Exploration and design, and the role of science

Integrative systems-oriented approaches deal with the competing claims on resources that serve as inputs and the multiple commodities and positive and negative externalities that agricultural systems produce as outputs, using selected indicators. In combination with adaptive approaches in which policies and system interventions are seen as experiments that need to be continuously monitored, updated and adjusted, systems approaches provide an alternative to single technology based adjustments and linear extension models. To develop improved livestock feeding systems following these principles, we could structure projects in several phases, coinciding with the classical steps of the problem solving cycle. Scientific effort can lubricate this process by supporting exploration (quantifying impacts, generating and evaluating alternatives, and visualizing relations between indicators) followed by design (selection, fine-tuning and implementation) of a desirable future management option.

In projects aiming to improve livestock production systems, exploration serves to systematically create a large diversity of alternatives to choose from. This enables scientists and planners to make the synergies and trade-offs among the system indicators explicit. The aim is to inform farmers and to feed the discussions among farmers, stakeholders and policy makers by providing quantitative insight in the 'room to manoeuvre' and in the resource use configurations of possible alternative systems. In the design phase, a decision needs to be made about the most desirable alternative to be implemented and to be fine-tuned to the local conditions. Identification of the most desirable alternative may be informed by the visualization of trade-offs and the resource use configurations. However, conflicts between indicators are likely to exist and an acceptable compromise may be difficult to attain. In addition, the indicators that describe the system outputs are usually based on scientific approaches and may be technical and complex in nature. To translate the multitude of possibly conflicting science-based indicators to a set of indicators that describe more directly the demands of farmers, policy makers or society at large, indicators may be weighted based on multi-criteria decision techniques. In various projects involving exploration and design of novel systems, integrative goal-oriented modelling approaches have proven to be effective to support innovative farming system development (e.g., Groot *et al.*, 2007; Tittonell *et al.*, 2007).

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Use of different technologic to guarantee feeding animals in the tropic

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Introduction

Feeding is one of the most urgent problems in tropical livestock production and in spite of the advances that allow utilization of local resources, due to poor knowledge transfer and lack of training for producers, they are not applied, and thus difficulties still remain to be solved.

Silages

The low nutritive value of grasses, the high moisture levels of some agro industrial residues, the poor crude protein contents of sugarcane and rice straw and the prevailing view that specialized machinery is necessary for the preparation of silages, have limited their use. With mixed silages of grasses and legumes, in ratios 70:30 a well-preserved feedstuff is obtainable with crude protein levels above 12% giving a 10% increase in food intake (Ojeda *et al.*, 2008b).

In four studies of silage making using wet byproducts, like citrus and pineapples pulp, the inclusion of between 10 and 15% of an absorbing material like grass hay, bean straw or sugarcane bagase, permits increases in total dry matter of more than 30% which allows better fermentative quality and avoids the loss of soluble compounds. There is an increase of nitrogen compounds with urea up to 4% but this feed is acceptable if 3% lactic strains are introduced (Ojeda *et al.*, 2008a).

This kind of citrus silage used over a five year period under production conditions and supplemented with an integral diet for bull fattening with forage, hay and commercial concentrate can achieve average, live gains of 0.633 Kg/Animal/Day (Ojeda *et al.*, 2010)

Ammonization of sugar cane or bean straw with urea, up to 4%, transforms this by products normally high in dry matter (over 50%) and low in crude protein (under 3%) into a much improved feedstuff with nutritive values above 30%. These procedures require chopping the materials until 2 cm with a stationary chopper.

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A simple silage store can be constructed using a one ring silo, consisting in two metal semicircles that are joined and opened through a hinge. One silo of 1.90 m diameter and 0.6 m high will store 3.2 t of silage with adequate compaction achieved through human foot stamping which then guarantees a good anaerobic environment once the mold is formed by the ring, the ring is withdrawn and the silage covered with polyethylene and made airtight by tying. (Améndola *et al.*, 2008).

Meal from trees

The production of meals from dehydrated foliages of trees is an available resource that can easily be introduced to livestock. Their protein contents are higher than cereal-based concentrates, with the advantage that they are produced from renewable sources.

The process consists in having young regrowths (60 days in the rainy season, 90 days in the dry season,) which are spread over a surface where they are not contaminated with dirt and exposed to sunlight until they reach between 85 and 90% dry matter.

The speed of this process depends on the plant: *Morus alba* is dehydrated in 12 hours under sunlight and the leaves can be separated passing the stems through a gloved hand. The dried leaves of *Leucaena leucocephala* are separated by beating the branches. In the case of *Gliricidia sepium* and *Albizia lebbeck*, it is best to separate the leaves from the stems to accelerate drying.

Due to the low density of these meals it is recommended to feed them wet by adding 5% molasses. This prevents their powdery nature from upsetting the animals and also improves palatability and the energetic value of the supplement (Savon *et al.*, 2006).

Table 1 *Chemical composition and quantity of nutrients for one ton of tree meal or cereal concentrate*

					Quantity of nutrients for one ton			
Tree species	DM %	CP %	CF %	ME MJ/kg MS	DM (t)	CP (t)	CF (t)	ME 10^3 (MJ)
L. leucocephala	90.4	20.1	18.5	8.88	0.90	0.18	0.17	8.05
Gliricidia sepium	97.7	24.7	28.5	9.26	0.98	0.24	0.28	9.05
Albizia lebbeck	95.7	23.9	26.6	8.92	0.96	0.23	0.26	8.55
Morus alba	96,7	24.9	13.1	10.17	0.97	0.24	0.13	9.84
Cereal concentrate	86.2	18.2	5.6	11.55	0.86	0.16	0.05	9.97

Conclusions

To best utilize the feed resources available in the tropics is both a need and a challenge. Both are complementary and it is up to researchers and farmers to match the two.

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Investigations into the value and use of local indigenous trees/plants as feed for goats in the semi-arid areas of Zimbabwe

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Introduction

Smallholder goat keepers in the semi-arid tropics rarely use conventional concentrate feeds in livestock production systems as they are expensive. Non-conventional feeds need to be considered for this sector. (Smith *et al.*, 2005). Small ruminants, particularly goats, depend

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