Food and Agriculture Organization of the United Nations

Animal Production and Health Division

Modeling livestock productivity under climatic constraints – implications for input data

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Why do we need remote sensing data on pastures?

Carbon sequestration

Land degradation

Biodiversity

GHG emissions

…

Food security and nutrition

→ Impact of climate change on pasture productivity and livestock productivity

And what type of information?

NDVI/Biomass ≠ Feed

Field scale vs landscape or even global

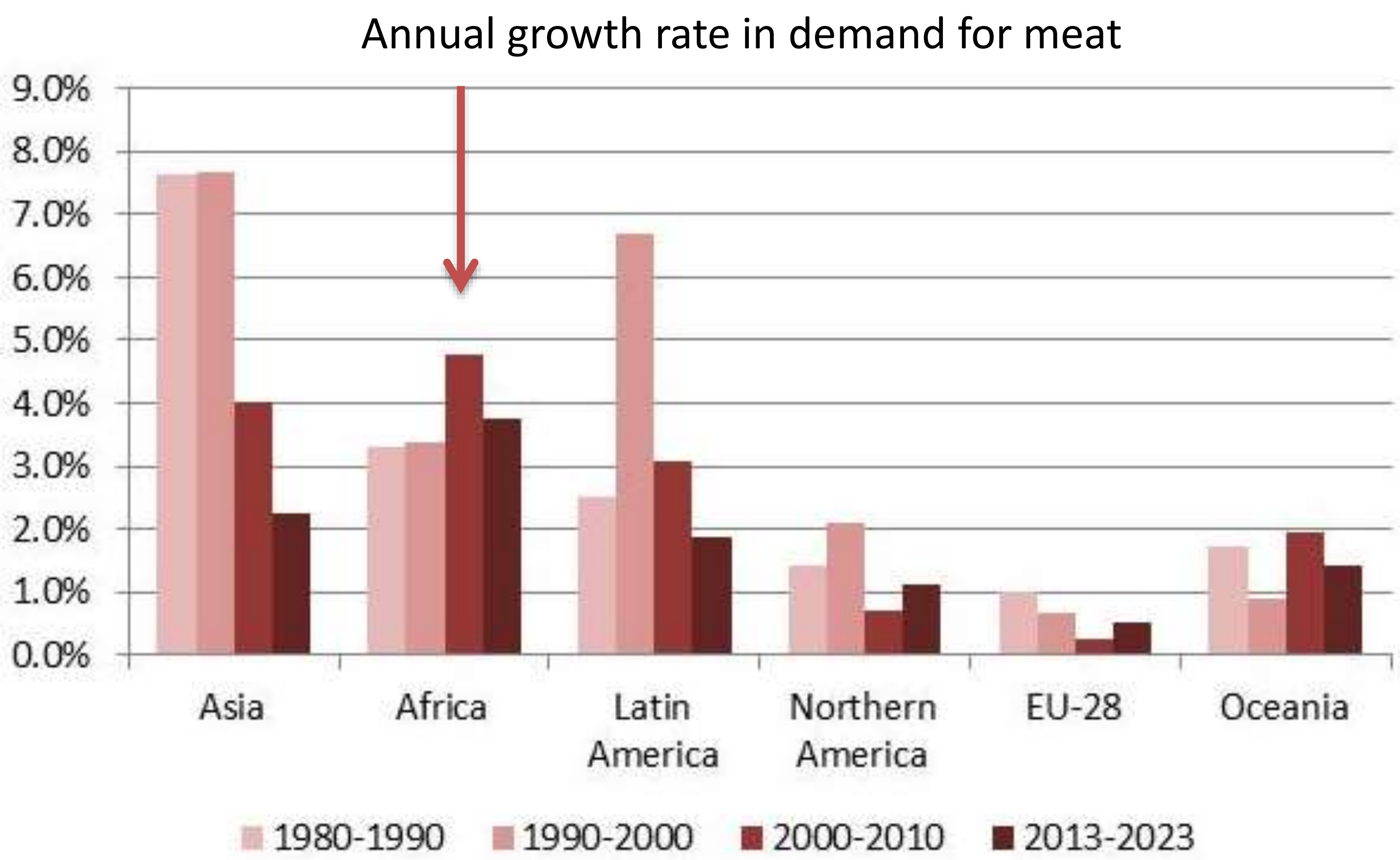
Dry season vs rainy season

Stratification (grass under tree cover)

Climate scenario

…

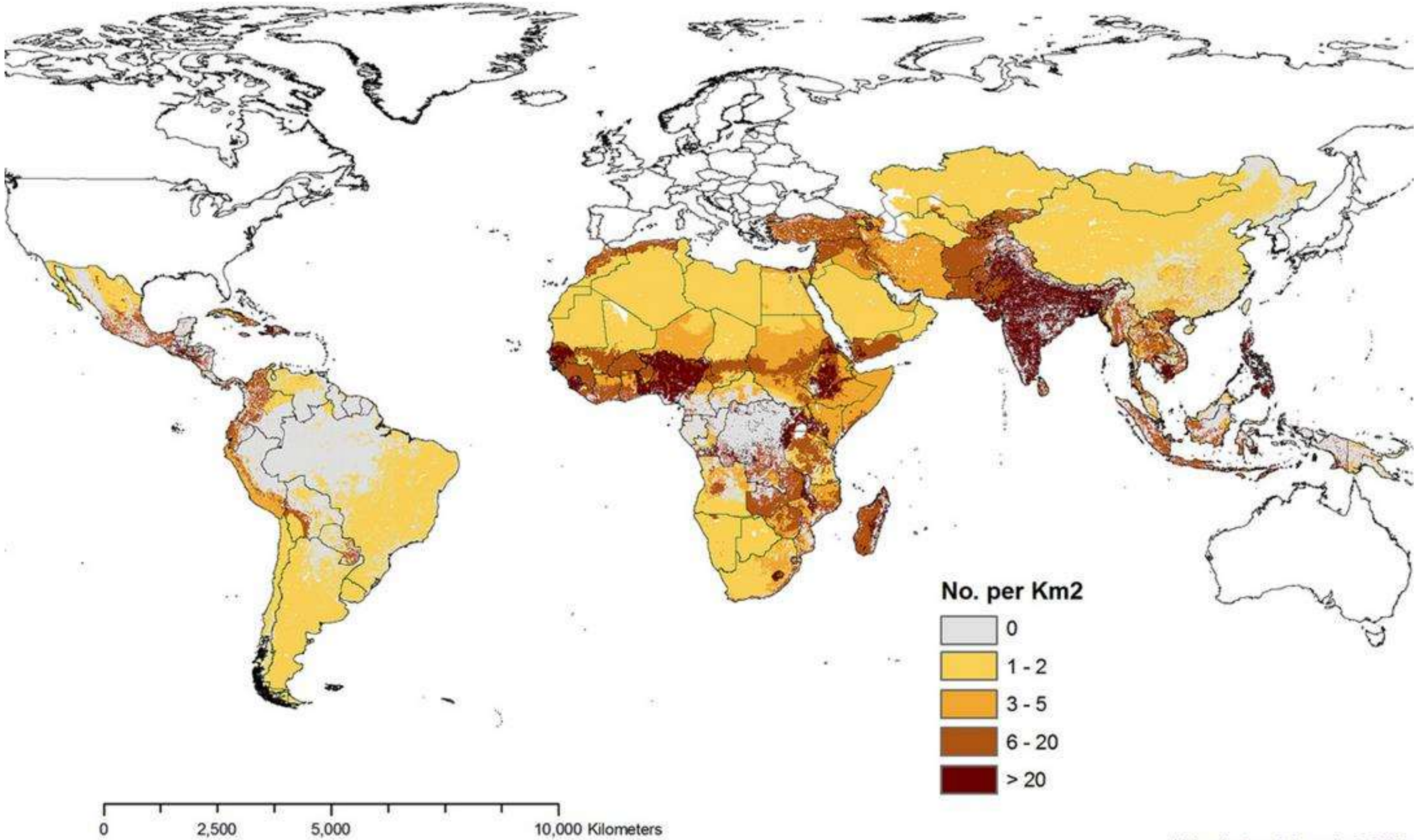
Geographical focus



Source: FAOSTAT & FAO-OECD Agricultural Outlook

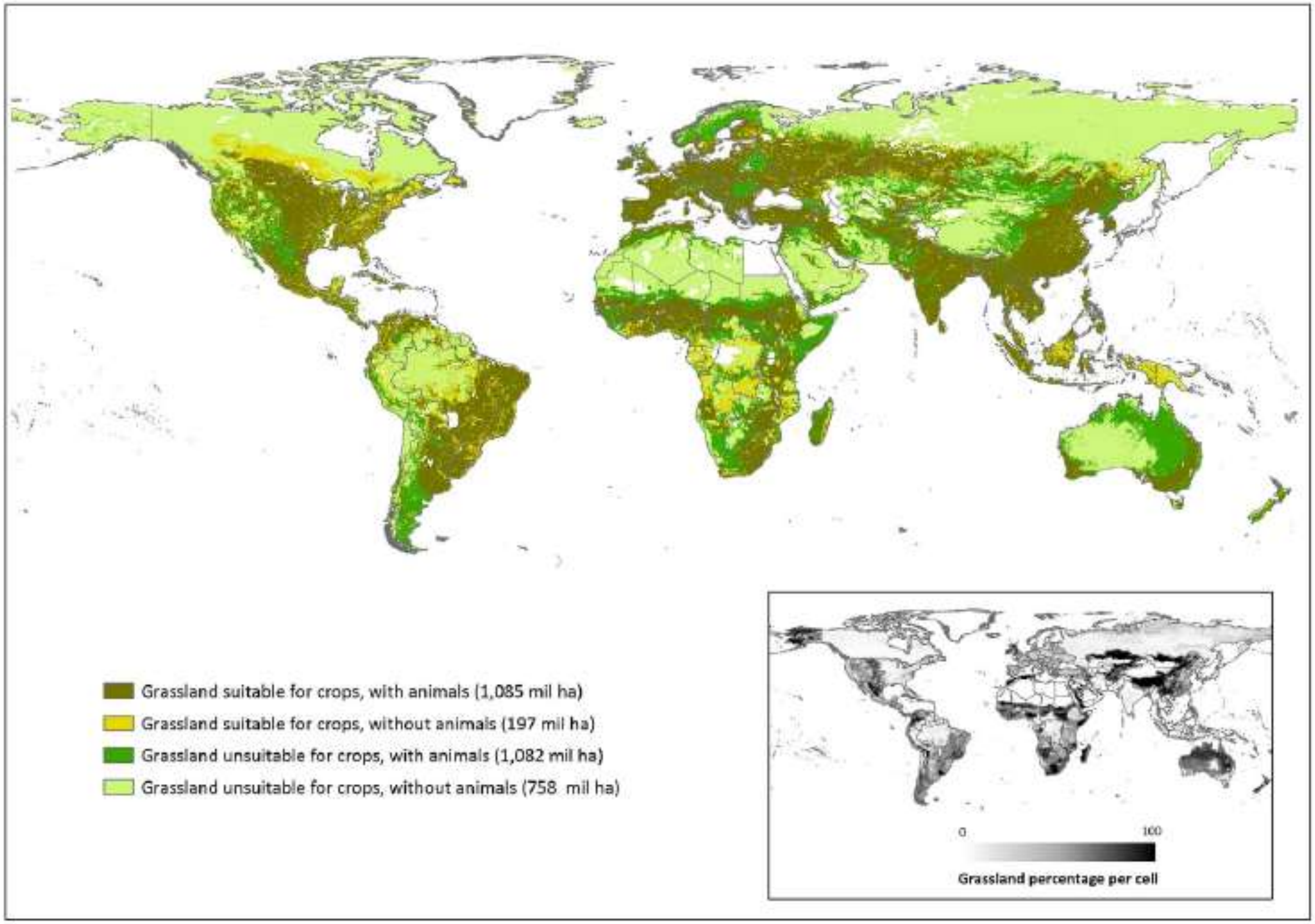
Geographical Focus

Density of poor livestock keepers



*Update: March 2012
Source: ILRI

Where are livestock on grasslands?



Map 1. Global grasslands suitable and unsuitable for crop production and share in land-use. Threshold of 25% ratio of actual/potential yield used for suitability, as defined by IIASA/FAO (2012). Livestock distribution based on Gridded Livestock of the World (Robinson et al., 2014).

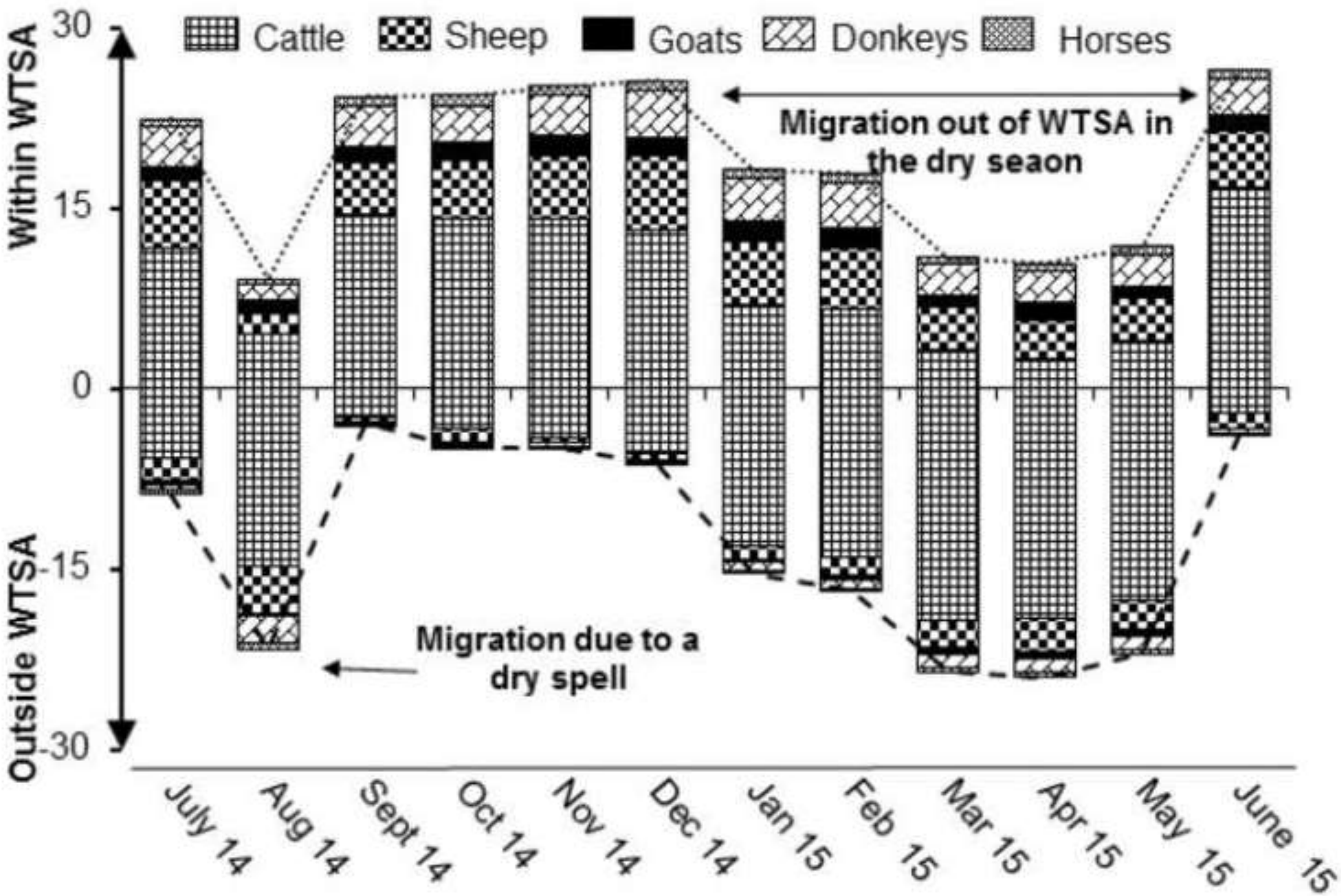
Land use for livestock grazing and feed

Table 2
Global land-use for forage and feed production by regions and species (million ha).

		Grasslands suitable for crops	Grasslands unsuitable for crops	Cereal and legume silage, fodder beet	Cereals grains	Oil seed and oil seed cakes	Other crops[a]	By-products[b]	Crop residues[c]	Total
Non OECD	Cattle & buffaloes	436.2	442.6	46.8	42.7	22.7	0	22.1	100.7	1113.8
	Small Ruminants	139.9	769.6	9.1	0.7	0.9	0	2.1	17.8	940.1
	Poultry	0	0	0	73.8	43.4	0.7	1.4	0	119.23
	Pigs	0	0	0	24.7	27.0	1.4	2.8	4.2	60.1
OECD	Cattle & buffaloes	88.5	40.0	9.6	28.0	8.2	0	3.7	2.2	180.2
	Small Ruminants	20.3	12.2	0.4	0.9	0.2	0	0.5	0.9	35.4
	Poultry	0	0	0	19.3	16.9	0.0	0.0	0	36.2
	Pigs	0	0	0	20.4	12.0	0.8	0.5	0.3	34.0
World	Cattle & buffaloes	524.7	478.5	56.5	70.7	30.9	0	25.8	103.0	1290.1
	Small Ruminants	160.3	781.8	9.5	1.6	1.1	0	2.6	18.6	975.5
	Poultry	0	0	0	93.1	60.3	0.7	1.4	0	155.5
	Pigs	0	0	0	45.1	39.0	2.5	3.3	4.4	94.0
	All	684.9	1260.4	65.9	210.5	131.3	2.9	33.1	126.0	2,505.6

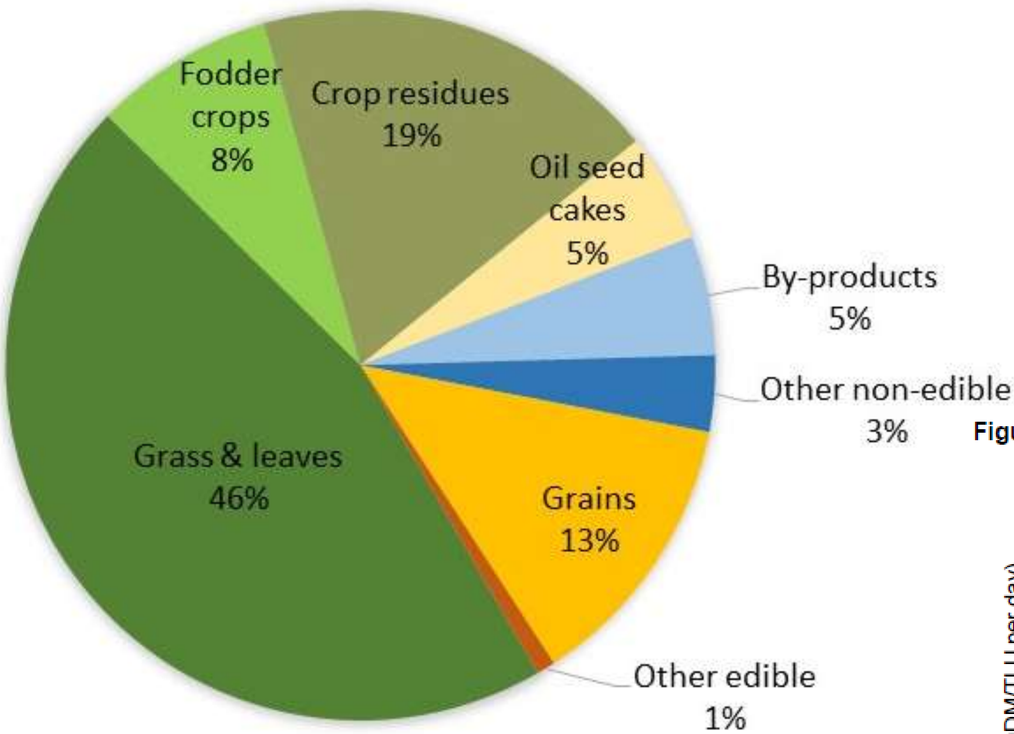
[a] Pulses, cassava and banana
[b] Corn gluten feed and meal, brans, middling, molasses, sugar beet pulp, and by-products from breweries, distilleries and biofuels
[c] Straws, sugar cane tops, banana stems

But.. livestock presence can be seasonal



Source: Assouma et al., Animals, submitted

Grass is almost half of the global livestock feed intake

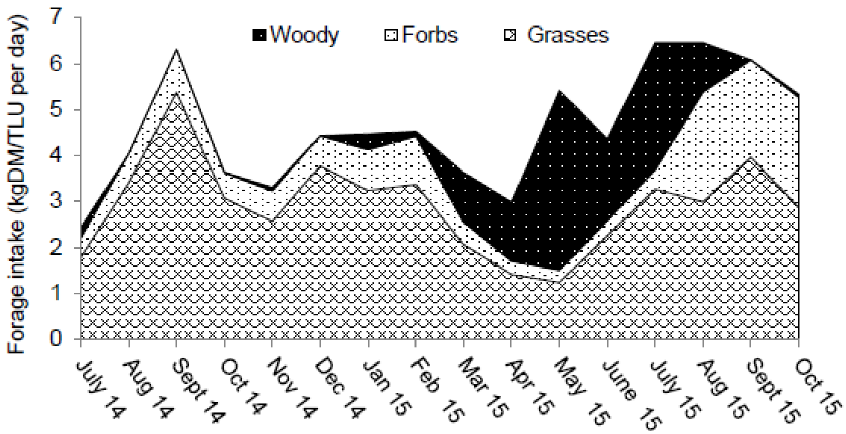


Fodder crops: grain and legume silage, fodder beets
Crop residues: straws and stover, sugar cane tops, banana stems
By-products: brans, corn gluten meal and feed, molasses, beetroot pulp and spent breweries, distilleries, biofuel grains
Other non-edible: second grade cereals, swill, fish meal, synthetic amino acids, lime
Other edible: cassava pellets, beans and soy beans, rapeseed and soy oil

Source: Mottet et al., 2017, Global Food Security

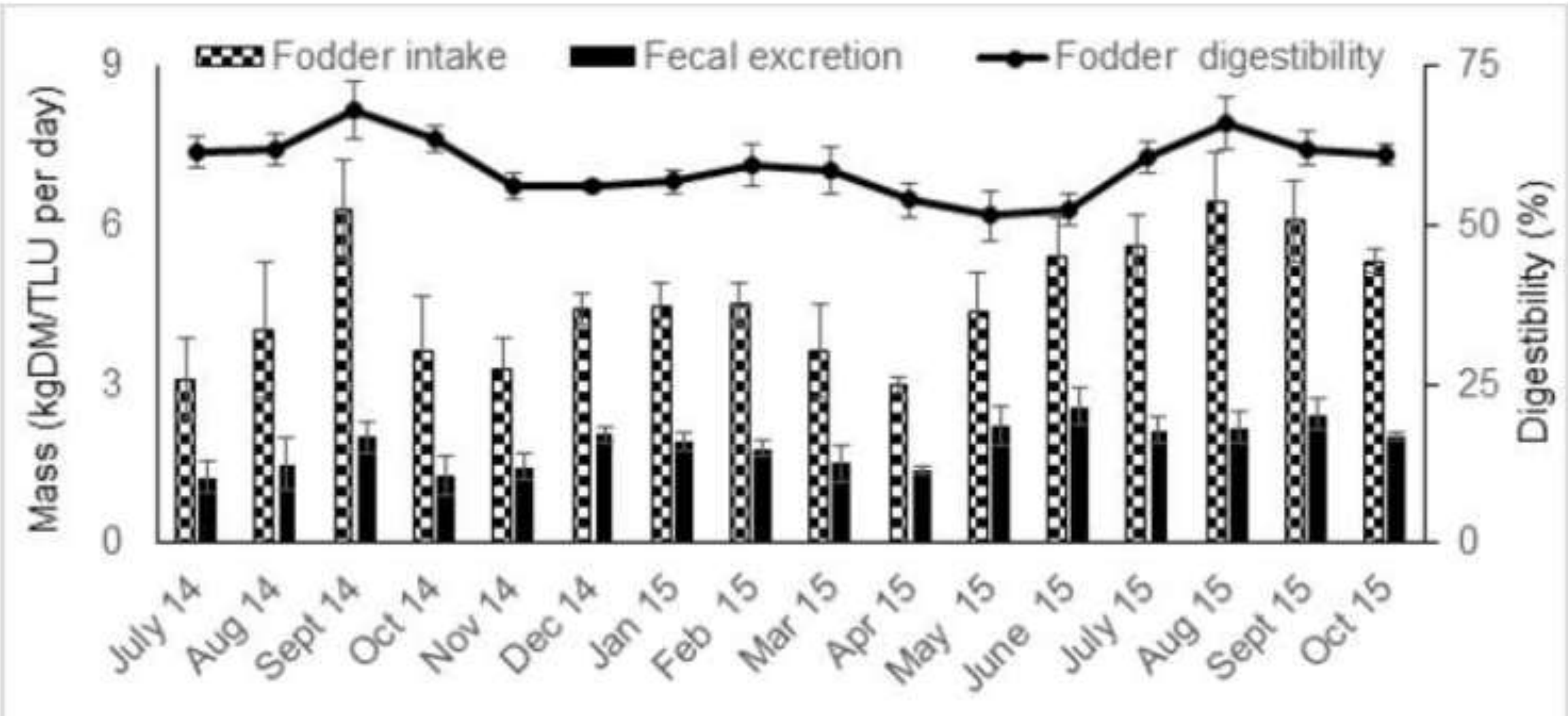
Daily dry matter intake varies between 4 and 8 kg/day for large ruminants

Figure S2. Variation in the composition of the cattle feed intake over time.



Source: Assouma et al., Animals, submitted

Fodder's digestibility is also seasonal



Source: Assouma et al., Animals, submitted

Our questions

- What is the impact of climate change on livestock and food security?
- What is the role of livestock in improving resilience to climate change?
- What **<u>options</u>** for improving adaptation to climate change?

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Global Livestock Environmental Assessment Model (GLEAM)

Model description | Results | In practice | Resources | Team | FAQs

What is GLEAM?

The Global Livestock Environmental Assessment Model is a GIS framework that simulates the bio-physical processes and activities along livestock supply chains under a life cycle assessment approach.

The aim of GLEAM is to quantify production and use of natural resources in the livestock sector and to identify environmental impacts of livestock in order to contribute to the assessment of adaptation and mitigation scenarios to move towards a more sustainable livestock sector.

GLEAM model in brief

GLEAM is a modelling framework that simulates the interaction of activities and processes involved in livestock production and the environment. The model can operate at (sub) national, regional and global scale.

GLEAM differentiates key stages along livestock supply chains such as feed production, processing and transport; herd dynamics, animal feeding and manure management; and animal products processing and transport. The model captures the specific impacts of each stage, offering a comprehensive and disaggregated picture of livestock production and its use of natural resources.

Features

GLEAM is designed to analyze multiple environmental dimensions, such as feed use, greenhouse gas emissions, land use and land degradation, nutrient and water use and interaction with biodiversity. The main features of the current version of GLEAM are:

- Systematic, global coverage of six livestock species and their edible products: meat and milk from cattle,

New!

Webinar: demonstration of GLEAM-i, a Tier 2 simulation tool for the livestock sector

GLEAM-i: a tool to support countries tackling climate change through livestock

Related links

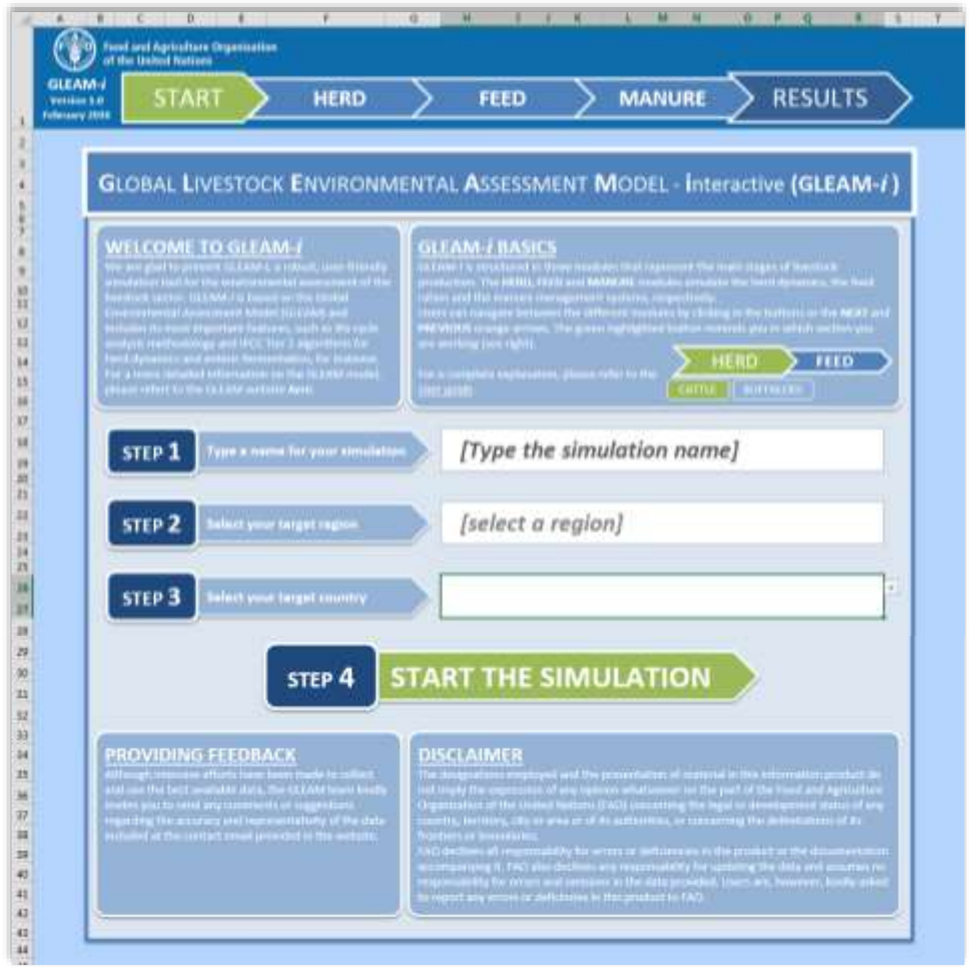
Global Agenda for Sustainable Livestock

Livestock Environmental

GLEAM-i (interactive)

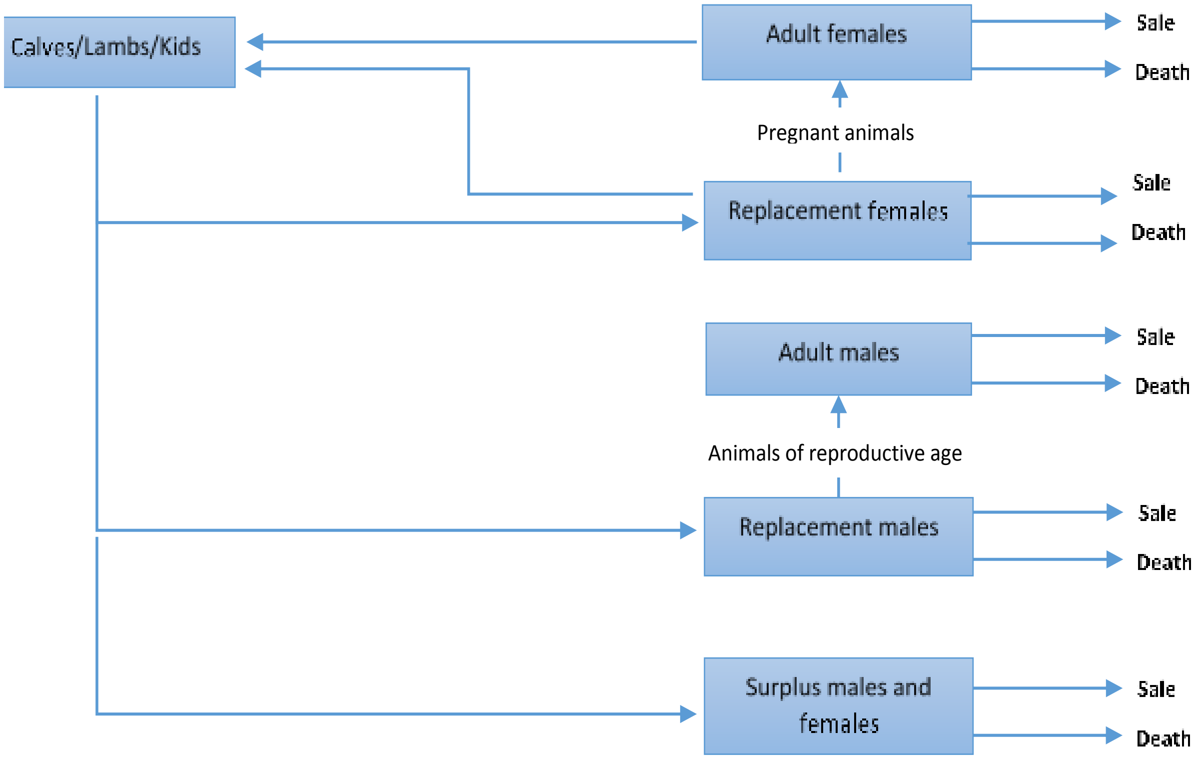
Publicly available, user-friendly tool for calculating livestock production, feed use and GHG emissions using Tier 2 methods in a single Excel file

http://www.fao.org/gleam/resources



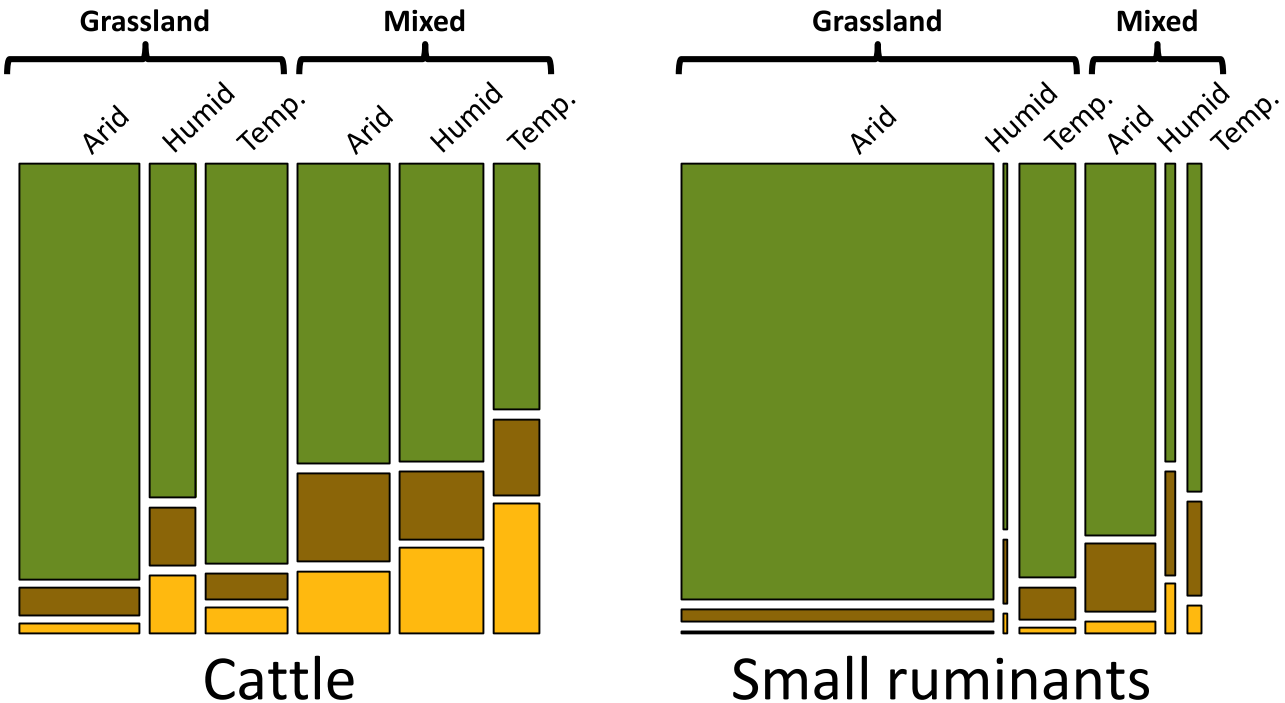
GLEAM - Herd

- Distribution: **Gridded Livestock of the World (Robinson et al., 2011)** based on GLC, MODIS and GPW
- Repartition in cohorts & production systems
- Detailed energy requirements



GLEAM – Feed rations

- Feed basket (30 feed components for ruminants)
- Grouped into 3 main feed categories
- Availability based on IIASA- FAO GAEZ 3.0



Global feed intake of ruminants

- Grass
- Crop residues
- By-products

INPUT DATA

Roughages share[1]: total share of roughage feed materials as input from existing database and expert opinion (in percentage).

Total Roughages = 70 %

Roughages availability[2]: total dry matter of roughages available (in kg). Leaves and imported hay are added if necessary.

GRASSF = 7	RSTRAW = 7	MSTOVER = 6
GRASSH = 3	WSTRAW = 9	SSTOVER = 5
GRAINSIL = 8	BSTRAW = 3	TOPS = 4
MAIZESIL = 1	ZSTOVER = 2	FDDRBEET = 2

Roughages availability = 57 kg

Leaves and hay: in case of diet deficiency, LEAVES and GRASSH2 are added to fulfill feed requirements according to the live weight of the animals (in kg).

LEAVES = 1 GRASSH2 = 2

Roughages, leaves and hay = 60 kg

By-products share[1]: total share of by-products fed individually (in percentage).

Total By-products = 20 %

By-products availability[2]: total dry matter of by-products available (in kg).

MLSOY = 6	MLCTTN = 7	MOLASSES = 9
MLRAPE = 4	PKEXP = 3	GRNBYDRY = 2

By-products availability = 31 kg

Concentrate share[1]: total share of compound feed (in percentage).

Total Concentrate = 10 %

Concentrate composition[3]: composition of concentrate feed as input from existing database and expert opinion (in percentage).

GRAINS = 6	MLCTTN = 7	BPULP = 8
CORN = 8	PKEXP = 12	MOLASSES = 9
MLSOY = 10	MZGLTM = 9	GRNBYDRY = 11
MLRAPE = 5	MZGLTF = 5	GRNBYWET = 10

Total = 100 %

INTERMEDIATE CALCULATION

Shares of available roughages: share of each roughage feed material (fraction).

GRASSF = 7 / 60 = 0.12
GRASSH = 3 / 60 = 0.05
GRAINSIL = 8 / 60 = 0.13
MAIZESIL = 1 / 60 = 0.02
RSTRAW = 7 / 60 = 0.12
WSTRAW = 9 / 60 = 0.15
BSTRAW = 3 / 60 = 0.05
ZSTOVER = 2 / 60 = 0.03
MSTOVER = 6 / 60 = 0.10
SSTOVER = 5 / 60 = 0.08
TOPS = 4 / 60 = 0.07
FDDRBEET = 2 / 60 = 0.03
LEAVES = 1 / 60 = 0.02
GRASSH2 = 2 / 60 = 0.03

By-products disaggregation: share of each by-product feed material fed individually in the total feed ration (in percentage).

MLSOY = 20 * 6 / 31 = 3.8
MLRAPE = 20 * 4 / 31 = 2.6
MLCTTN = 20 * 7 / 31 = 4.6
PKEXP = 20 * 3 / 31 = 2
MOLASSES = 20 * 9 / 31 = 5.8
GRNBYDRY = 20 * 2 / 31 = 1.2

Concentrate disaggregation: share of each concentrate feed material in the total feed ration (in percentage).

GRAINS = 10 * 6 / 100 = 0.6	MZGLTM = 10 * 9 / 100 = 0.9
CORN = 10 % * 8 / 100 = 0.8	MZGLTF = 10 * 5 / 100 = 0.5
MLSOY = 10 * 10 / 100 = 1	BPULP = 10 * 8 / 100 = 0.8
MLRAPE = 10 * 5 / 100 = 0.5	MOLASSES = 10 * 9 / 100 = 0.9
MLCTTN = 10 * 7 / 100 = 0.7	GRNBYDRY = 10 * 11 / 100 = 1.1
PKEXP = 10 * 12 / 100 = 1.2	GRNBYWET = 10 * 10 / 100 = 1

OUTPUT FEED RATION

Share of each roughage feed material in the ration (in percentage).

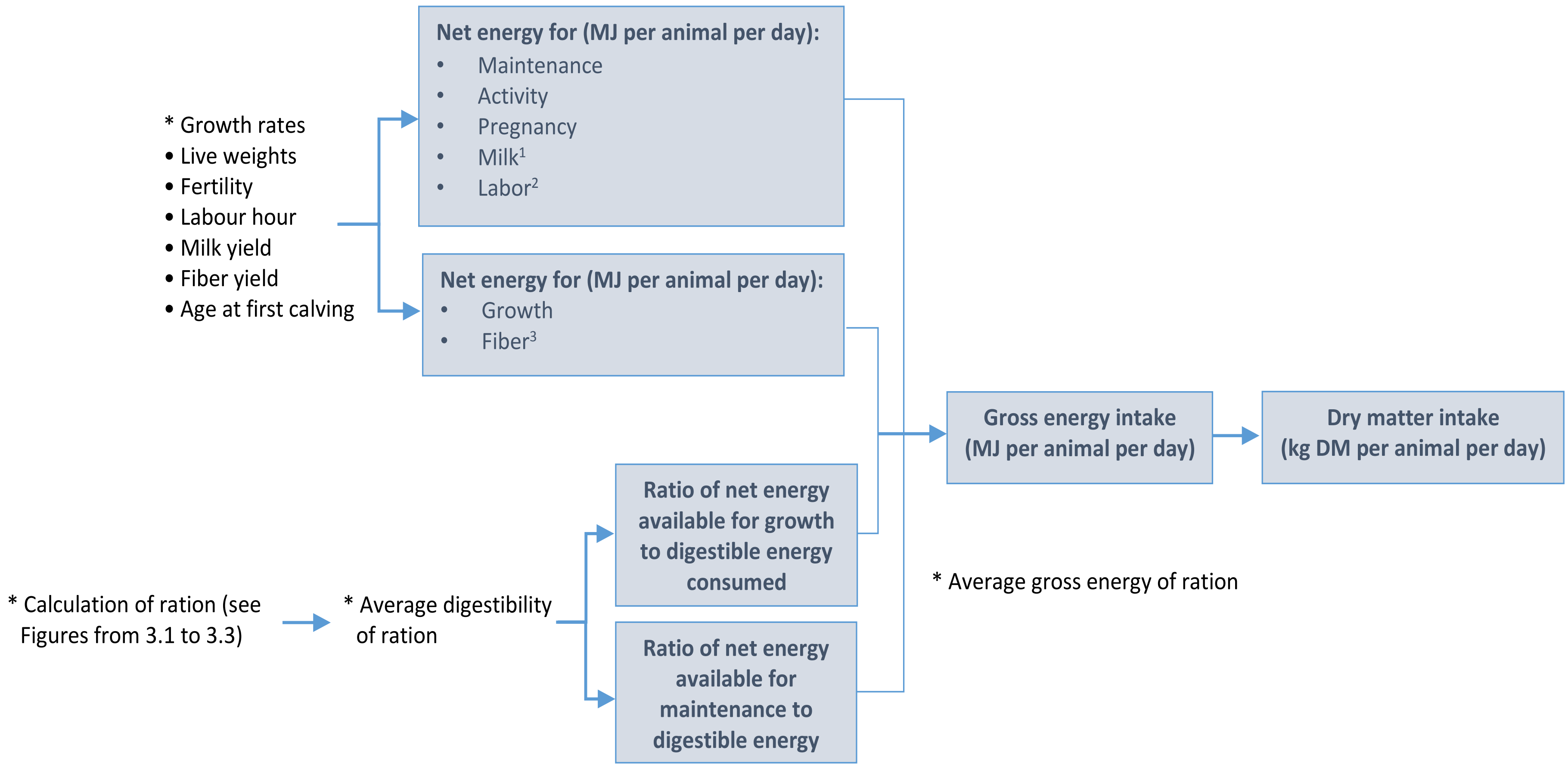
GRASSF = 70 * 0.12 = 8.2 %
GRASSF = 70 * 0.05 = 3.5 %
GRAINSIL = 70 * 0.13 = 9.3 %
MAIZESIL = 70 * 0.02 = 1.2 %
RSTRAW = 70 * 0.12 = 8.2 %
WSTRAW = 70 * 0.15 = 10.5%
BSTRAW = 70* 0.05 = 3.5 %
ZSTOVER = 70 * 0.03 = 2.3 %
MSTOVER = 70 * 0.10 = 7.0 %
SSTOVER = 70 * 0.08 = 5.8 %
TOPS = 70 * 0.07 = 4.7 %
FDDRBEET = 70 * 0.03 = 2.3 %
LEAVES = 70 * 0.02 = 1.2 %
GRASSH2 = 70* 0.03 = 2.3 %

Share of each cereal or by-product feed material in the ration, fed individually or in concentrate (in percentage).

GRAINS = 0.6 %
CORN = 0.8 %
MLSOY = 3.8 + 1 = 4.8 %
MLRAPE = 2.6 + 0.5 = 3.1 %
MLCTTN = 4.6 + 0.7 = 5.3 %
PKEXP = 2 + 1.2 = 3.2 %
MZGLTM = 0.9 %
MZGLTF = 0.5 %
BPULP = 0.8 %
MOLASSES = 5.8 + 0.9 = 6.7 %
GRNBYDRY = 1.2 + 1.1 = 2.3 %
GRNBYWET = 1 %

[1] Specific by country and feeding group
[2] Calculated from the yield and harvested area of each material (see Equation 3.8)
[3] Specific by continent and species

GLEAM - Animal energy requirements and feed intake



[1] Only for the dairy sector
[2] Only for cattle and buffalo, and only in Asia, S America and Africa
[3] Only for sheep and goats for production of wool, cashmere and mohair

* Intermediate calculations within GLEAM
• Input data from literature, existing databases and expert knowledge

Scenarios climate change impact & adaptation options

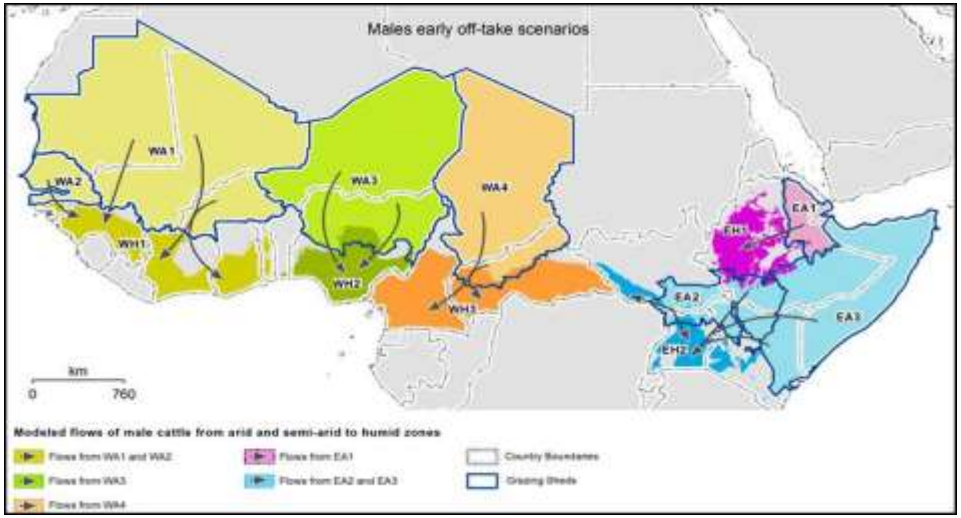
Climatic patterns	x	Management interventions

- *Stable Climate*
- *Mild drought*
- *Severe drought*

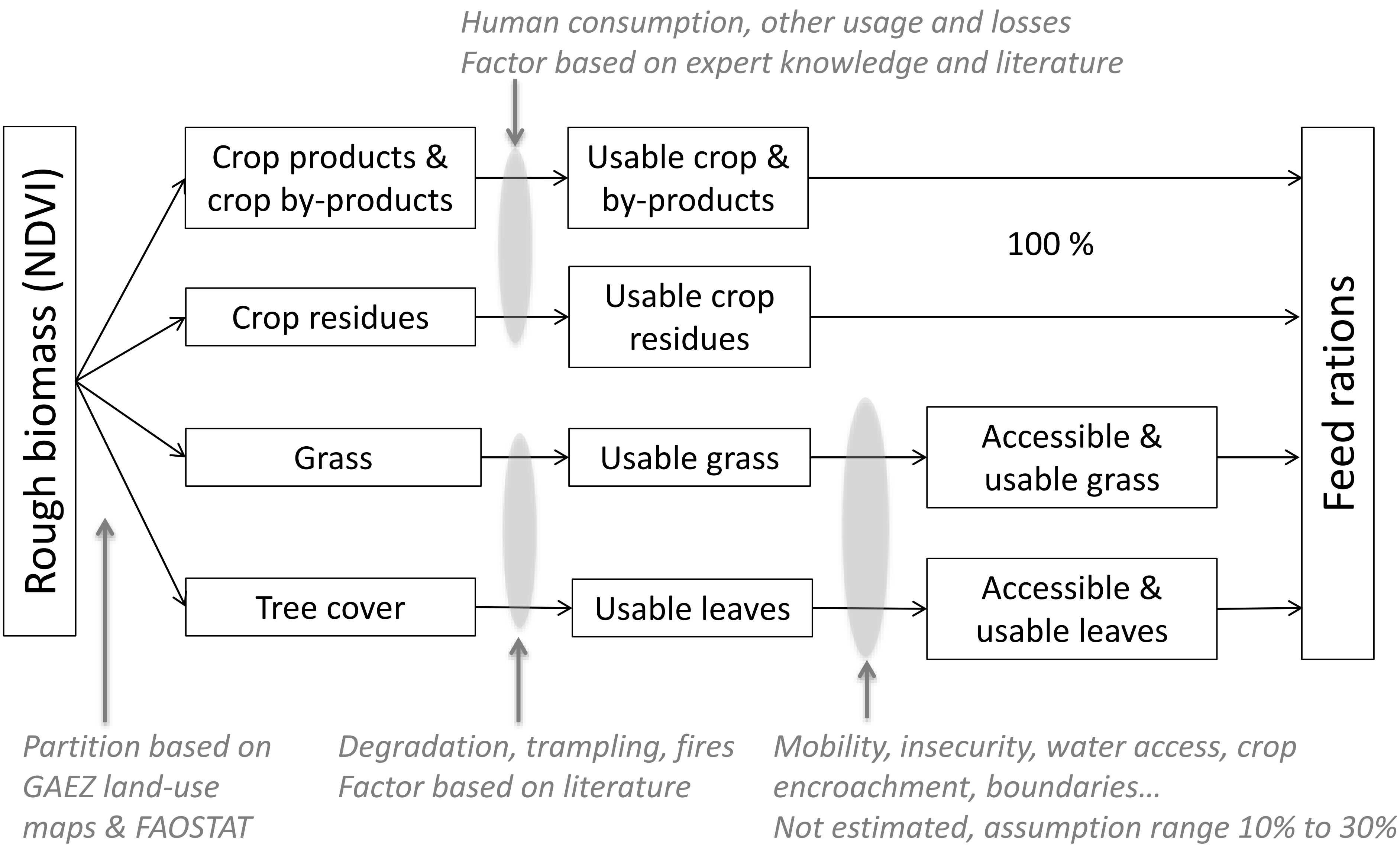
- *Animal health improvements*
- *Early offtake of bulls*

Mild drought: 10 years of mild drought, 3 years of average rainfall and 7 years of good rainfall

Severe drought, 3 years of severe drought, 7 years of mild drought, 3 years of average rainfall and 7 years of good rainfall



From biomass to feed



Absolute feed balances

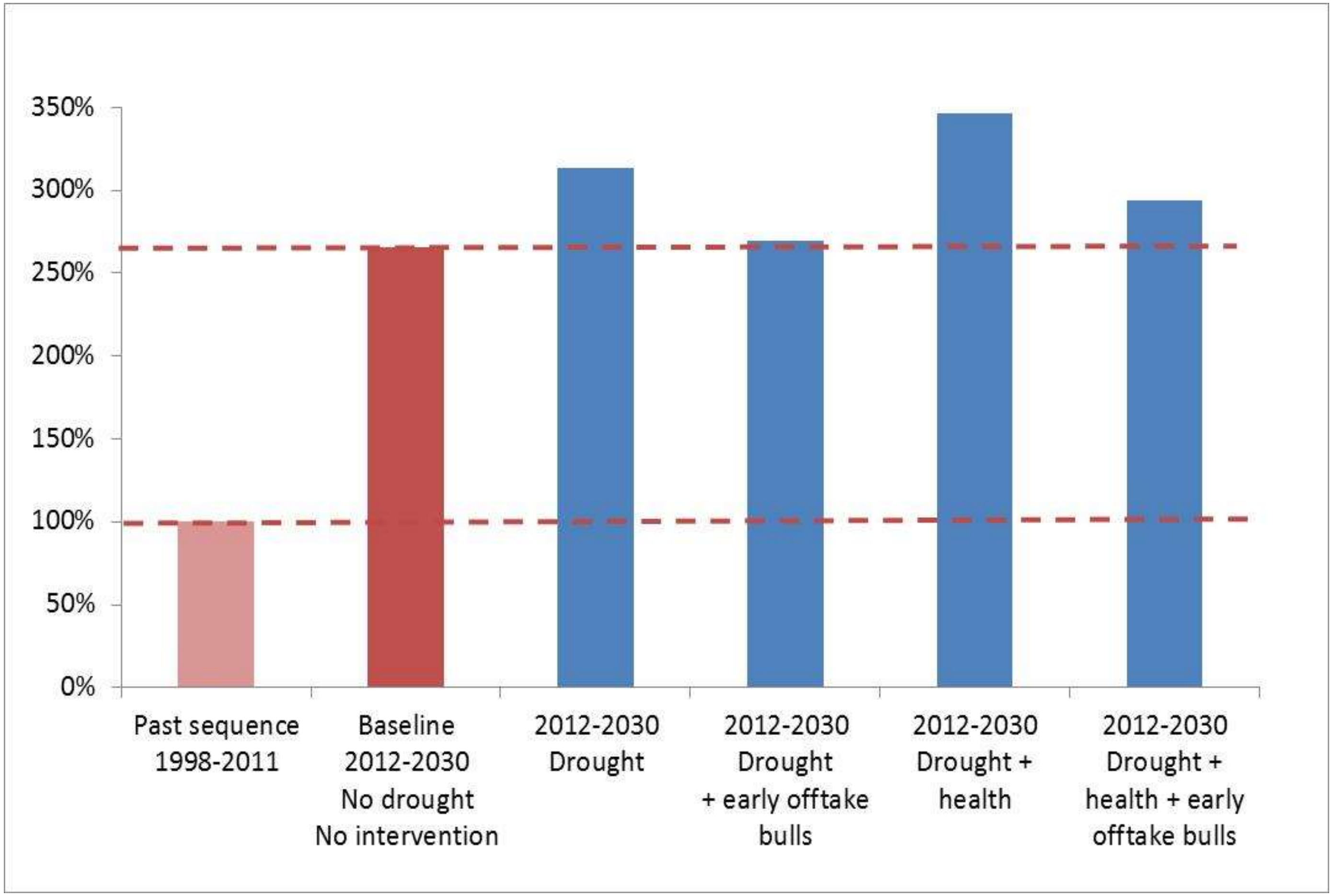
Balances between biomass and animal requirements, assuming full mobility within grazing sheds and 10% and 30% accessibility to natural vegetation

	Crops + by products	Crop residues	Natural vegetation 10% accessibility	Natural vegetation 30% accessibility
Past reference	100%	100%	95%	75%
Baseline	46%	100%	106%	86%
Drought	56%	100%	109%	89%
Drought + early offtake bulls	39%	100%	108%	88%
Drought + Health	62%	100%	111%	91%
Drought + Health + early offtake bulls	39%	100%	109%	89%
Mild Drought	61%	100%	109%	89%
Mild Drought + Health intervention	68%	100%	111%	91%

Source: de Haan et al, World Bank publications, 2016

Feed deficit index in the drylands of Sub-Saharan Africa

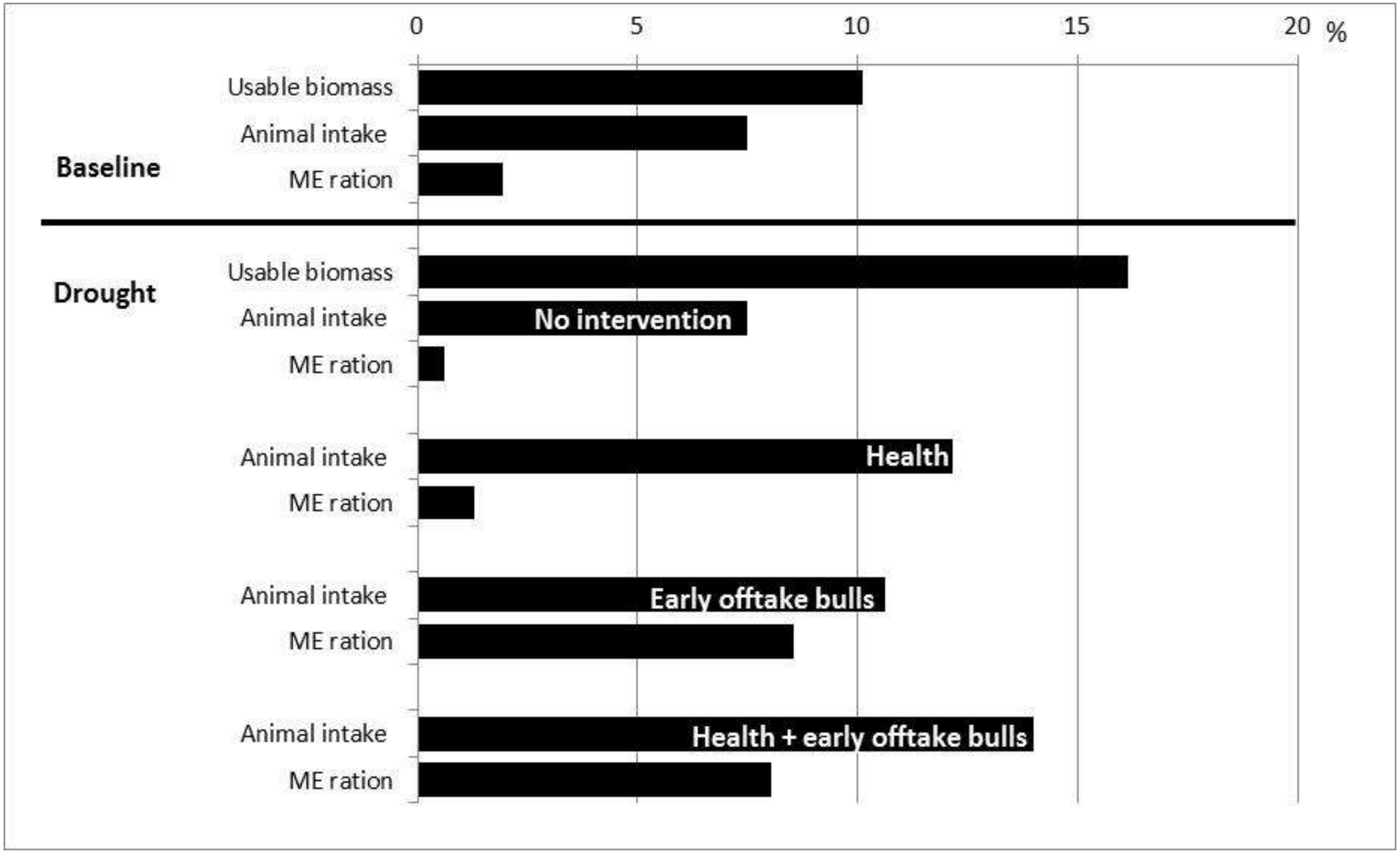
Annual average of the balance between usable biomass and animal requirements, using the sequence 1998-2011 as baseline (= 100) assuming full animal and feed mobility within grazing sheds



Source: de Haan et al, World Bank publications, 2016

Inter-annual relative variability

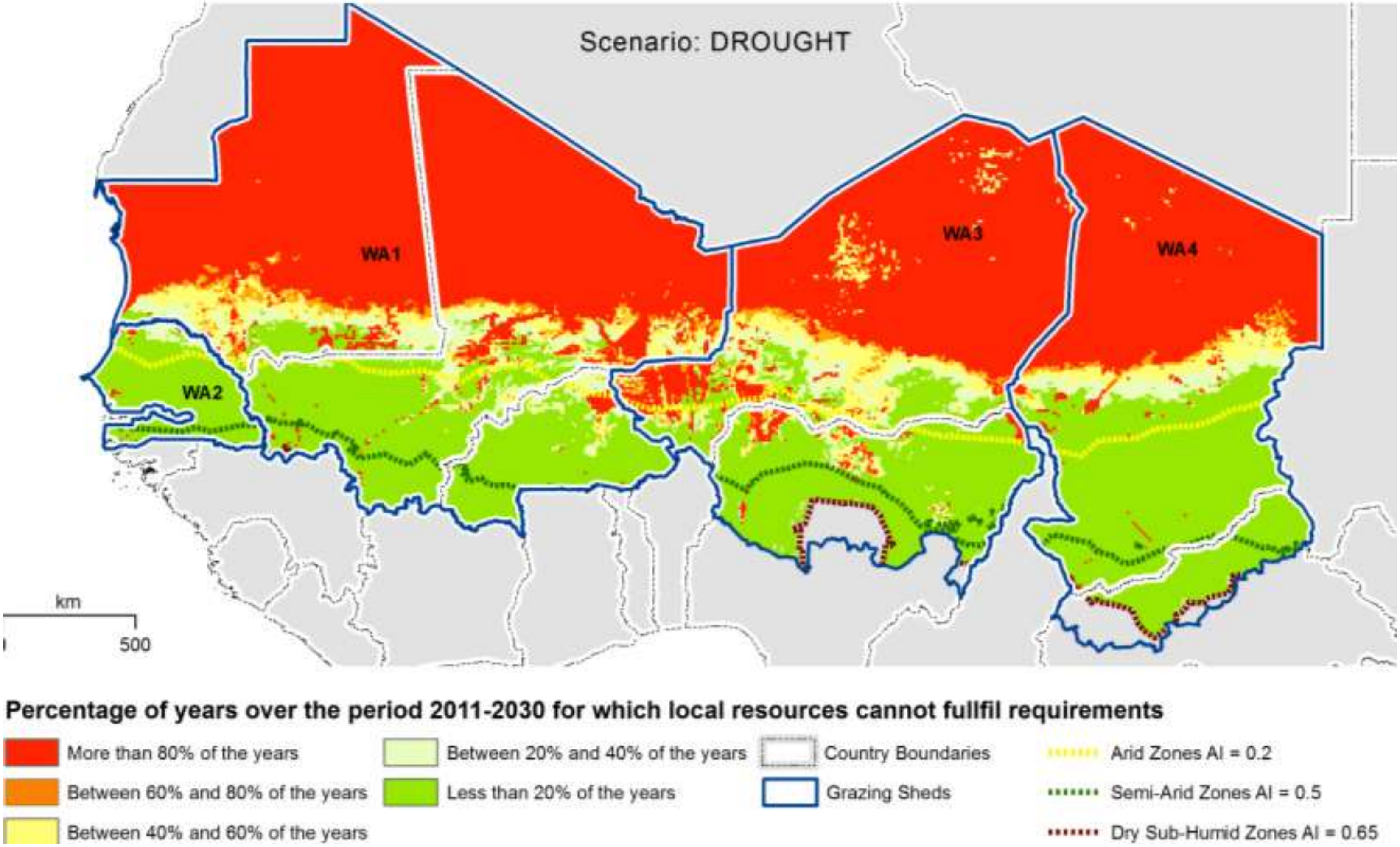
Relative standard variation of usable biomass, animal intake and metabolisable energy (ME) in the baseline and the drought scenarios with different levels of interventions.



Source: de Haan et al, World Bank publications, 2016

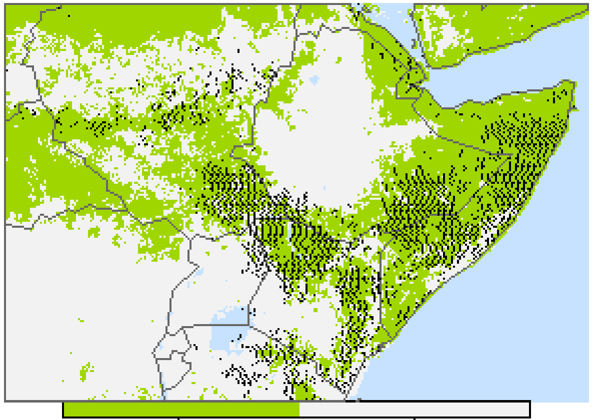
Livestock & resilience in the drylands of Africa

Mapping feed balances under a drought scenario



Possible impacts of 2017 drought in East Africa

Potential impact on pastoralist people and livestock



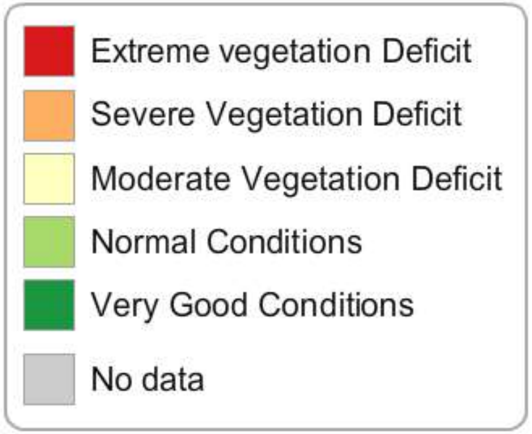
		Livestock TLU (% country)	Population # people (% country)	
			0.75 TLU per capita threshold	2 TLU per capita threshold
Pastoralist systems	Ethiopia	1027 (2.6)	879 (1.1)	410 (0.5)
	Kenya	1851 (10.9)	939 (2.3)	573 (1.4)
	Somalia	2193 (38.9)	1454 (16.2)	795 (8.9)
	South Sudan	810 (10.2)	993 (10.9)	611 (6.7)
	Total	5881 (8.3)	4265 (3.1)	2389 (1.7)
Other systems	South Sudan	407 (1)	314 (0.4)	166 (0.2)
	Ethiopia	1956 (11.5)	1080 (2.7)	633 (1.6)
	Kenya	512 (9.1)	569 (6.3)	251 (2.8)
	Somalia	459 (5.8)	460 (5.1)	261 (2.9)
	Total	3334 (4.7)	2423 (1.7)	1311 (0.9)

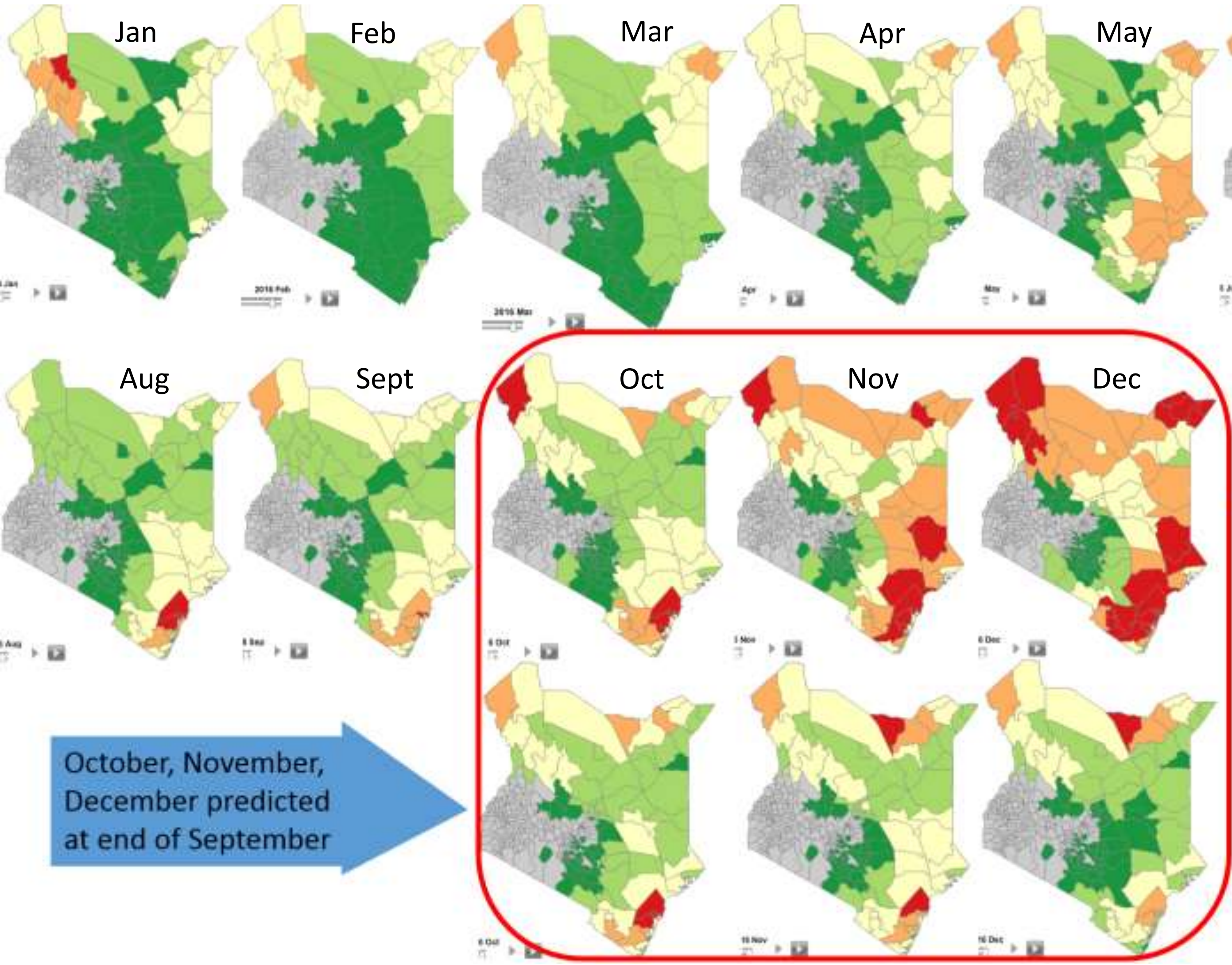
Predictive Livestock Early Warning System (PLEWS)

MODIS NDVI data against edible vegetation, surface water availability and past data

Current forage availability split into 5 categories

Prediction 6 months forage availability





October, November, December actual values following failed rains

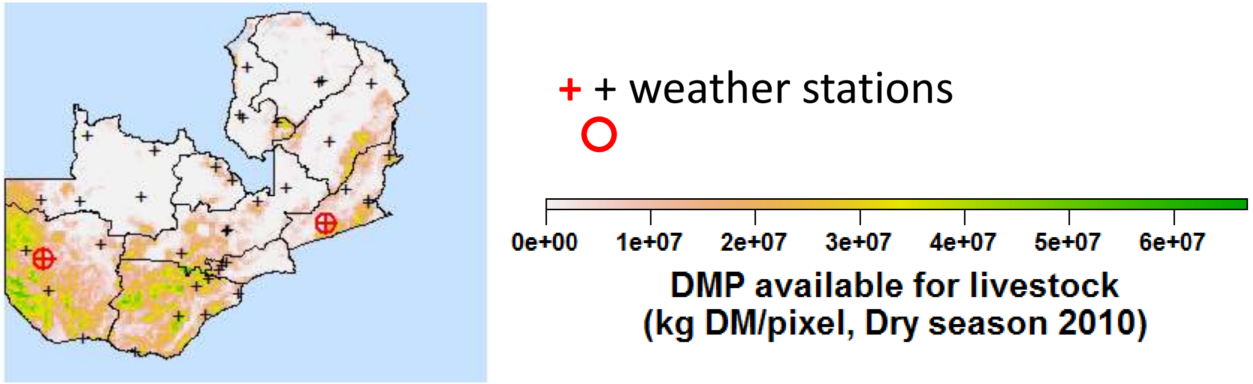
October, November, December predicted at end of September

PLEWS maps for Kenya in 2016

Data needs and developments – climate scenarios

Modeling effect of climate scenarios on natural biomass productivity

- Adaptation of models designed for crops (MOSAIC)
- Need for long time series on natural vegetation productivity and climate (without missing data)
- Moving from point data to raster data – scale mismatch
- Approximations and uncertainty on the long term
- Forecast vs. projection



Data needs and developments – remote sensing

Improving the integration between rangeland and livestock data:

- Biomass usability and accessibility
- Animal mobility
- Better distinction between vegetation category (from NDVI data?) and feed quality
- Rangeland condition and degradation
- On-site validation

Summary: main areas of collaboration

Integrated approaches of rangelands and livestock are critical to food security and sustainable development

- Early warning systems and climate change vulnerability monitoring
- Scenarios: climate, biomass availability, livestock
- Validation in pilot sites

Thank you