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The role of systems research in grazing management: applications to sustainable cattle production in Latin America.

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Abstract

In the last twenty five years, advances in pasture science have considerably widened the scope for improvement in ruminant livestock production from grazing systems. The introduction of improved pastures and legumes to increase output per animal and/or per hectare is a classic example of such advances.

To ensure the long term success of these technologies, management of the grazing system has to be improved and the ability to deal with strategies integrating multiple choices over an extended planning horizon has to be taken into consideration. For example, the control of stocking rates, paddock rotation lengths and fertilizer practices become important to maintain pastures in the long run.

However, sustainable grazing cannot be achieved if management strategies like these are taken without a holistic understanding of the whole farming system and the interactions between its components.

This paper describes current efforts and the role of decision support systems created by linking livestock information systems and whole farm models to support management decisions in cattle farms of Latin America.

Keywords: decision support systems, models, cattle production, farm management, grazing management, land use, Latin America.[*]

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Introduction

Grasslands are one of the major natural resources of Latin America. They comprise about 28% of the total land of the region and support approximately 25% of the world's cattle population (1.3 billion head) (FAO 1994). A large proportion of them are rangelands which support relatively low levels of animal production. Therefore, in the past 25 years, efforts to increase animal production have been directed towards technologies such as introduction of improved pastures, legumes and their associations (Lascano 1990).

Substantial evidence of the benefits of these introductions in terms of animal performance is available (see Skerman et al. (1988) or Humphreys (1991) for reviews). However, a delicate balance between animal production per unit of area and per animal is required to ensure the persistence of these species on the long term (Lascano 1990). These types of technologies require an increased managerial capacity from the farm household and in many cases an increased participation and interaction between the farmer and extension personnel. This suggests the need for decision-support tools to assist in the selection of appropriate grazing system designs and management practices. A requirement of these tools is that they provide a holistic view of the farming system in order to provide realistic management solutions (Dent et al. 1994, Herrero et al. 1996).

The objective of the present paper is to show the importance of a systems approach in sustainable cattle production systems in Latin America and to describe technologies that may help to ensure their long term success.

Sustainable cattle production systems: concepts and compromises.

The term sustainability has become fashionable in the past decade but it is a subjective concept. Many definitions have been formulated depending on the context of its use, but one of the most quoted ones is the proposed by the WCED (1987):
'...*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*'.

In a pastoral context, Figure 1 illustrates in the left hand column grazing management issues which although often conflicting, together, in compromise, lead to sustainability at the field level. Figure 1 also shows how sustainability measures at different levels within the farm, demand compromise management to achieve overall sustainability. It is evident that grazing management is one of the key determinants of sustainability for the whole farm in the long run. However, because all the requirements (see Figure 1) have to be met simultaneously, a series of compromises arise which cannot be studied unless the whole system and associated objectives are represented. For example, in biological terms, the provision of an adequate year-round forage supply of a desired botanical composition and quality is central to animal performance. However, to obtain this while at the same time maintaining soil fertility or the legume component, keeping a flexible system to minimise risks due to climate and markets and minimising residues from fertiliser and chemical inputs is a formidable task (Humphreys 1994). The problem is multiplied several fold if socio-economic and external aspects which are fundamental to the decision-making process are included (Dent et al. 1994).

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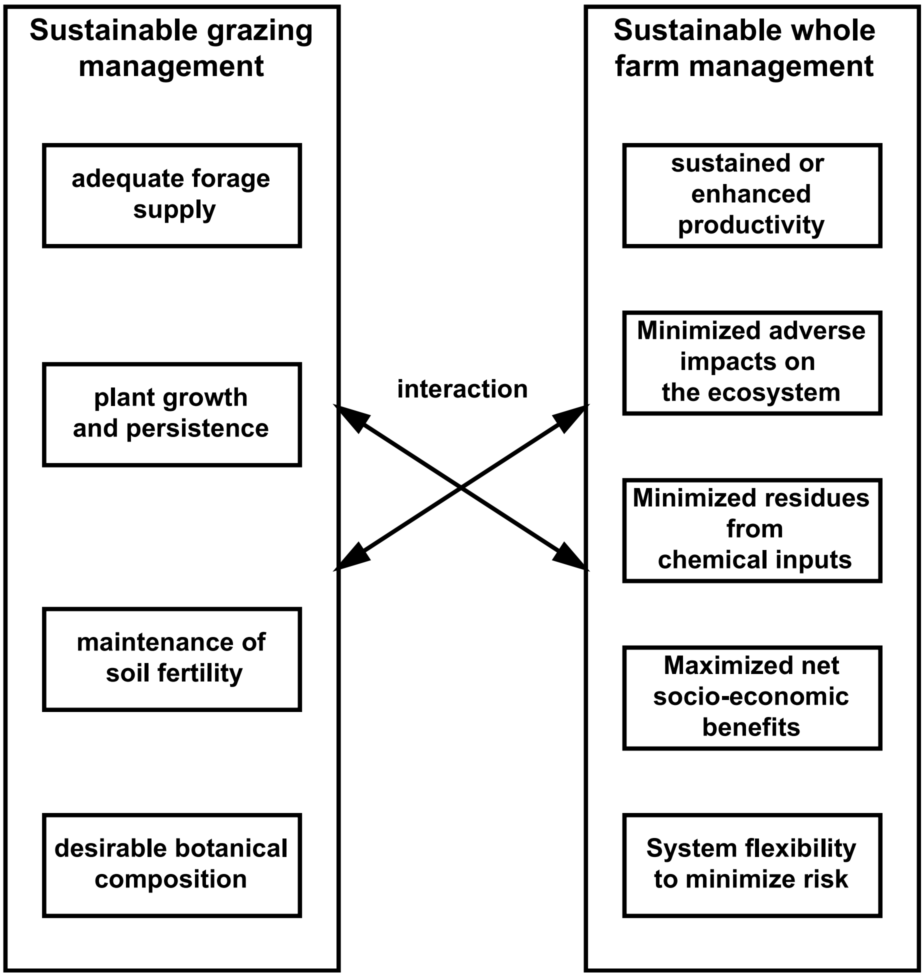

Figure 1. Attributes of sustainable grazing and sustainable farm management.

Decision-support for pastoral systems.

The complexity of pastoral systems justify the need to build dynamic decision-support systems (DSS) based on simulation and optimisation techniques to represent different components and the main interactions (i.e. Dent et al. 1994, Herrero et al. 1996). Figure 2 shows the general methodology for modelling pastoral production systems. Given the overall framework, it is obvious that grazing management decisions cannot be taken excluding the other components of the system. For example, grazing management strategies cannot be taken without consideration of herd or nutritional management, since herd dynamics or feed supplementation practices will determine the grazing intensity and utilization of the forage resource and subsequently animal performance. This is why within the modelling framework (see Figure 2), a simulation system representing the biology of pastoral enterprises needs to include flexible, mechanistic models representing: pasture growth, structure and quality; an individual ruminant digestion and metabolism model to test nutritional strategies, and a population model describing management practices at herd or flock level (i.e. stocking rates, sales of animals, mortality or replacement rates, calving intervals, etc.) which subsequently determine animal numbers and their age or physiological state (lactating vs. pregnant cows, heifers, calves, etc.) classes.

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Nevertheless, individual mechanistic models can be used to improve the understanding of a particular part of the system and the biological feasibility of some of the strategies. For example, Herrero (1995) used a pasture growth simulator representing the growth and structure of tropical pasture swards under rotational or continuous grazing with responses to N fertilizer applications, temperature and irradiance, to devise physiologically-based management guidelines for rotational grazing systems in the highlands of Costa Rica.

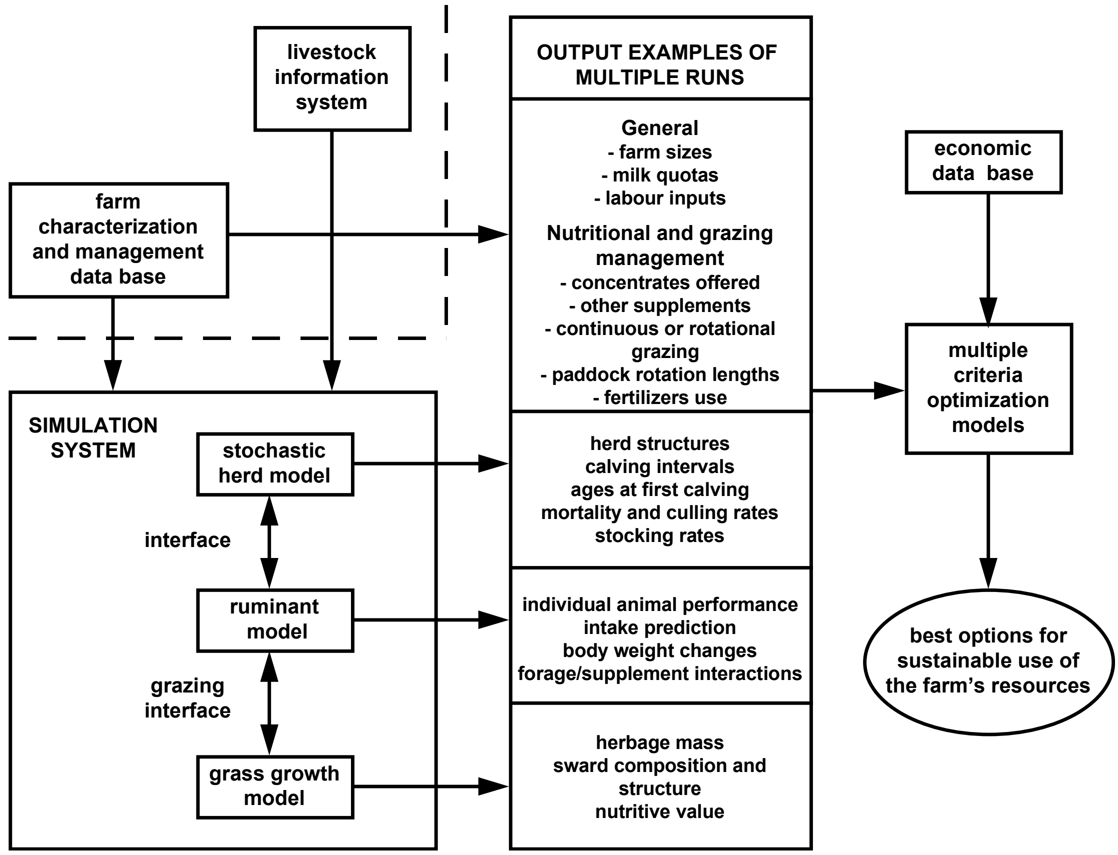

Figure 2. General pastoral systems modelling methodology. Adapted from Herrero et al. (1996).

Land use options are central to management outcomes and require a mechanism to select between alternative farm resource allocation strategies. Due to the nature of the problem and the variety of objectives, multiple criteria decision models (MCDMs) are ideal structures to study these compromises (Romero and Rehman 1989; Fawcett 1995; Herrero et al. 1996). The outputs of the validated simulation system become the inputs for the MCDMs (i.e. Veloso et al. 1992)(see Figure 2) and these explore the effects of different management options on the resource use strategies of the farm. Finally, the best resource use alternatives are selected according to the various objectives of the decision/maker and are implemented at field level.

It is important to recognise the difference between systems analysis and decision-support because modelling objectives and the variables under study can be very different. Systems analysis can occur at a variety of levels of aggregation but does not require a dynamic interaction with the decision-makers, these being the farm household, the policy-makers, extensionists, etc. Decision-support implies an analysis of the system, support to the management cycle and a constant interaction with the decision-makers via performance monitoring.

The variables driving the system should represent the variables handled by the decision-makers, according to the planned time horizons for the different goal achievements. The variables and the decision rules can be quantitative or qualitative depending on the information available (Röling 1994, Dent 1995). In quantitative systems, there is a trade-off between the level of aggregation, the accuracy required and the ease of validation and understanding. 'Hybrid' models based on a mechanistic platform but with empirical site-specific parameters obtained from local data may be the ideal for decision-support purposes.

Livestock information systems.

A key element of any DSS involves monitoring of the actual performance of the system and the provision of analysed data for the decision-maker. This is shown in the top left hand corner of Figure 2.

In the context of tropical cattle production systems, this concept was pioneered by the Herd Health Project of the School of Veterinary Medicine of the National University of Costa Rica (Pérez et al. 1989). The VAMPP (Veterinary Automated Management and Production control Program), originally developed by Utrecht University, The Netherlands (Noordhuizen 1984) was introduced and adapted to the local farming systems and information requirements. The main objective of its introduction was to provide information to the farmer according to his needs for his operational (day to day) farm management while at the same time creating livestock databases for research and teaching purposes. This function was developed as a farmer-oriented livestock information system (LIS). The system works by periodic monitoring of individual farms and the collection of production, reproduction and health data from individual animals. Databases are created and analysed and an immediate feedback to the farmer is given via action lists (cows to inseminate, to calve, to dry-off, etc.) to support his operational management. Other longer-term performance indexes are also provided (calving intervals, ages at first calving, replacement rates, etc.) (see Baaijen and Pérez 1992).

In 1988, the system was introduced in 23 farms through a small pilot project and now periodical monitoring (every two weeks or once a month) is provided for more that 400 dairy, dual purpose and beef cattle farms in Costa Rica.

After the positive acceptance of the information system by the Costa Rican livestock farmers, links with other Latin American countries began in 1990 to establish similar systems. These were made through farmers organisations, cooperatives or Universities, and a regional network was created. Today, the livestock monitoring system is present in Nicaragua, Guatemala, Honduras, Panama, Colombia and Mexico and contacts have also been developed to introduce it in Bolivia, El Salvador and Venezuela.

The implementation of the LIS in the region has proved to be an efficient method for providing operational technical support to farmers while at the same time capturing information for research and teaching purposes (Baaijen and Pérez 1992). The descentralised structure of the system can also collate data from individual farms to provide regional or group information to assist advisors, policy-makers and researchers if required.

The link between the modelling framework and the livestock information system.

Drawing together the modelling framework (planning and resource use allocation) and the LIS (operational management support and monitoring) creates a DSS and can be observed in Figure 3. The LIS supports operational decisions while the DSS creates the opportunity for strategic and tactical planning and target setting.

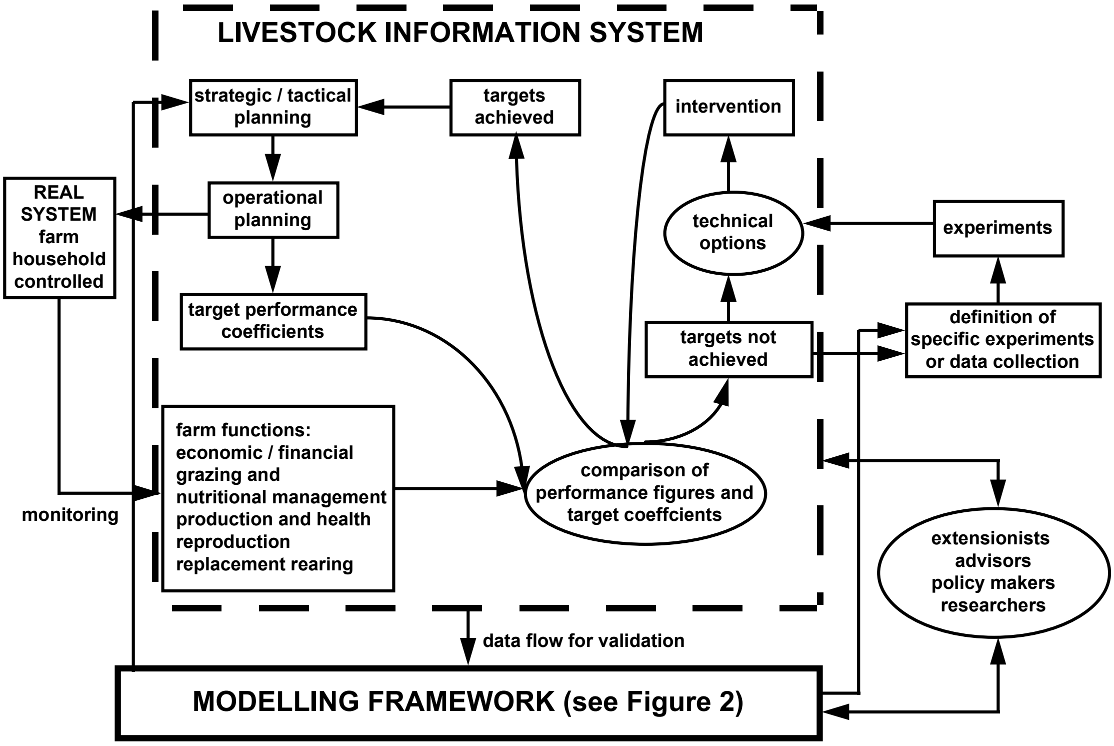

Figure 3. The decision-support system for pastoral enterprises.

Once the DSS is sufficiently validated across a range of production systems, its role would be as a planning tool in conjunction with extension services to improve farm management and resource use.
For individual farms it will:

- provide alternative strategies dealing with technical and land use options.
- set target performance figures for the farm functions (i.e. grasslands utilisation, replacement rates) for the preferred selected strategy.
- monitor the current performance of each farm on a routinely basis.
- do periodical analyses to check if the targets are being achieved.
- suggest ways to adjust the current system if targets are not being met.
- provide a basis for replanning if necessary,

At a more aggregated level it will be used as a policy-making and as a research/teaching tool. This use has the potential to create a link between the farmer, the extension agent, the policy-maker while at the same time creating livestock performance databases for research purposes. As the livestock information network is already working in several countries, a robust validation of the modelling framework would give the whole system the potential for regionalisation according to the farming systems and farm characteristics of the countries of the region.

Required research.

In terms of the modelling framework, the agroecological diversity of Latin America and the distribution of pasture species mean that adaptation of the models need to deal with a variety of ruminant production systems (i.e. dual purpose, beef cattle). This would imply the adaptation of these models to a range of pasture species with different growth habits and phenological attributes (i.e. *Brachiaria spp*., *Cynodon spp*.), grass/legume associations and rangelands.

Successful adaptation of the models is largely dependent on the availability of appropriate data for validation and parameter values. It is believed that if sustainability is the key issue for the long term stability of grassland ecosystems, more research is required on soil N dynamics in tropical grassland systems and on the physiology of tropical pastures, legumes and their associations. Although several efforts have been made (see Humphreys 1994), there is still a lack of quantitative information on these processes for tropical Latin American grazing systems.

Studies on intake, diet selection and grazing behaviour of ruminants grazing rangelands and improved pasture/legume swards with different morphological characteristics are also necessary to provide understanding and to improve the prediction of intake of ruminants at pasture.

Sociological studies on the farmers decision rules and behaviour are required in order to understand the justification of some of their actions. This is important to provide decision support in areas of real importance to the farming community.

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