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Livestock in FAO Global Agriculture Perspectives System (GAPS): brief history, current work and next steps

Marc Müller

FAO – Global Perspectives Studies (GPS) team

Livestock Modelling Workshop:
GLW-GLEAM-GAPS/IMPACT Integration

22 – 24 May 2018 | FAO, Rome

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Global Perspectives Studies at FAO: Publications

Corporate reports on key issues

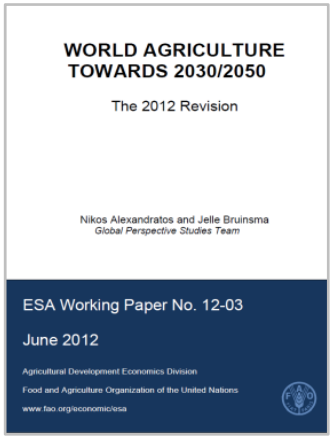
- E.g. report on "*The future of food and agriculture – Trends and challenges*" (2017)

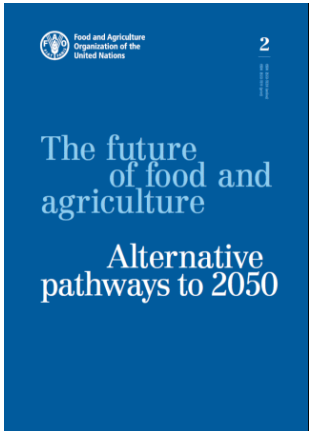
World Agriculture towards 20XX

- long-term projections of agriculture, food security and natural resource use. Last baseline projection until 2050 (**AT2050**, Alexandratos and Bruinsma, 2012)

Upcoming report:

The future of food and agriculture – Alternative pathways to 2050





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Global Agriculture Perspectives System (GAPS)

- **GAPS v1**
- Partial equilibrium model for agricultural commodities
- Replicates the AT2050 projections for 110 countries and 34 commodities
- Strongly influenced by IMPACT regarding equations and deep parameters
- Base year 2005/07
- Implemented in GAMS

- **For upcoming report: Extension and Upgrade to GAPS v2**
- Build around 2011-2013 FAOSTAT Food Balance Sheets (FBS) and Productions Statistics
- GAEZ v4 for climate change impacts on land and water resources and crop yields
- **GLEAM** for feed requirements, herd dynamics, and proportions of animal production systems (4 ruminant species in 4 herds and production systems; 2 monogastric species in 3 systems)
- UN DESA World Population Prospects 2015
- OECD Shared Socioeconomic Pathways for income projections
- 154 countries and 68 commodities

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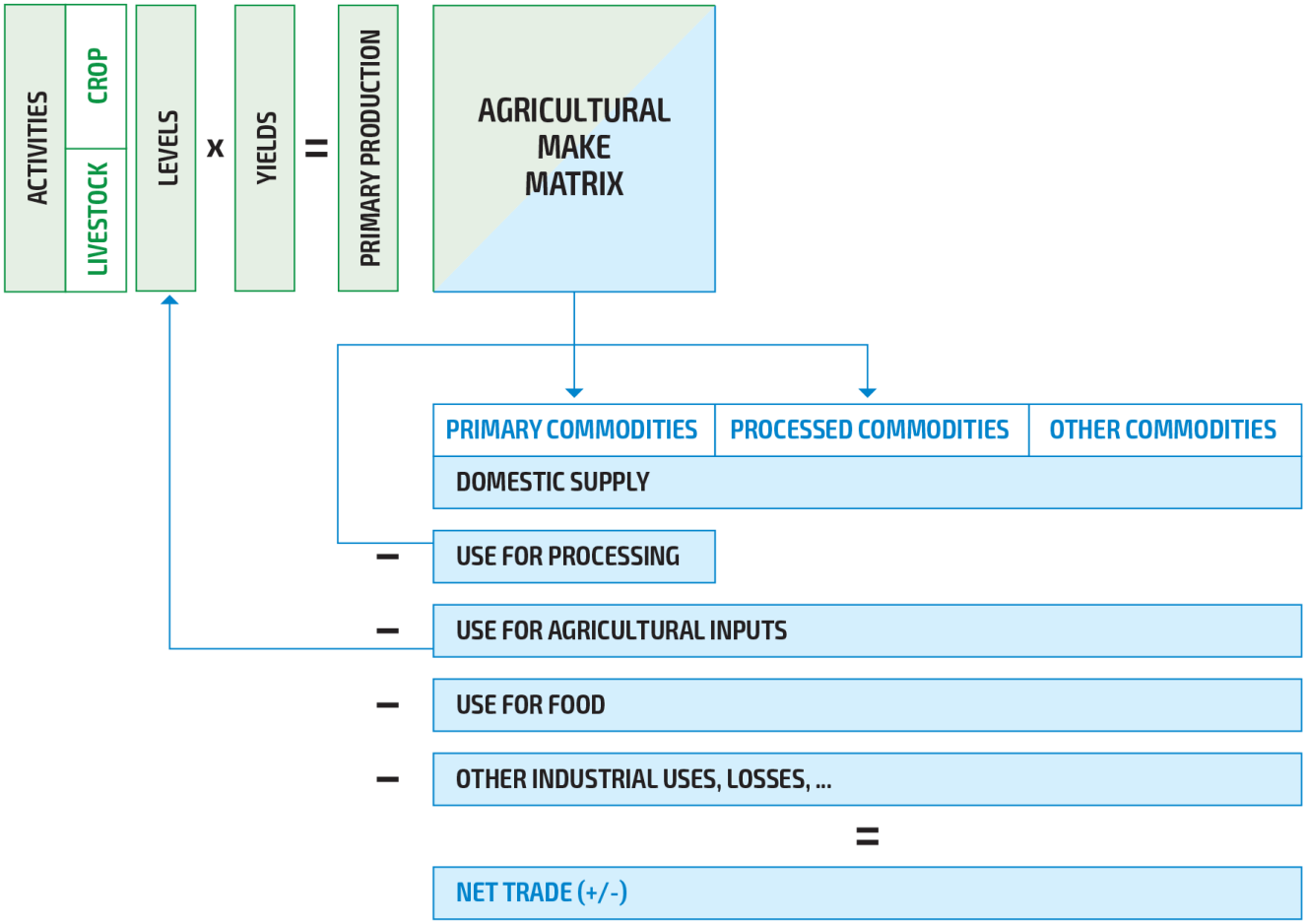
GAPS – Basic structure



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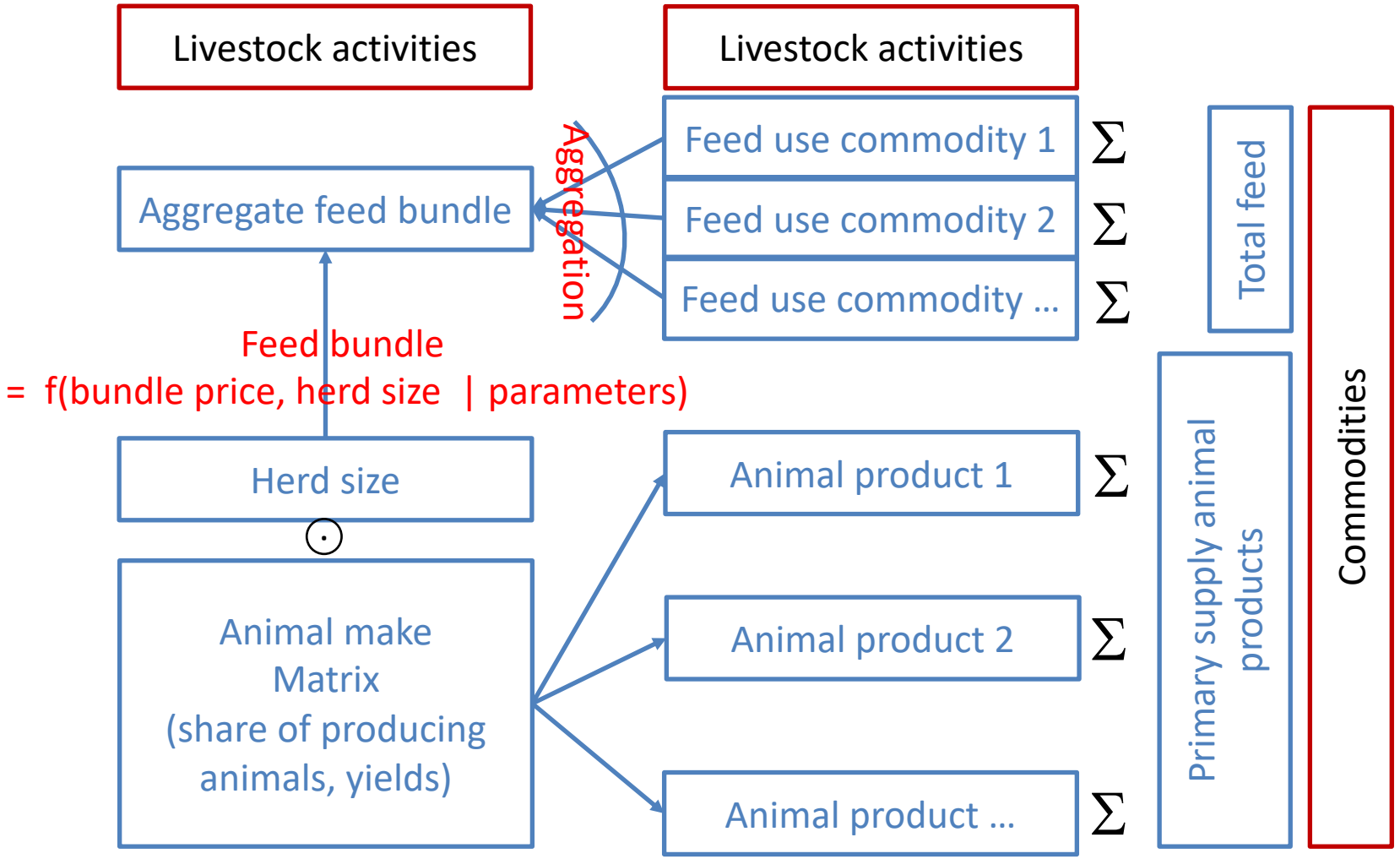
GAPS – Livestock module



GAPS – Herd size

- **Equations:**
- Number of animals:

$$herd_{a,l,t} = \lambda_{a,l,t} \cdot PP_{a,l,t}^{\omega_{a,l,t}^{PP}} \cdot PFEED_{a,l,t}^{\omega_{a,l,t}^{PFEED}}$$

With a: species, l: herd x system, λ: shift parameter, PP: Producer price, PFEED: Aggregate feed price

- GAPS solves for prices to clear markets in time t
- Shift parameters refer to price-independent growth of herds

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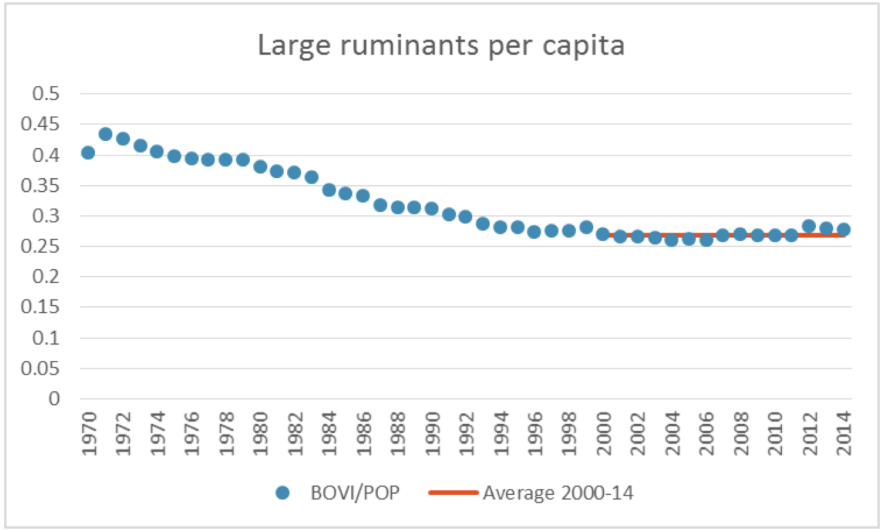
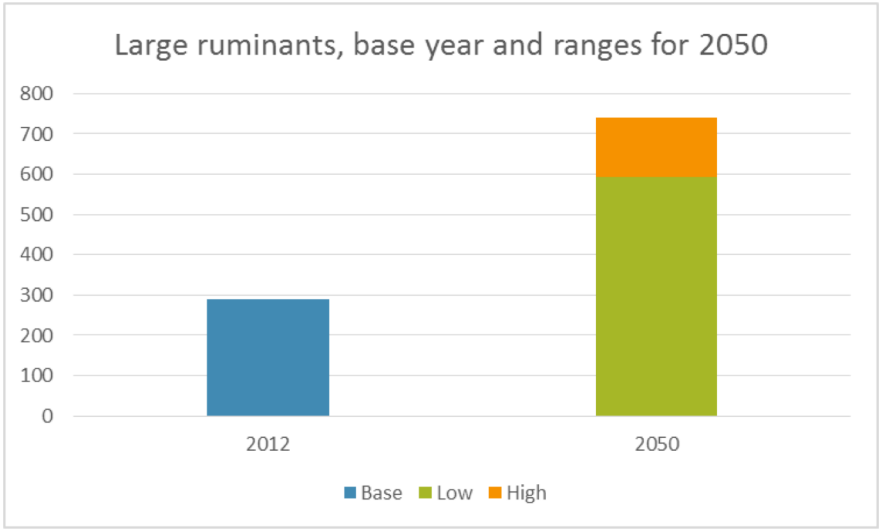
Derivation of shifters - example large ruminants in SSA – only population and income shifts





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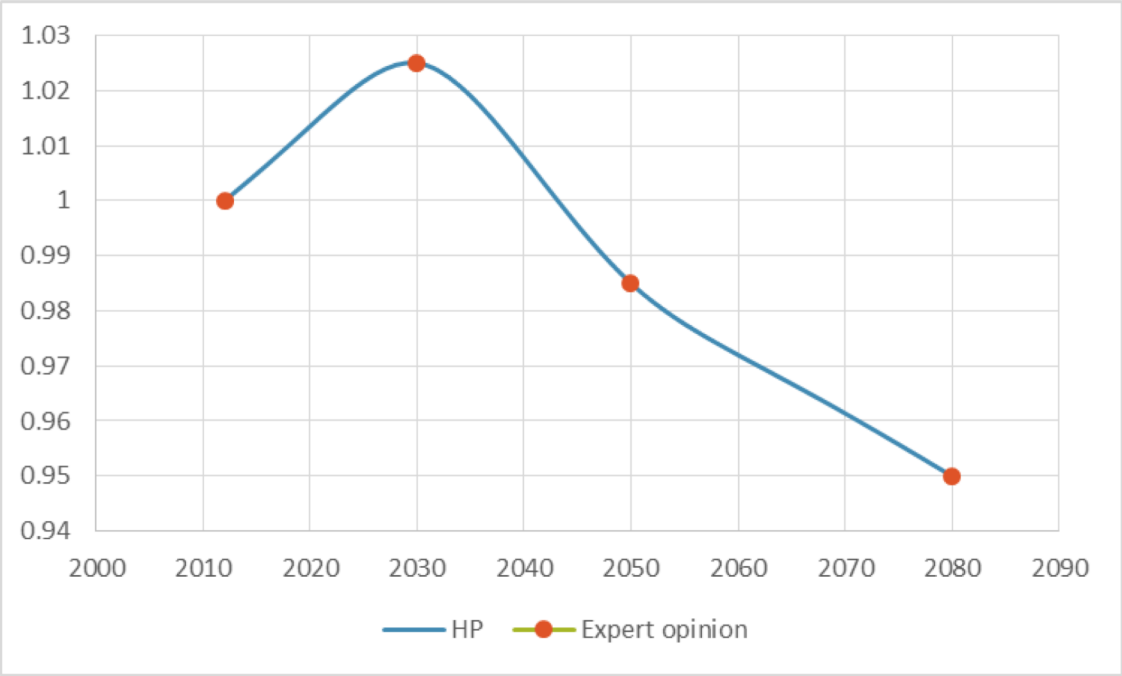
Including Expert Opinions: E.g Herd size



Stylized expert statements:
“That’s not possible”, “[…] too high […]”, […] too low […]”
“Until 2030, countries will push towards achieving SDGs, get funding, too,…”
“Climate change will cause losses of pasture land, will become visible after 2030,…”
“Beyond 2050, population growth slows down and pressure on herd sizes declines a bit”

GAPS - Feed demand

Equations:

- CES-Aggregation:

$$bundle_{a,l} = \left[\sum_i \beta_{a,l,i} feed_{a,l,i}^{\frac{\sigma_{a,l}-1}{\sigma_{a,l}}} \right]^{\frac{\sigma_{a,l}}{\sigma_{a,l}-1}}$$

With a: species, l: herd x system, β: share parameter, σ: substitution elasticity

- First-order condition for cost-minimization:

$$feed_{a,l,i} = bundle_{a,l} \beta_{a,l,i}^{\sigma_{a,l}-1} \left[\frac{PFEED_{a,l}}{PC_i} \right]^{\sigma_{a,l}}$$

With pbundle: bundle price, pfeed: feed market price

- Feed demand levels by herds and systems, and share parameters (β) obtained from GLEAM feed coefficients
- Precondition: align feed uses from FBS, herd sizes from production statistics, and GLEAM coefficients

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GLEAM2GAPS: Database challenges

Comparability of databases

- GLEAM
  - follows its own classification of animal feeds
  - feed coefficients expressed in maximum intake, dry matter base
  - Includes traded (e.g. maize) and non-traded (e.g. grass) feeds

- GAPS
  - is built on FAOSTAT food balance sheets and production statistics
  - market balances expressed in primary equivalents (except oilseeds)
  - no distinction of feed destinations (herds or systems), only one column per country and year
  - Does not include roughages or other non-traded feeds

- Without additional information, feed balances cannot be completed
- Pasture/rangeland requirements calculated post-solve as plausibility check

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GLEAM feeds (e.g. grains and products)

FeedItemCode	FeedItemName
GRAINS	Grains from wheat (Triticum spp.), barley (Hordeum vulgare), sorghum (Sorghum spp.), rye (Secale cereale) or oat (Avena sativa) plants.
GRNBYDRY	'Dry' by-products of grain industries such as brans, middlings, etc.
GRNBYWET	'Wet' by-products of grain industries such as biofuels, distilleries, breweries, etc.
WHEATS	Grains from wheat (Triticum aestivum).
WHEATN	Grains from wheat (Triticum aestivum).
BARLEY	Grains from barley (Hordeum vulgare).
MILLET	Grains from millet (P. glaucum, E. coracana, P. miliaceum…).
RICE	Grains from rice (Oryza sp.).
SORGHUM	Grains from sorghum (Sorghum sp.).
CWHEAT	Grains from wheat (Triticum aestivum).
CBARLEY	Grains from barley (Hordeum vulgare).
CMILLET	Grains from millet (P. glaucum, E. coracana, P. miliaceum…).
CRICE	Grains from rice (Oryza sp.).
CSORGHUM	Grains from sorghum (Sorghum sp.).
CGRNBYDRY	'Dry' by-products of grain industries such as brans, middlings, etc.
CORN	Grains from maize (Zea mays) plant.
MZGLTM	By-product from maize processing. It is a protein-rich feed, with about 65% crude protein content.
MZGLTF	By-product from maize processing. Unlike the gluten meal, its protein content is lower, of about 25% crude protein content.
MAIZES	Grains from maize (Zea mays).
MAIZEN	Grains from maize (Zea mays).
CMAIZE	Grains from maize (Zea mays).

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GAPS and FBS commodities (e.g. grains and products)

FBSName	FBSCode	GAPSCode
Wheat and products	2511	C_WHEA
Barley and products	2513	C_BARL
Maize and products	2514	C_MAIZ
Rye and products	2515	C_XCER
Oats	2516	C_XCER
Millet and products	2517	C_MILL
Sorghum and products	2518	C_SORG
Cereals, Other	2520	C_XCER

Comparability of GLEAM and GAPS databases

- Categories for feed commodities do not allow direct (1-to-1) mapping
- Comparability is a bit better for oilseed cakes, worse for other tradables and processed feeds
- Need to create an intermediate grouping…

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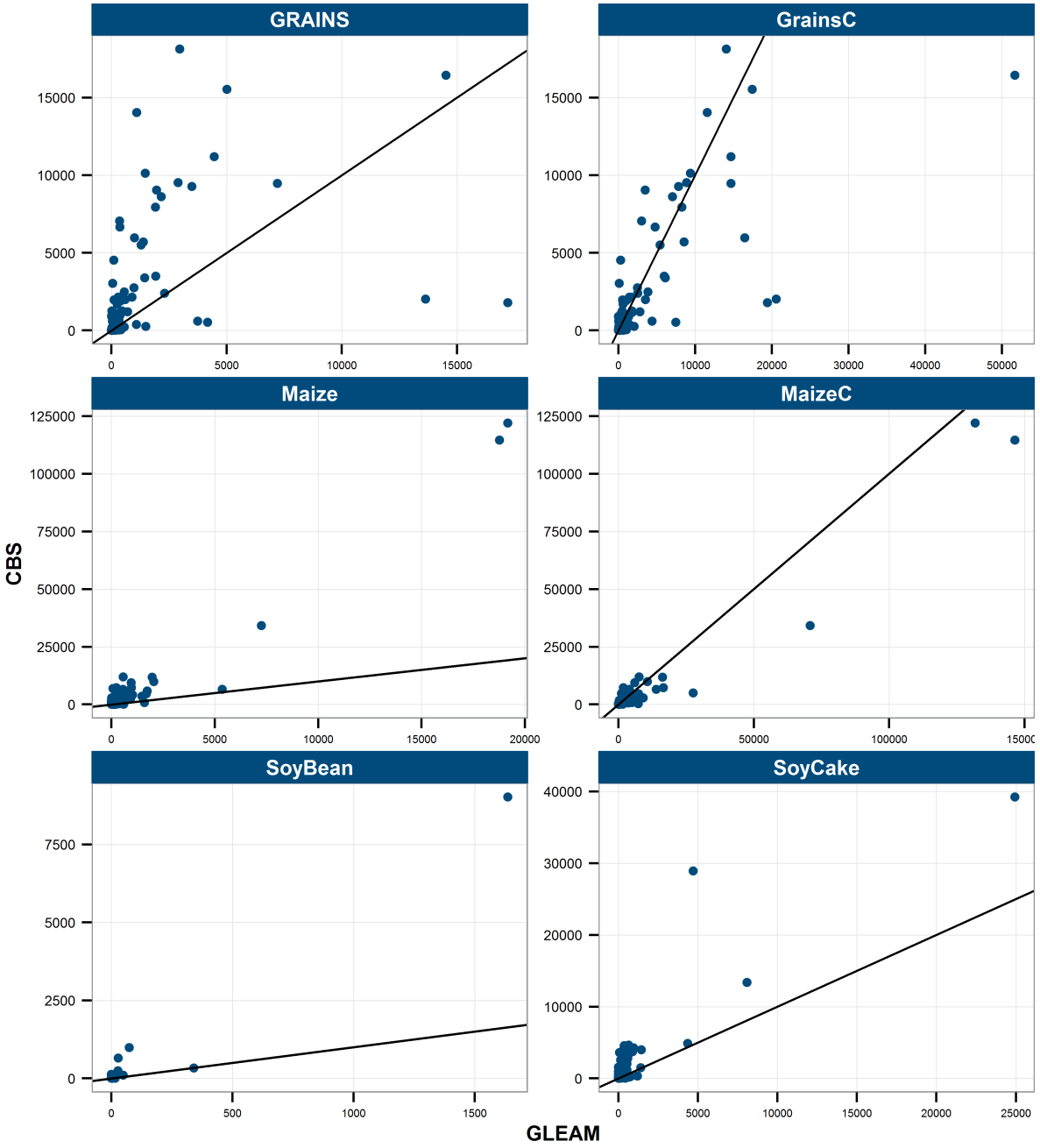
… some trial comparisons …



… to obtain a procedure for data integration:

Steps:

- Determine feed groups ig with many-to-1 correspondence to GAPS commodities (i) as well as GLEAM feeds (g).
- General criterion for ig: Low substitutability between groups, high substitutability within groups
- Compute shares of herds by productions systems within each group ig:

$$share_{h,s,ig} = \left[\sum_{g \in ig} \gamma_{h,s,g} herd_{h,s}\right] \Big/ \left[\sum_{h,s,g \in ig} \gamma_{h,s,g} herd_{h,s}\right]$$

With γ : GLEAM maxinitake

- Distribute FBS feed uses by shares:

$$feed_{h,s,i \in ig} = tfeed_i^{FBS} \cdot share_{h,s,ig}$$

With tfeed: Total feed uses

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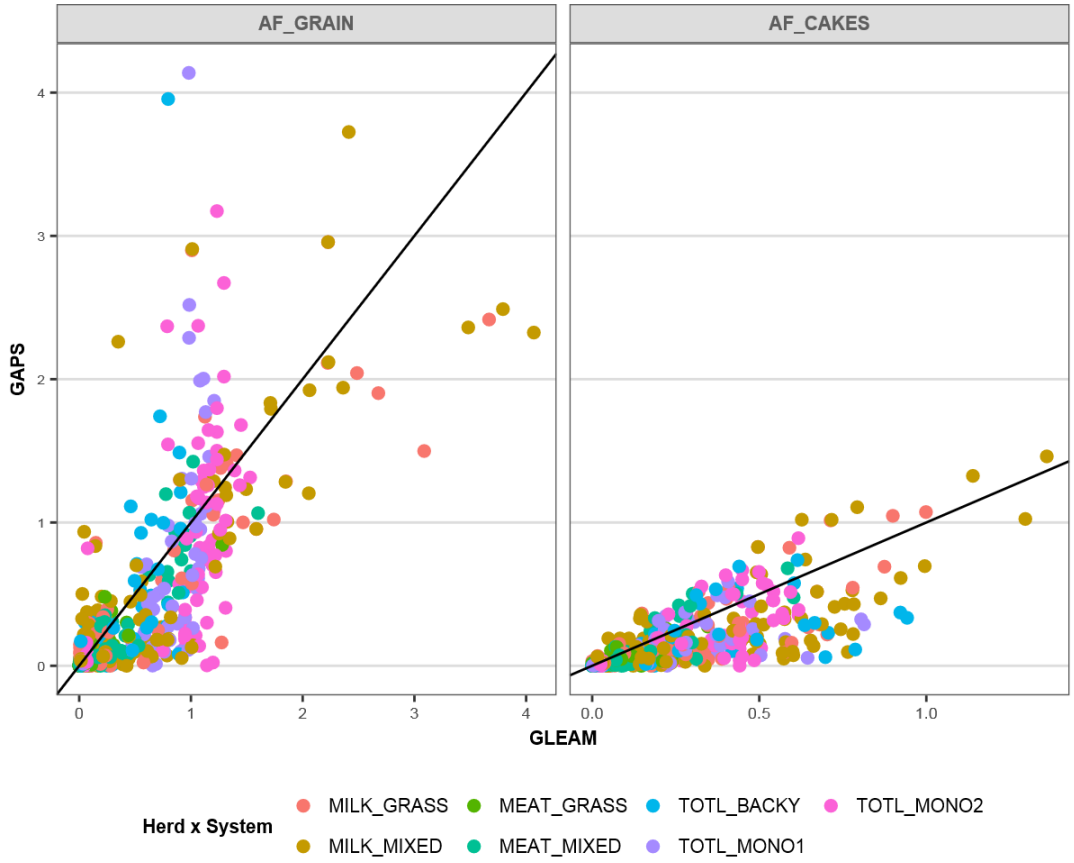
Combined feed uses, GLEAM vs GAPS, high aggregation, average DM content



GLEAM2GAPS: Next steps

Adjust DM contents of tradable feeds

Close feed balances by including non-tradables

- Straw / crop residues
  - By-product of crop production
  - Very important e.g. in SSA countries
- Maize silage
  - Not included in FBS, ProductionStatistics discontinued
  - Important farming activity in HIC and ECA countries
- Grass
  - Availability determined by exploitable NPP and location of pastures and rangeland
  - Some conceptual challenges regarding transition from rangeland to pasture
  - Including pasture/rangeland supply in equilibrium equations would permit pricing

More on feed balances and pasture/rangeland demand now!

Thank you

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