Dynamic Integration of Sugarcane Agriculture and Cattle Production

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Introduction

A methodology for dynamic optimal planning for the integration of sugar cane plants and meat production areas has been developed, based on mathematical programming techniques. This work has been developed at CTBE (Centro de Ciência e Tecnologia do Bio Etanol), a Brazilian institution for bio ethanol research and development, with the purpose of quantifying the interaction of sugar cane plantations for new ethanol plants and cattle production. The modeling methodology represents the dynamics of business interests of plant owners and farmers, showing, for example, that for 1 ha of planted sugarcane, 1.03 ha of cattle can be intensified through the use of confinements and/or supplementary feeding in pasture, resulting in a reduction of the number of months from purchasing to selling of cattle from 23 months to 14.2 months. Considering a scenario with aggressive expansion of standard bio ethanol plants, installed on 5% of the total current pasture areas, if cattle and sugar cane integration is considered, it is possible to maintain meat production without occupying more land, in other words, without an iLuc effect (indirect land use change). Also, it is indicated how the mathematical programming approach can be applied to more complex integration of meat production and processing with sugar and bio ethanol plants.

Modeling scenario

In this research, a sugarcane ethanol distillery with a total annual milling of 2 million tones of sugarcane is considered reference.

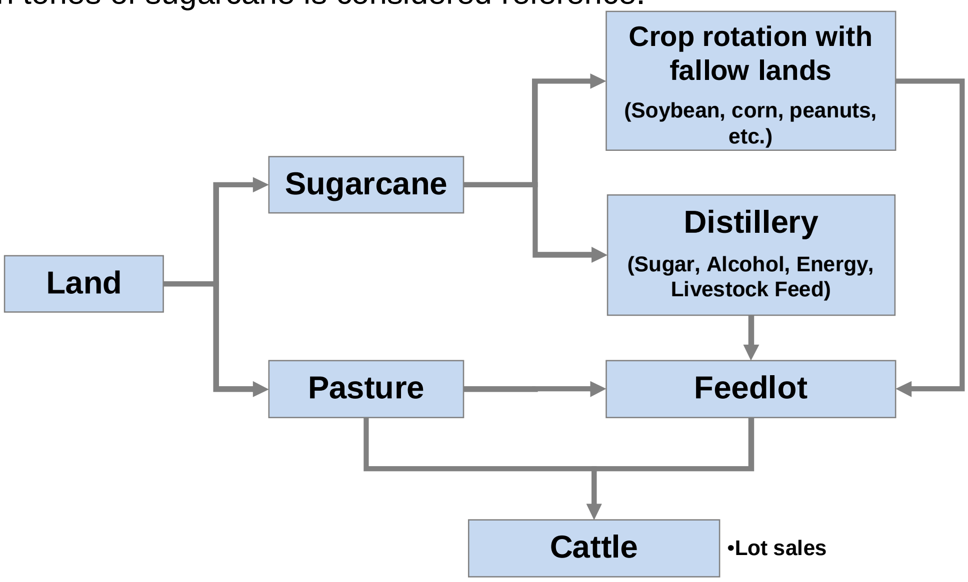

Figure 1: Interaction between Distillery and Cattle Farmers

It is assumed that the distillery owner is facing an investment horizon in confinement and pasture improvement of his sugarcane suppliers in order to optimize the dynamics of animal purchase, growth and selling in a planning horizon of few years. The dynamic aspect consists of the combination of decisions of purchasing and feeding cattle in pasture under extensive and/or intensive technology, with the possibility of the termination phase occurring in confined feedlots three months before selling. These decisions occur in a planning horizon of 10 years in order to capture the best way of managing the integration, starting from empty pasture, and allowing for investments payback. Forecast of cattle purchase and sales prices, as well as other economical and performance parameters, are given for each month of the entire planning horizon. For example, for every month of the planning horizon and for each feeding option rates of growth are predicted, which can vary annually depending on investments on technologies available to the decision maker (planner) at given prices. Feed formulations for supplementing cattle on pasture under the intensive technology and for feedlots are based on ingredients available in the plant (regular and hydrolyzed bagasse, yeast and molasses) and also grain obtained from corn and soybean planted in yearly available areas resulting from sugar cane plantation reforms (about 15% of the whole plantation every year, from which 60% are assumed to be used for soybean and corn). The cost of the feed formulation takes into consideration the alternatives of selling the ingredients. Costs of supplementary ingredients are also considered.

The standard bio ethanol plant was considered to be installed in an area of extensive pasture in the southern region of the State of Goiás, from which parameter values were taken. The idea is to find the potential for improving meat production considering only feed ingredients available in the plant (except micro ingredients), as illustrated in the figure bellow.

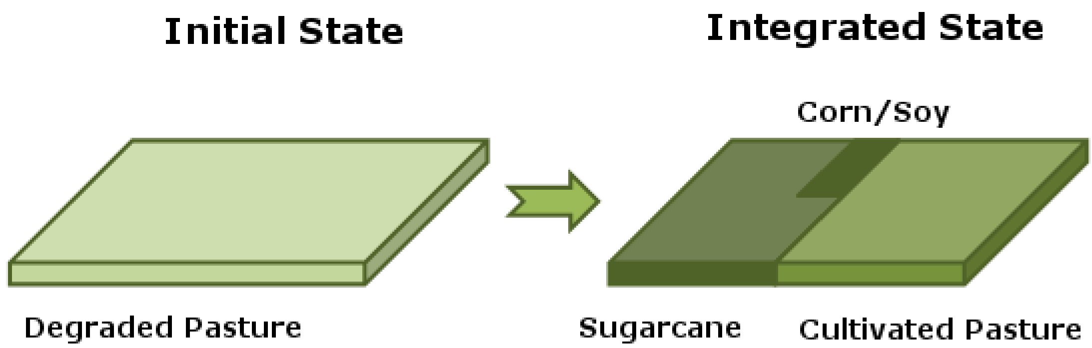

Figure 2: Before and after integration

Results and Conclusions

Assuming that 10% of available bagasse is used for feeding, and limited technology for pasture intensification (1.2 animal units[1]/ha) and other performance and economic parameters are constant throughout the planning horizon, the following results are obtained:

[1] One animal unit is equivalent to 450kg of live weight

- Plant and sugarcane fields occupy 28.000 ha;
- Ideal intensified pasture area occupies 28.988 ha;
- For 1 ha of planted sugarcane, 1.03 ha of cattle are intensified through the use of confinements and /or supplementary feeding on pasture;
- In total, the integrated system, with 28.988 ha of pasture, produces 51,9% more meat than an extensive cattle farm of 56.988 ha (sum of areas), that is, 451,6 kg of live weight/ha instead of 151,2 kg of live weight/ha;
- The profitability of the meat production is also higher for the integrated scenario;
- The average number of months from purchasing to selling of cattle decreased from 23 months to 14.2 months;

A sensitivity analysis, based on more complex pasture technology, with higher animal density, showed that the corresponding intensification costs are compatible with those shown in practical situations in Brazil.

Further Potential Applications

Cattle supply to beef plants became a crucial problem for many Brazilian companies, some involving daily slaughter of more 20,000 animals distributed in many plants. Traditionally, most of this supply comes from extensive pastures with low technology in terms of breed availability and nutrition. Some of the companies are now investing in infrastructure for the termination phase of the growth process in confined feedlots. Given that plants are located in many states, the investment for the location of this infrastructure, which depend on feed supply, roads and farmers from whom to purchase animals to form the feedlots, must be carefully planned, hopefully, optimized. Linear integer programming planning models can be developed for optimal investment analysis, as well for optimal operation of the resulting complex of feeding facilities. This development is now possible due to improved computing power and modeling algebraic languages like AIMMS, GAMS and OPL (Optimization Programming Language, belonging to IBM’s ILOG Optimization Suite). Higher level of integration, as shown in Figure 3, due to Correia (2009), considers a potential integration of land and industrial plants.

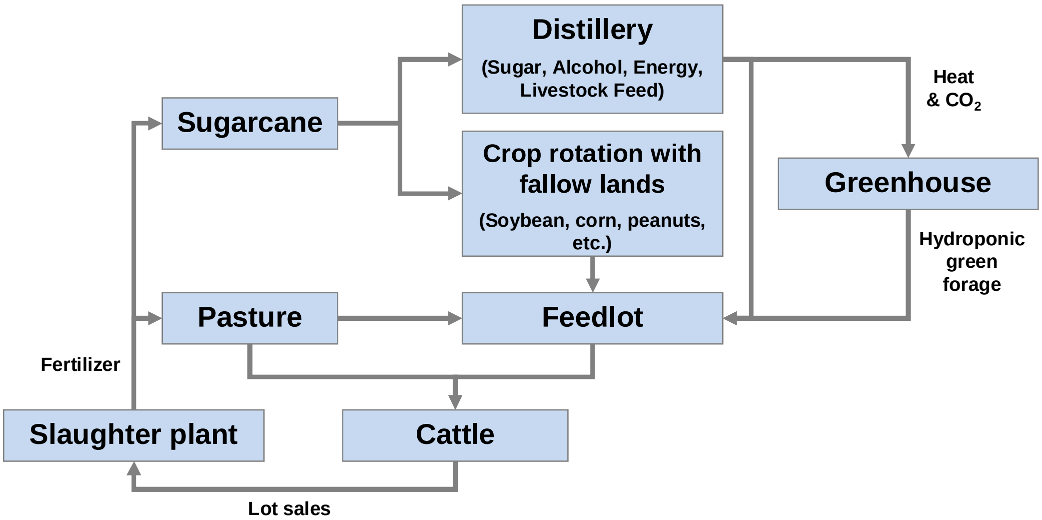

Figure 3: Potential integrations

Comments

Brazil is the largest beef cattle producer in the world (Anualpec, 2010), with cattle herds of more than 171.6 million in 2006, occupying an area of about 158.7 million ha (IBGE - Censo Agropecuário 2006). Sugar cane plantations occupy an area of about 9.2 million ha, with a total annual production of 729.6 million tons in 2010 (IBGE, 2010).

Considering a scenario were clusters of standard bioethanol plants (which only produce ethanol) are installed in 5% of the total pasture areas (8.58 million ha), exclusively substituting extensive cattle production, the ethanol production could increase in over two and a half times its current total.

Moreover, if we consider that all new plant adopt an integrated production system, 8.88 million hectares of degraded pasture could be improved and intensified. This is based on pasture cultivation and feed formulations with soybean and corn (planted in about 60% of the annual sugar cane reform area), 10% of bagasse obtained in the refinery, and the corresponding growing activities resulted from an optimal combination of 8.88 Mha of intensified pasture and confined feedlots. Considering that the total cattle meat production in Brazil will remain the same, the integrated meat production could free 9.2 million hectares of degraded pasture area for other agriculture activities, considering that the combined area of sugar cane plantations and cultivated pasture (17,46 Mha) produce the same amount of meat as an area of 26.62 Mha of degraded pasture.