon sequestration
  - Assess economic and social feasibility of implementing practices at scale
  - Prioritize practices applicable at large scales
  - *Competitiveness with other options and need for rapid uptake will be major constraints, so incentives and support beyond the farm level needed*

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GENERAL RESOURCES

- IPCC 4th and 5th Assessment reports; IPCC Good practice guidelines
- CCAFS and GACSA Practice briefs https://ccafs.cgiar.org/publications/csa-practices-and-technologies
- Mitigation Options Tool: https://ccafs.cgiar.org/mitigation-option-tool-agriculture#.VubD4scbI4E
- FAOSTAT emissions database: http://faostat3.fao.org/download/G1/GT/E
- FAO MICCA website
- FAO: Tackling Livestock: http://www.fao.org/docrep/018/i3437e/i3437e00.htm
- Strategies for mitigating climate change in agriculture http://www.climatefocus.com/sites/default/files/strategies_for_mitigating_climate_change_in_agriculture.pdf

SOME SCIENCE

- Quantifying emissions - samples.ccafs.cgiar.org
- Identifying secure and low carbon food production practices: A case study Bellarby et al 2014. https://ccafs.cgiar.org/es/node/51558#.VubF_scbI4E
- Does conservation agriculture deliver climate change mitigation through soil carbon sequestration in tropical agro-ecosystems? Powlson et al. 2016
- Limited potential of no-till agriculture for climate change mitigation Powlson et al. 2014
- Current and future nitrous oxide emissions from African agriculture – Hickman et al. 2011 http://www.millenniumvillages.org/uploads/ReportPaper/Current-and-future-nitrous-oxide-emissions-from-African-agriculture.pdf
- Science to support climate smart agricultural development (East Africa) http://www.fao.org/3/a-i4167e.pdf

- Small group discussions (20 min)
  - What practices could you support to improve LED outcomes while still prioritizing FtF goals?
  - What further information or evidence would you need to achieve these outcomes?

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PERENNIALS- AGP-AMDe ETHIOPIA

5 million new coffee tree seedlings provided to farmers

Perennial Renovations- Increasing coffee density and replace worn perennial plants.

- Carbon sequestration from increasing density from 2500 to 3300/ha- 1.7 tCO_2e per hectare
- Increased yields, increased 41%
- Post-harvest loss, reduced 18 to 11%
- Emissions intensity, decreased 34%

New perennial expansion - transitioning annual to perennials crops and improved practices - sequester significant carbon (-13.4 tCO_2e per hectare) in soils and above ground biomass.

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IPCC emissions factors and uncertainty levels

Emissions source	Range of emissions factors for tropical* conditions	Unit	Uncertainty/error for Tier 1 emissions factors
Biomass C storage	12 to 228	t C/ha/yr	6-126%
Relative stock change in soil C	0.48 to 144	t C/ha/yr	26% (7 - 61%)
N_2O fertilizer	0.01	kg N_2O-N/kg N	0.003 - 0.30
CH_4 paddy rice	1.3	kg CH_4/ha/day	0.8-2.20
CH_4 Enteric fermentation - dairy cattle	46 to 72	kg CH_4/head/yr	30-50%
CH_4 manure	1 to 2	kg CH_4/head/ yr	30%
N_2O urine	0.32 to 1.57	kg N/1000 kg animal mass/day	50%

*if scaling factors used, ranges from 0.35 to 1.34

*warm wet/warm moist

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LED- REDUCING THE IMPACT OF LIVESTOCK GHG EMISSIONS THROUGH IMPROVED PRODUCTIVITY

John Goopy/ Polly Ericson. International Livestock Research Institute

Photo credit: Name/Organization

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THREE THEMES

- Setting the Stage – Can we reduce total GHG emissions from Livestock production systems? Is it just as good to reduce emissions intensities(EI)? Measurement, Mitigation …..or Both?
- Dairy/Mixed Smallholder Systems. Opportunities and Challenges.
- Pastoralist Systems what can we do?

1. CAN WE REDUCE LIVESTOCK GHGS?

- YES – BUT WE MAY NOT WANT TO.
- MAJORITY OF LIVESTOCK GHGS COME FROM ENTERIC FERMENTATION – OBLIGATORY DIGESTIVE PROCESS OF RUMINANTS.
    - SUPRESS METHANOGENSIS OR GET RID OF RUMINANTS
- Why not? Digestion, Integration, Protein, Diversification

WHAT ABOUT EMISSIONS INTENSITY?

- Emissions are driven by INTAKE
- Emissions Intensity (EI) is driven by ANIMAL PRODUCTIVITY.
- INTAKE is used by the animal for two things: BODY MAINTENANCE and GROWTH/PRODUCTION.

The Maintenance requirement is constant AND CAN'T BE TURNED OFF.

Ruminants in "Western" systems may use as much as 50% of food eaten for "production". For ruminants in SSA this may be as little as 10% or even 5% - POOR NUTRITION and LITTLE of it

MEASUREMENT DOESN'T PROVIDE MITIGATION. BUT IT DOES ALLOW US TO MEASURE THE EFFECTIVENESS OF WHAT IS DONE- AND PROVIDES CLUES FOR WHAT MAY WORK

- What we know:
  - No measurements of GHGs and very little of animal productivity in SSA
  - Feed and diets are very different to Europe/USA.
  - Important assumptions in models are largely violated in Smallholder systems.
- What we know we don't know
  - Animal productivity parameters
  - Feed parameters
  - Fate of animals and products
  - The effects of sub-maintenance feeding on GHG emissions
- What we need (to know)
  - Quantitative, empirical knowledge of animals, husbandry, feeds, markets
  - This is why (Next slide)

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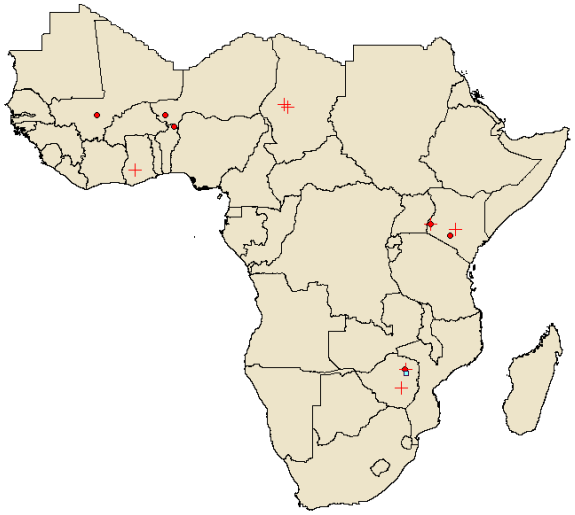
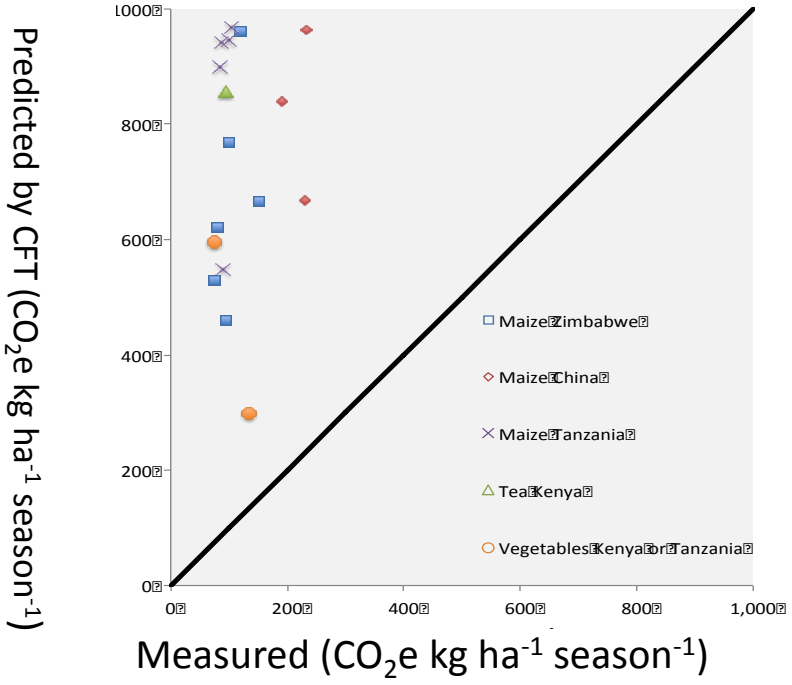
WHY WE NEED EMPIRICAL STUDIES

Why are the emission factors incorrect?

- Limited dataset
  - Models use emission factors from other regions
  - These other regions have different climate / soils / management / animal breeds, etc



Prediction error for smallholder cropping systems using the "cool farm tool"



Richards et al. in prep

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2. DAIRY/MIXED SMALLHOLDER SYSTEMS

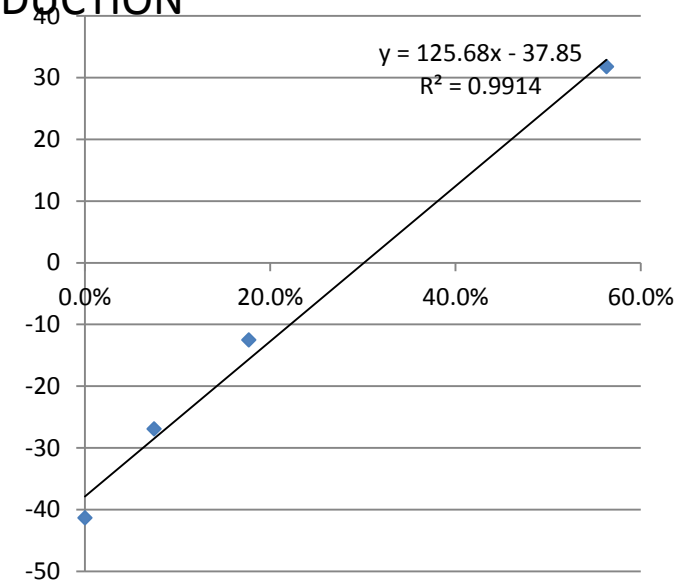
- WHY??? A. Mitigation Potential (MP)
- MP = LIVESTOCK (Nos X Size) * Effective intervention(s)* Uptake
- E African Smallholder systems have the greatest MP because:
  - Densely populated with Large cattle herd (1-5/farmer)
  - Effective interventions around improved crop/livestock nutrition
  - Established, unmet, market need for product (Milk)
  - Greater numbers of farmers have “commercial” focus – will respond to price signals
  - Huge productivity gains are feasible without concentrate use
    - From 2.5 up to 10L/d
    - Age at first calving down from 4 to 2.5 years

MIXED SYSTEMS – WHAT DO WE KNOW?

- Livestock feeding is based on grazing + stover (maize, wheat rice sorghum) + small amounts of purchased feed (including concentrate)
- Thus, farm outputs highly interdependent Crop > Livestock > Manure
- So, low N soil content > low crop yields+ poor quality stover> poor animal performance and low intake> Low manure N (<50% IPCC estimates) etc
- Human food crops can't be displaced for animal feed in a low productivity environment.
- BUT! Opportunity for WIN (Human) WIN (Animal) Win (environment) scenario.
- Increasing Productivity SUSTAINABLY has positive effects on all farm outputs

FEEDING SWEET POTATO VINE SILAGE IMPROVES ANIMAL PRODUCTIVITY WITHOUT DIVERTING RESOURCES FROM HUMAN FOOD PRODUCTION

- A strong, positive and linear relationship between SPVS inclusion rate, and LW change



Variable	Control	20% SPVS	40% SPVS	80% SPVS	SEM
% of SPVS as DM	0.0%	7.5%	17.7%	56.3%	
Intake as fed	333.5^{a}	408.5^{a}	616.3^{b}	1,465.5^{c}	118.36
DMI	302.2^{a}	332.1^{a}	436.9^{b}	597.9^{c}	31.55
DMI %LW	1.68%	1.85%	2.43%	3.32%	
LW gain (g/d)	-41.3^{a}	-26.9^{a}	-12.5^{a}	31.7^{b}	6.92

Relationship between DM inclusion rate of SPVS silage in diet and Live weight change (g/d) in growing lambs receiving a basal diet of maize stover

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PASTURE LEGUMES!

- Intercropping pasture legume (Desmodium ssp) with maize:
  - Increases grain yield (150-300%) (+Humans)
  - Controls parasites (Striga) (+ Humans)
  - Improve yield and quality (N content) of stover (+Animals)
  - Provides very high quality feed (up to 22%CP) for ruminant livestock (+Animals)
  - Increases soil C and N, (+Environment)
  - Seems to improve water holding capacity
    - (Preliminary data only courtesy ICIPE).
  - WE KNOW THIS IS POSITIVE, but we need to be able to quantify the effects

SO WHAT ARE THE CHALLENGES?

- JUST 2
  1. We need to do measurements – of animal productivity, of soils, of feeds – even of GHGs!
     - We know we can't trust models based on data from developed economies
     - We need to know where we start from so that we can measure where we get to.

2. Getting the message out: dissemination > adoption
   - Farmers are (very) conservative
   - Knowledge about livestock is very poor
   - NGO fatigue
   - We work hard to collaborate with our partners

3. PASTORAL SYSTEMS: WHAT CAN WE DO?

- LIMITED ENGAGEMENT AROUND LED (OTHER MAJOR WORK:IBLI)
- WHY? LOW MP!!!
  - LOTS OF LIVESTOCK but..
  - FEW EFFECTIVE INTERVENTIONS AVAILABLE
  - POORLY DEVELOPED SUPPLY CHAINS AND LOW INTEREST IN COMMODIFYING LIVESTOCK

  - “Potential” exists, but difficult to see how this can be realised

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OPTION 1:IMPROVED PASTURE MANAGEMENT

- Better management of pastures (modified cell grazing) can:
  - decrease erosion and improve water penetration.
  - Increase sustainable stocking rates
  - Increase Soil C stocks (up to 2% of biomass)
- BUT unclear land tenure and communal rights tend to encourage overgrazing and make the required management difficult to achieve

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OPTION 2 – COMMODIFYING LIVESTOCK

- In the absence of any other change, creating a strong supply chain that will encourage the regular off-take of livestock at an equitable sale price, would greatly improve the productivity of land under pastoralist management.
- However, it is difficult to conceive the conditions under which this would be enthusiastically received.

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THANKS FOR YOUR ATTENTION

(Any Questions?)

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