

Modeling crop-livestock integration systems on a regional scale in Reunion Island: sugar cane and dairy cow activities

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Introduction

Sustainable rural development is one of the Reunion Island priorities, where a large part of the economy is based on agriculture. One option would be to create a self sufficient system where dairy cows' manure would be used as organic fertilizer for sugar cane fields and sugar cane by-products would be used as a forage for dairy cows. This type of option meets aspirations to deal with insularity constraints, volatility of input prices and policies to preserve the environment.

The efficiency and the effectiveness of these technical choices could be greatly improved if their ex-ante analysis is achieved. The key challenges for enhancing the usefulness of search tools for multi-criteria assessment is defined by their ability to change the scale level from micro to macro analysis, their ability to provide multicriteria analysis, and their generic flexibility to cope with a wide range of issues.

This paper presents the justification, the components and the illustration of a modelling approach that represents farming systems in Reunion Island that can assess impacts of technical alternatives to cattle feeding and crop fertilisation.

A framework allowing data linkage to each model's components was opted for which offered flexibility of model and data coupling. A multidisciplinary approach was used, based on a dynamic linear programming model that integrates technical, socio-economic and environmental constraints.

Model description

The model components were developed with the General Algebraic Modelling System (GAMS) using an Interactive Multiple Goal Linear Programme approach, based on the standard linear programming structures as given by Nidumolu (2008). The model focuses on the nutritional balance for dairy cows based on their nutritive requirements (energy and protein; Hassoun *et al.*, 2000) and capacity of intake (UEL; Salgado *et al.*, 2008). It takes into account the genetic milk potential and the physiological characteristics of dairy cows. A ratio between fodder and concentrate feed intake was established in order to control the proportion of both feeds. The nutritive value of fodder and concentrate feed results from laboratory analysis and Near Infrared Spectroscopy (NIRS) predictions. By-products from sugar cane activity (cane-trash and straw) are used as alternative fodder by dairy cattle. The NPK balance for sugar cane and fodder fertilisation take into account the use of the dairy cattle manure.

The model algorithm combines the fodder and crop types and areas and the concentrates needed to meet animal nutrient requirements. The objectives of the models are to maximise total revenue and minimise operational costs.

Scenarios

The use of sugar cane by-products as a supplement feed and the use of manure as fertilizer for sugar cane activity increased (about 3.5%) the gross margin of both activities. This increase is due to lower concentrate feed costs (about 11%) and mineral fertilizer (about 50%) and an increase of dairy herds. The adoption of these technical alternatives are highly dependent on transportation cost¹ used and by-product qualities². The negative impact of a decrease in milk production subsidies in the global profit is attenuated if crop and livestock activities are integrated at a regional level.

Conclusions

The results show how an integrated modeling approach can be a useful tool to assess the impact and eventual consequences of exogenous changes in agricultural systems at regional level.

References

- Nidumolu U 2008. Report of the project 'MODLAIT', 97pp.
Hassoun et al, 2000. L'élevage bovin à La Réunion. CIRAD, 225–248.
Salgado et al, 2008. Dairy Vietnam Farm Model (DAIVIE). CIRAD, 82pp.

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¹Transportation cost is around 1€/ton/km.

²Nutrients (energy and protein) or the NPK' rate of contributions.