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Aligning FAO Global Livestock Environmental Assessment Model (GLEAM) and FAOSTAT balance sheets for animal feed

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

22 – 24 May 2018 | FAO, Rome

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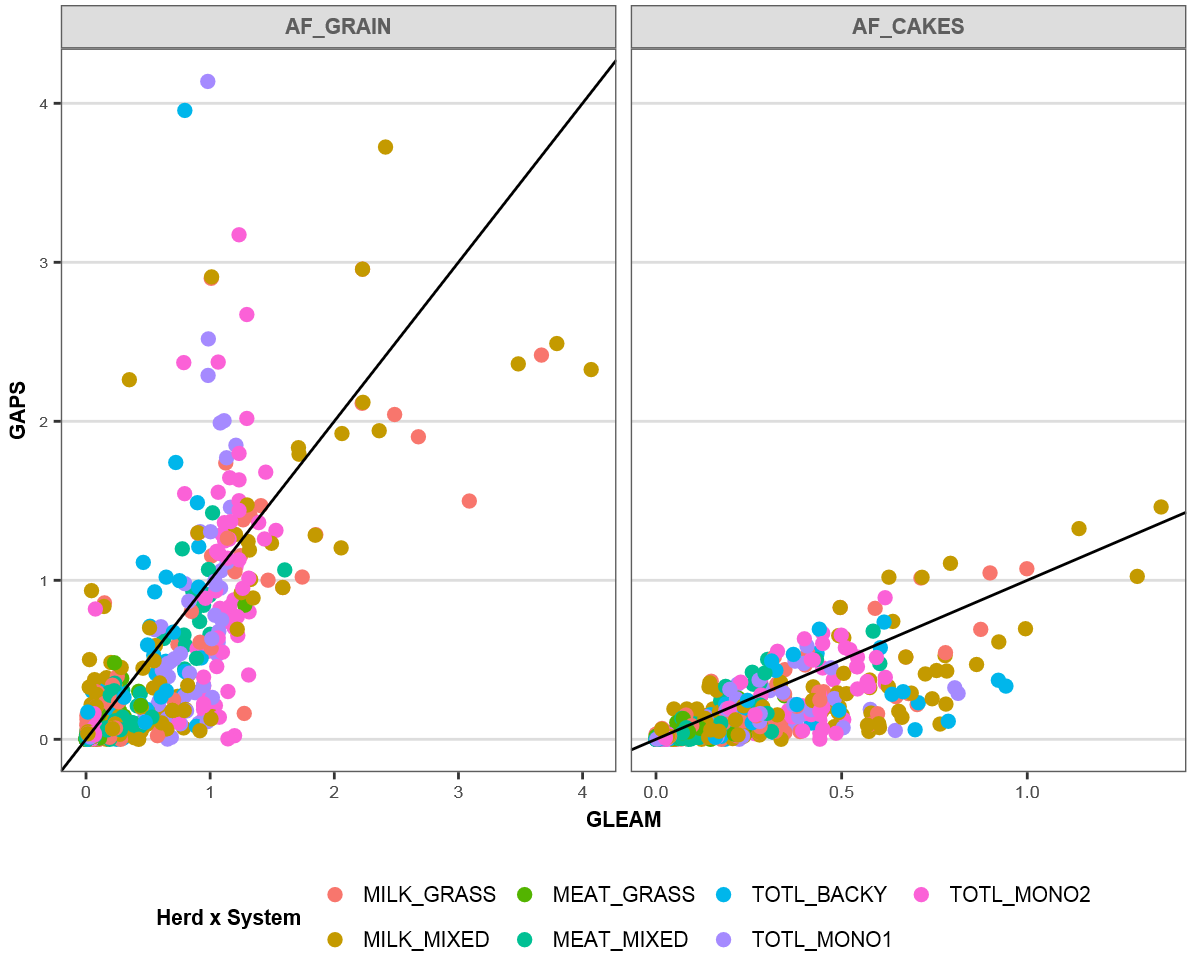
Combined feed uses, GLEAM vs GAPS, high aggregation, average DM content



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!

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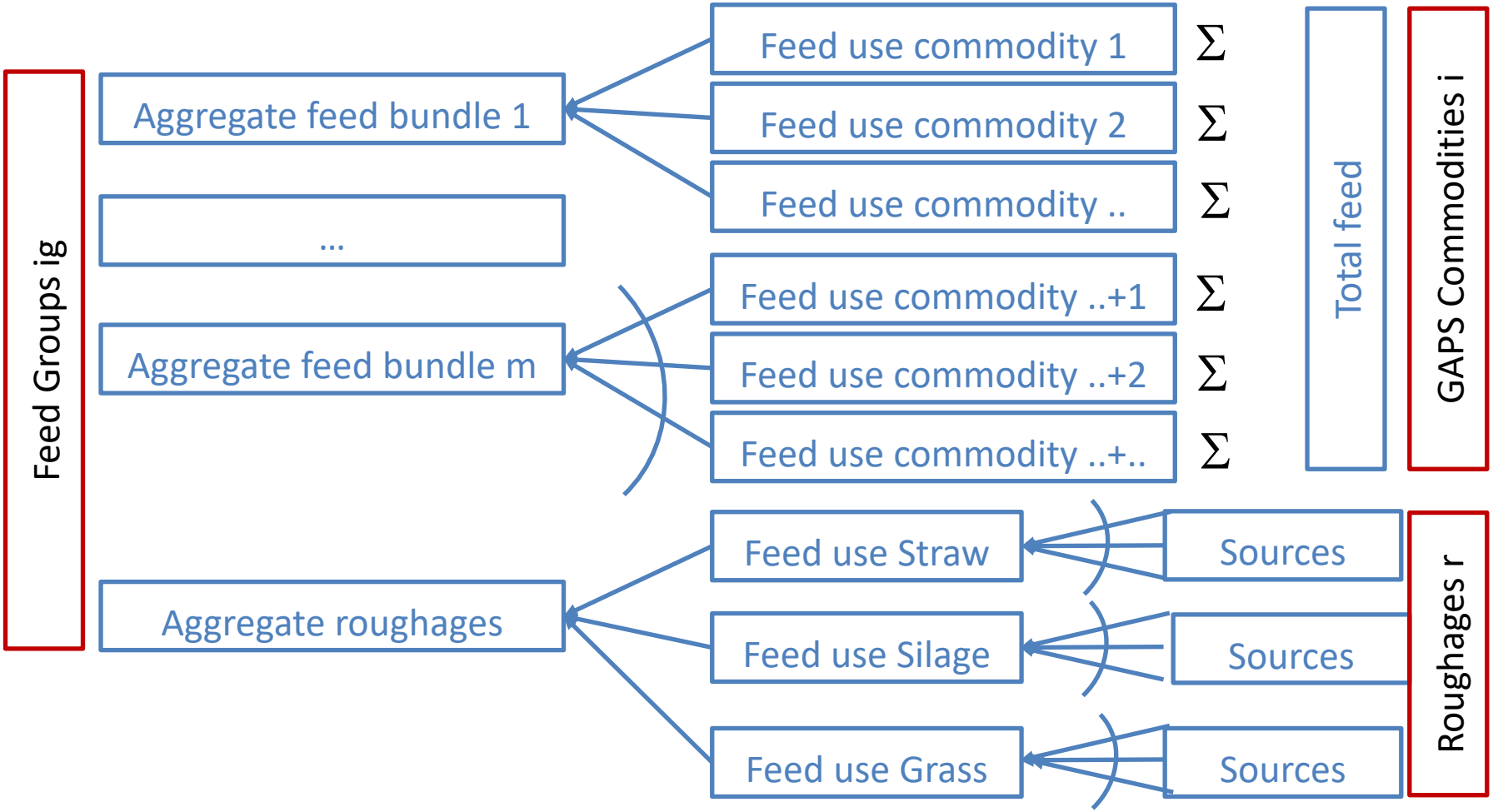
Feed aggregations



Feed coefficients in GAPS

- In base-year, feed demand is determined by herd size and demand per animal and year

$$feed_{a,l,i} = \chi^{FD}_{a,l,i} \cdot herd_{a,l}$$

With a: species, l: herd x system, χ: Intake per animal and year, fresh matter

- Total feed demand:

$$tfeed_i = \sum_{a,l} feed_{a,l,i} = \sum_{a,l} \chi^{FD}_{a,l,i} \cdot herd_{a,l,i} \qquad (1)$$

- Consistency with FAOSTAT food balance sheets (FBS):

$$tfeed_i = tfeed_i^{FBS}$$

Linking traded feed coefficients to GLEAM

- Feed intake per animal and day, dry matter base:

$$\gamma^{FD}_{a,l,ig,n} = \sum_{i \in ig} \chi^{FD}_{a,l,i} \cdot \kappa^{FD}_{i,n} / 365 \qquad (2)$$

With ig: feed group, n: nutrient, γ: Intake per animal and day, dry matter base , κ: Intake nutrient content per unit of fresh matter

- Relevant nutrients: $n = \{DM, RP, GE\}$

- Note: regional indexes have been omitted to avoid index clutter! κ has a regional index like γ!

Roughages coefficients

- Roughages feed intake per animal and day, dry matter base:

$$\gamma^{RG}_{a,l,ig,n} = \sum_{r \in ig} \chi^{RG}_{a,l,r} \cdot \kappa^{RG}_{r,n} / 365 \qquad (3)$$

With r: roughages

- Elements of r: $r = \{STRAW, SILAG, GRASS\}$

- Each element treated differently:
  - Straw/residues are by-products of other farming activities
  - Silage is deliberately farmed
  - Grass may originate from managed (pastures) or unmanaged (rangeland) suitable (?) lands

Elements of r: Straw/residues

- Straw balance:

$$\sum_i xs_i \cdot \left(\frac{1}{HI_i} - 1 \right) \cdot \eta_i^{"STRAW"} = \sum_{a,l} \chi_{a,l,"STRAW"}^{RG} \cdot herd_{a,l} \qquad (4)$$

With xs: domestic crop production, HI: harvest index, η: share of straw production used for feed

- Note: No distinction of straw types in feed coefficients, only aggregates!

- Fraction of produced straw used for feed very much dependent on country context, but certainly: $0 \leq \eta \leq 1$

Elements of r: (Maize) Silage

- Silage balance:

$$\sum_{sila} xs_{sila} = \sum_{a,l} \chi^{RG}_{a,l,"SILAG"} \cdot herd_{a,l} \qquad (5)$$

With xs: domestic silage production, sila: types of silage crops

- Note: Silage production taken from discontinued FAOSTAT
- Assumption: All silage production used for animal feed

Elements of r: Grass

- Grass balance:

$$\sum_{w} area_{w} \cdot npp_{w} \cdot \eta_{w}^{"Grass"} = \sum_{a,l} \chi_{a,l,"GRASS"}^{RG} \cdot herd_{a,l} \qquad (6)$$

With w=type of grassland, area: available area, npp: net primary productivity, η: share of net primary production exploited for feed

- Note: No distinction of straw types in feed coefficients, only aggregates!

$$w = \{PASTR, RANGE\}$$

- Fraction of npp used for feed very much dependent on country context, but certainly: $0 \leq \eta \leq 1$

Variables and supports

- Variables to be estimated:

$$VAR = \begin{bmatrix} \gamma^{(..)} \\ \eta^{(..)} \\ HI \\ \kappa^{(..)} \end{bmatrix} \quad \begin{matrix} Intake\ per\ animal\ and\ day, dry\ matter \\ Use\ shares \\ Harvest\ indexes \\ Nutrient\ contents\ per\ unit\ of\ \ fresh\ matter \end{matrix}$$

- Entropy requires variables to be expressed by weights and supports:

$$VAR = \sum_{s} WGT_s \cdot SPT_s, s = \{LOW, EXP, UPR\}$$

Constructing supports

- Intakes (γ):
  - LOW: GLEAM global minimum value or 0
  - EXP: GLEAM coeffcients
  - UPR: GLEAM global maximum*1.25

- Use shares (η):
  - LOW: FAOSTAT/GLEAM global minimum value or 0
  - EXP: FAOSTAT/GLEAM median country observation
  - UPR: FAOSTAT/GLEAM global maximum

- Harvest indexes(HI):
  - LOW: Various sources …
  - EXP: …
  - UPR: …

- Nutrient contents(κ):
  - LOW: FEEDIPEDIA global minimum value or 0
  - EXP: FEEDIPEDIA average
  - UPR: FEEDIPEDIA global maximum (1 for DM)

Objective function

- Cross-entropy objective, subject to contraints:

$$\min_{WGT} GCE = \sum_{\ldots} \sum_{s} WGT_s \cdot \ln\left(\frac{WGT_s}{pwgt_s}\right)$$

$$s.t.(1)-(6)$$

- pwgt are prior weights, set to mimic assumed distributions
- Procedure solves each country in parallel, implemented as NLP in GAMS using CONOPT

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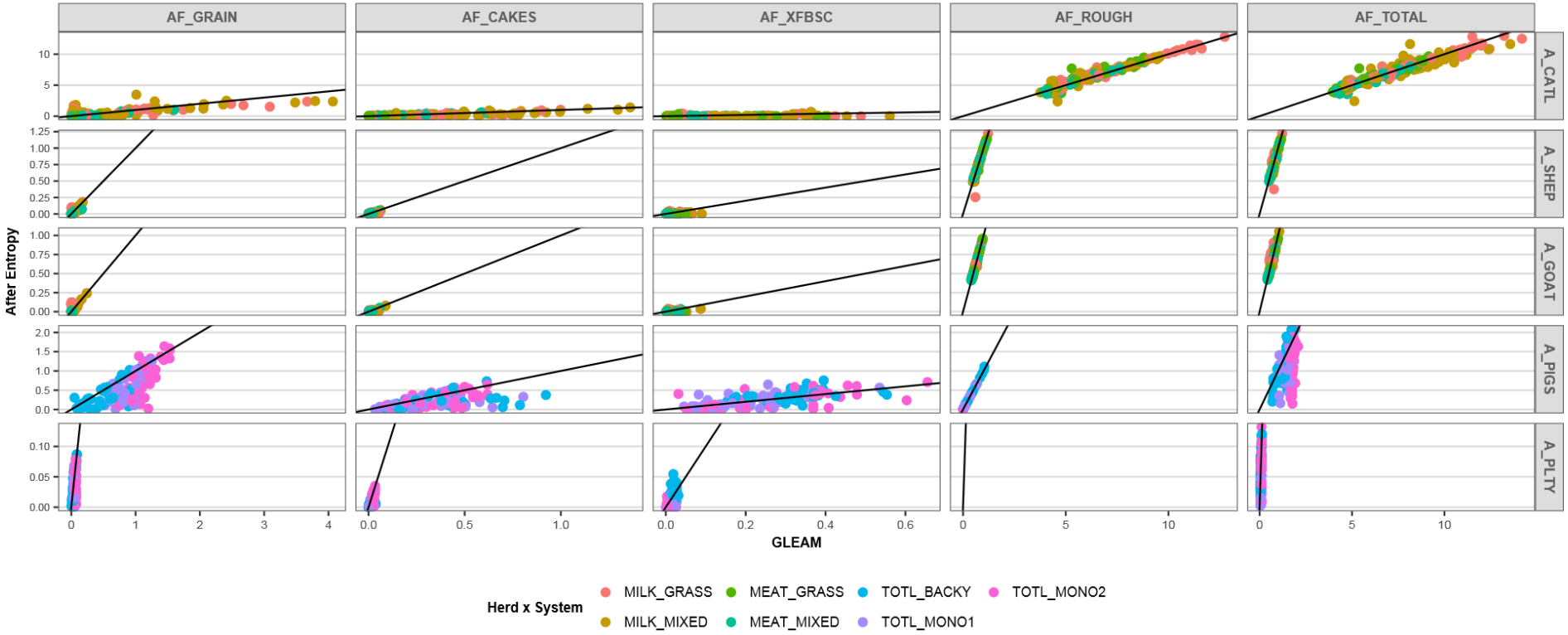
Feed intakes before and after entropy



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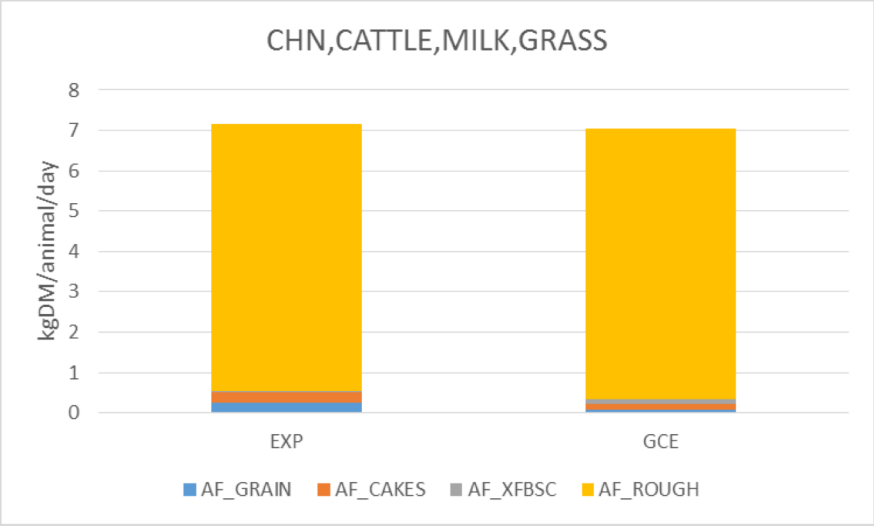
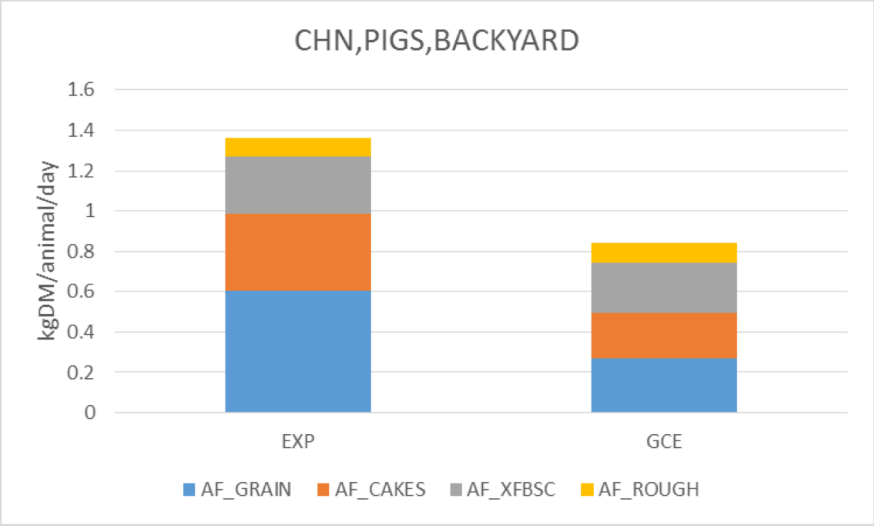
Selected results for rations



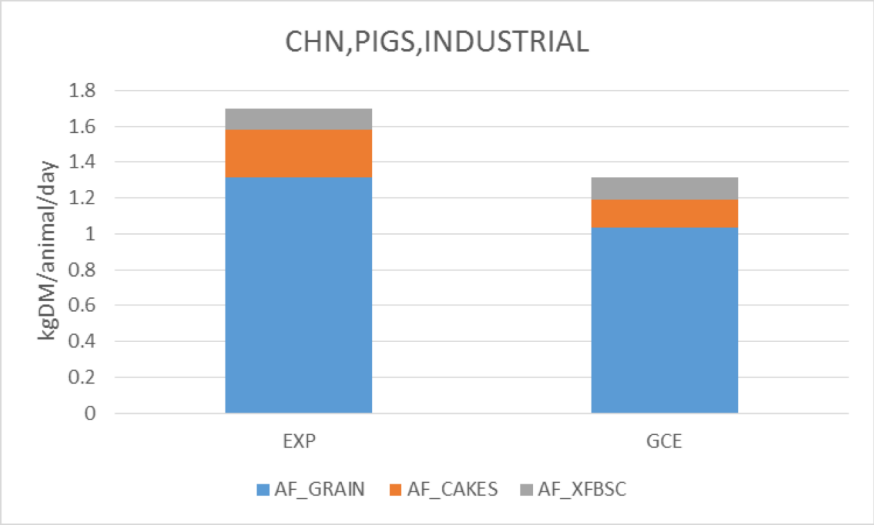


Monogastrics

- Tendency to underestimate total intake
- Include swill? How?

Ruminants:

- Generally good fit: roughages permit sufficient degrees of freedom



And now?

- **Scrutinize fitted rations, improve GCE procedure**

- **Include roughages demand and supply in GAPS**
- Straw / crop residues
  - Straw market, but what are other uses?
  - Express use shares as function of prices?
- Maize silage
  - Possible to treat as any other crop
- Grass
  - Conversion from rangeland to pasture
  - Make use shares price dependent

Thank you

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