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An Optimization Model to Deal with Livestock Production and Emissions While Maximizing the Overall Net Revenue

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Introduction

The Brazil is second world´s largest beef producer (FAO, 2016), with a great variety of climate and natural resources on its Biomas. The grassland area allocated to livestock systems is about 170 Mha, with a great variety of production systems adopted on each one of them (IBGE, 2016). Beef production systems have different input of resources and result on different outputs, as beef, money and greenhouse gases (GEE) emissions. Finding promising solutions dealing with the complexity of the drivers of the trade-offs between profit, production and GEE´s is not trivial. Some authors have evaluated such trade-offs through detailed mathematical models of the technological dynamics in a production system (OLIVEIRA SILVA et al, 2015; 2016).

This work uses an alternative approach where the transition of production systems is modeled. The main objective was to develop a

linear programming optimization model with that could represent the dynamics of cattle production system's adoption, maximizing the total net revenue or family revenue profit over the period on different future scenarios. Those considered a beef demand to be met, the amount of capital available, the maximum GEE emission, while complying with constraints considering the producer´s low inclination to adopt new technologies.

Material and Methods

The optimization model is a linear integer programing model that seeks to maximize the Brazilian beef cattle net revenue or family revenue (GUIDUCCI et al, 2012) over a designed horizon of time. The model´s decisions variables include the area allocated to a specific production system, in a specific Bioma on each year; and the area, on a specific Bioma, which changes from a production system (exit system) to another available system on the model (system adopted).

The solution is subject to (I) Meet the annual beef demand projected over the period; (II) Maximum annual greenhouse gases (GEE) emissions (considering soil carbon absorption, emissions by cattle and pasture fertilization) must be lower than a level designated. (III) The demand capital to invest on structure, pasture and animals for land use change, must be lower them the financial resource available.

Other constraints were set to deal with flows among the land use options (the land use on year t is equal to land use on anterior year, plus the amount of land that change from other production systems to this one, minus the land changed from this production system to others). Additionally, a set of constraints was set to allow the model to mimic the fact that, in general, producers are averse to changes. The model then uses three groups of inertia equations: the first one constrains the maximum annual area available for conversion from each production system to all others on the same Bioma (system inertia constraint). The two remaining groups of equations constrains the amount of land available to conversion from other production systems to a specific one (system aversion constraints), the first is based on a percentage of the land already in use on the production system, the second on an absolute value. The model chooses endogenously the equation that allow the greatest land amount available to each production system on each ear. The model also deal with the equilibrium on the supply and demand of calves between the productions systems. The first group of equations balance the supply and demand of male calves between the Amazon´s production systems. The second deal with the balance of female calves between production systems on Cerrado, Mata Atlântica and Pantanal. The last group deal with the male calves between those systems plus a number of male calves supplied by dairy operations, set as an exogenous parameter.

The model was implement on General Algebric Modelling System (GAMS), version 23.7.3, and solved on CPLEX version 12.3.0.

Results and Conclusions

The Picture shows some of the results of the model described herein. On Figure1a it is possible observe an increase in Net Revenue, Family Revenue and beef production, a slightly increase on Soil Carbon, and a greenhouse gases emission´s (GEE´s) over time. The emission intensity stays stable around 30 MgCO2eq/ton until 2015, and then falls to

26.5 at the in 2023. Figure 1b illustrates the corresponding allocation of different types of production systems in the solution for the Cerrado Biome.

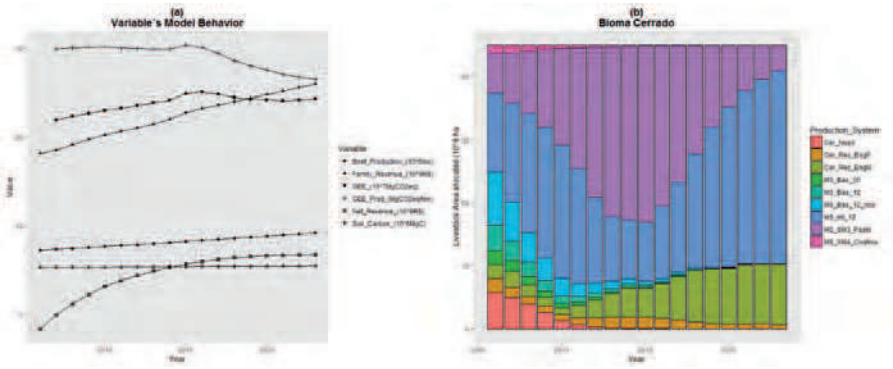

Figure 1 – (a) Dynamics of beef production, total GEE emission, emissions intensity, soil carbon stocks, net revenue and family revenue in preliminary results for one specific scenario for the five Biomes considered. (b) Dynamics of land allocation for different types of production systems for the Brazilian Cerrado.

Those results encourage the model´s use as a tool to analyze public and private policies dealing with livestock revenue, production, investment and emission. The model improvement by the PECUS project´s research team continues, as its validation aiming to analyze possible trade- offs between GEE´s goals and investment, and their impact on net and family revenue on some scenarios. Those will consider the international agreements and perspectives about GEE´s, income and population growth, beef and investment demand behavior and producer´s willing to adopt new technologies.

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