

Can beef cattle intensification reduce environmental pressure on Brazilian areas? A case study for Corumbá city(Pantanal biome) and Mato Grosso state(Legal Amazon) using a mathematical model

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Abstract: The bovine beef cattle in Brazil are predominantly extensive, what turns great natural areas into grazing. An alternative to reduce the occupied area is to intensify cattle creation, increasing productivity, but it demands a bigger use of water and animals supplements, that are based principally in soy. The deviation of high quantities of water to economic activities can cause a shortage of it on the future, and intensifies cattle raising could mean an increase of soy production. This work realized a study using a mathematical model in fuzzy language to accomplish a simulation of two Brazilian areas in risk because of beef cattle expansion: Pantanal and Legal Amazon. The results indicate that the intensification strongly decreases the grazing areas, what theoretically reduces deforestation. However, analyzing the socio-economical context, the intensification doesn't solve the deforestation problem, because in Legal Amazon, it revolves around the estate speculation, not linked to beef production, and in Pantanal, the extensive beef cattle have caused less impact on environment, because it is developed by small creators that produce without going beyond ecosystem capacity. Besides, simulations indicate that intensification means strong pressure on hydric sources.

Keywords: bovine beef cattle; Pantanal; Amazon Legal.

1. Introduction

The bovine raising is developed all over Brazil, expressing 225 millions hectares of grazing area and 195,5 millions of animals [1], and represented 8,7% of the national GDP (PIB) in 2004 [2]. However, its expansion is discussed due to the high levels of deforestation associated to this activity. [3] points that in Legal Amazon, the bovine beef cattle occupied about 3% of the total area in 1970,

number that increased 10% in 1995 and represented more than 70% of the deforested areas in 2003. In the Pantanal, was calculated that 8,8% of total area in 2000 was deforested by grazing cultivation[4]

There are three systems of beef cattle production in Brazil:

- Extensive: It represents 80% of bovine meat production, and uses only grazing as proteic and energetic source.
- Semi-Intensive: The dietary base is also grazing, but animals receive proteic and energetic supplements during the dry period.
- Intensive: The animals are confined, quitting from grazing and receiving voluminous feed, which is rich in protein.

The Brazilian government has a great encouragement program to intensify the bovine beef cattle. In 2003, the Senate approved a credit line to cattle creators who change from extensive to intensive production, aiming higher productivity, reducing grazing areas and, consequently, decreasing deforestation [5]. In 2011, a change of Brazilian Forest Code was approved; the main reason was the lack of agriculture areas, but there are about 61 million hectare of area being used as grazing, which has high productivity levels for agriculture[6]. These are useful areas for beef cattle intensification implant.

The intensification, however, demands supplements based principally in soy, what can create a competition between areas allocated for animal and human alimentation [7]. It also brings about soil lixiviation because of the high levels of water used for irrigation in this culture [8].

Beef cattle in Pantanal

The Pantanal is considered the most conserved ecosystem of Brazil, with 88,78% of native vegetation cover and the smallest area with human action (11,7%) [9]. Private properties comprise 95 % of the region, and 80% of this area has been utilized for beef cattle creation for 250 years [10]The beef cattle of Pantanal are developed in natural extensive creation with traits of handling regulated by flows [11].

Beef cattle in Legal Amazon

The Legal Amazon is a region formed by the states of Acre, Amapá, Amazonas, Pará, Rondonia, Roraima, Mato Grosso, Tocantins and Maranhão, with a surface of 5.217.423 km², corresponding to 61% of Brazilian territory [12].

The policies associated with the economic development of the Amazon region have been deeply attached to deforestation caused by roads, growing cities, beef cattle raising, wood exploration and agriculture, like soy and cotton production [13].

The beef cattle raising has the biggest coefficient of deforestation activity between the Legal Amazon cities (correlative coefficient of 0.7345). The expansion occurs because of multiples causes like liquidity of the activity, productive process simplification and lower levels of capital investments [14]. The author suggests that the intensive beef cattle can be a strategy to reduce deforestation.

2.Objective

The objective of this work was:

- To do an analysis using a mathematical model published in [15], whose input variable is the animals number in a herd and output variables are the quantity of grazing area, water used for animal consumption and water and plantation area used on soy culture. After that, using the results, compare the environmental pressure in extensive and intensive systems in a simulation to Corumbá city (Pantanal biome) and to Mato Grosso state (Legal Amazon). The model was elaborated using specialized literature and consulting to experts in animal nutrition.
- To do a socioeconomically analysis linked to beef cattle simulation for Pantanal and Legal Amazon.
- To verify if intensification really reduces the deforestation.

3.Methodology

- The analysis was accomplished using a mathematical model in fuzzy language(see subsection 3.1), published in [15], whose input variable is the animals number in herd and output variables are the quantity of grazing area, water used for animal consumption, water and plantation area used on the soy culture constituent of supplement . The model was elaborated with help of specialized literature and consulting to experts in animal nutrition from Maringa State University (Paraná-Brazil), Embrapa (Brazilian Cattle-Raising and Agriculture Company) and UNESP(Paulista State University) .The model can be obtained by sending an email to <adriano_gg@hotmail.com>.
- Two simulations were accomplished using the model: one for Pantanal biome (Corumbá city) and other for the Legal Amazon (Mato Grosso state).
- Socio-economic dates from specialized literature were studied with the model results to verify the sustainability of systems.

3.1 Fuzzy ruled-based system

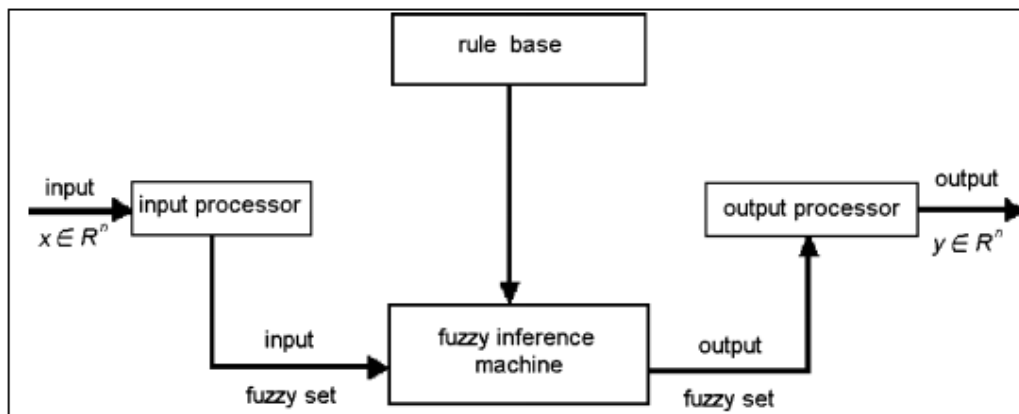
A fuzzy subset is characterized by a membership function mapping the elements of a domain, space, or universe of discourse X to the unit interval $[0,1]$ [16]. Fuzzy variables are processed using a fuzzy ruled-based system that has four components(Figure 1):

- Fuzzification: process in which the input values of the system are translated into fuzzy sets of their respective universes using experts knowledge[16].
- Rule base: It characterizes the objectives and strategies used by specialists in the area through of a linguistic rule set[16].
- Fuzzy inference method: It performs an approximate reasoning using the compositional rule of inference. In this work was used Mandami method, aggregating the rules through the logical operator

OR, modeled by the maximum operator and, in each rule, the logical operators AND and THEN are modeled by the minimum operator[16].

- Defuzzification: the value of the output linguistic variable inferred from the fuzzy rule is translated to a real value through center of mass method[16].

Figure 1: Structure of fuzzy rule-based system. Source: [16]



We suggest [17] and [18] for a detailed study of the fundamentals of fuzzy set and the systems theory and applications.

4. Results and Discussion

4.1 Pantanal simulation

The simulation was realized using as reference Corumbá city, that has the biggest cattle creation in Brazil, with 1.072.478 animals from beef cattle and 4.405.388 ha of area on the awash plain [19]. The table 1 contains the simulations for this herd:

Table 1- Simulation results for the Corumbá bovine herd.

	Extensive	Semi-intensive	Intensive
Grazing area (10⁴ha)	440,5	92,9	19,8
Water for animal consumption nk(10¹¹L)	0,41	0,25	0,25
Soy used for animals feed(10⁷kg)	-	12	18,3
Area used for soy plantation(10⁴ha)	-	0,46	0,72

Water used in the irrigation for soy plantation(10^{11}L)	-	2,67	4,56
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In a first look, the intensification seems to be a way to reduce the environmental impact of grazing areas in Pantanal: the intensification can reduce until 96% of grazing area, but these dates can dissemble the reality.

The extensive beef cattle in Pantanal have a low impact, because the cattle are established as part of the ecosystem, being fed with natural grazing and without occurrence of deforestation for grazing implantation. An energetically analysis realized by [9] also indicated the traditionally extensive beef cattle as a highly sustainability on the region, and represented a low environmental load, what indicates a low environmental impact.

The demand of water in intensive systems is higher than in the other systems, what causes a strong stress on the region, mainly because this area goes through periodic dry periods. In the semi-intensive system, considering only the main compound of proteic supplement, the soy, the water quantity demanded increases 700% because of the irrigation for soy culture. This number increases 1100% in the intensive system simulation. The deviation of high water quantities for agricultural cultures irrigation, like soy, has been followed by many impacts as nutrients lixiviation, intemperization, soil salinization and reduction of water levels in riverbeds (as already seen in Paraguay basing) [8].

Besides, a better grazing quality implies agrottoxins use, what causes sources hydric pollution. Many pesticides used in soy production are potential contaminants of underground waters, like metomil, maneb, triadimefon, atrazina,metribuzina, simazina, clorimuron etil, flumetsulan, fomesafen, glifosato, imazaquim,imazetapir and metolaclor[20].

4.2 Legal Amazonia simulation

The simulation was realized using as reference the Mato Grosso state, which has 1.838.719 animals in the extensive system[21]. The results of simulation are in table 2:

Table 2. Simulation results for Mato Grosso state

	Extensive	Semi-intensive	intensive
Grazing area (10^5ha)	20,7	13,9	4
Water for animal consumption (10^{11}L)	0,76	0,46	0,46
Soy used for animals feed(10^7kg)	-	19,6	19,6
Area used for soy plantation(10^4ha)	-	0,46	0,72
Water used in the irrigation for soy plantation(10^{11}L)	-	4,35	4,35

The ratio grazing / number of animals was too close of national average in extensive system, 0,93 and 0,88, respectively, what indicates the effectively of model. It's noticed that grazing area, the factor that more menaces the forest destruction currently, decreases more than 30% in the transition to semi-intensive system and 78% in the transition to intensive system. The water quantity, however, increases 6 times in the intensive, what indicates a strong pressure on hydric sources for soy production. Despite these increases of water demands, areas reduction can indicate a stronger decrease of the main threat for Legal Amazon that is deforestation.

[22] believes that intensification doesn't solve the question of Amazon deforestation. The economic production wouldn't be decelerated and the great farmers would buy the small farmers properties, which have less environmental impact. Besides, the purchase of properties to grazing areas establishment has a stronger real estate speculation character than beef production. The grazing implantation, even in bad situations, is more profitable than having it for forests only.

In 1998, national enterprises controlled by foreign capital could buy terrains in any part of Brazil without prior permit, through an "Union General Advocacy"(UGA) permit , what hampered the Federal Policy action mainly in Pará, Amazonas and Mato Grosso[23]. In 2008, the UGA revised your permit, but a delay in the govern revision approbation occurred because of the strong pressure of Paper and Cellulose Factories, arguing that it would decelerate foreign investors. President Luis Inácio Lula da Silva approved, in 2010, by means of Union Official Diary, the UGA permit revision, imposing more control under foreign properties ownership [24].

If only the model results was analyzed, beef cattle intensification would indicate a significantly decrease of deforestation. However, analyzing the socio-economically view, the causes of deforestation are associated to others factors not linked to beef production.

4.3 Growth without limits

The study of "grazing area" parameter confirms the Brazilian Senate decision in 2008[5], and the affirmation of the ONG SOS Florestas [6] that changing from extensive to intensive beef cattle production could double the areas used for agriculture production. The beef cattle intensification can result in a reduction of grazing areas, decreasing the necessity of changing natural areas into grazing areas and releasing these areas to agricultural cultures, what have more productivity. However, as seen in the Brazilian studies, the intensification can be disadvantageous if considered regional aspects and strong pressure on hydrics sources..

The evaluation of intensification benefits must be done carefully, without creating a delusional sustainable speech of environmental neoliberalism that intensification comes to be a solution for environmental degradation, and represents a rational use of natural sources, because the economic activities are looking for unlimited growing without considering ecosystem carrying capacity, disregarding the sustainability [25]. Therefore, it's necessary to consider ecosystems carrying capacity to grant deforestation decrease and it must direct the economic activity growing, not the inverse.

5. Conclusions

The model results indicate that intensification strongly decreases the grazing areas, what theoretically reduces deforestation. However, analyzing the socio-economical context, the intensification doesn't solve the deforestation problem, because in Legal Amazon it revolves around the estate speculation, not linked to beef production, and in Pantanal, the extensive beef cattle have caused less impact on environment, because it is developed by small creators that produce without going beyond ecosystem capacity. Besides the water demanded increases about more than 5 times in intensives system what indicates a strong pressure on this source.

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Conflict of Interest

The authors declare no conflict of interest.

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