ASSESSING FOOD (IN)SECURITY SCENARIOS IN CERRADO USING OFICIAL LAND COVER CHANGE PRODES DATA

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ABSTRACT

Land use changes in Brazil are justified to supply national and international demands for food, feeding and other commodities. In 2011 the Brazilian undernourishment prevalence (UnP) and starvation were faced by 16,27M people, with a much worse scenario in 2022 as estimates indicate 33,1 M facing any type of hunger. On the other hand, the total planted area in Brazil increased from 61,8 to 81,2 Mha in the same period according to IBGE. FEEDME model simulates food (in)security scenarios and, beyond socioeconomic variables, it is based on land use/cover maps retrieved from remote sensing data. This work analyzes UnP scenarios assessed using oficial recently released data on land cover change PRODES and TERRACLASS data. Under the current Brazilian diet the amount of land required to decrease UnP cannot be achieved only by increasing protecting areas, but requires large-scale implementation of climate change mitigation actions.

Keywords **—** food security, land use and land cover change, PRODES, scenario, Brazil.

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1. INTRODUCTION

In 1946, the landmark publication of *The Geography of Hunger (A Geografia da Fome)* , was the basis for the first estimates of 15% undernourished population in Brazil in 1990 [1]. Seventy-six years later Castro´s method is still quite updated and in coherence to recent studies attaching undernourishment to income, land tenure and technological level at the different spatial scales in Brazil and Latin America [2,3]. As a response to the political agenda on income distribution, food production and access, in 2011 Brazil halved the number of starving people and dropped even more the undernourishment prevalence (UnP) [4]. Between 2011 and 2021 the number of Brazilians facing undernourishment prevalence (UnP) and starvation increased from 16,27 M to 33,1 M people [5]. In the same period total planted area in Brazil increased from 61,8 to 81,2 Mha, with new soybean areas only, responding to 15,1 Mha [6]. As a consequence natural vegetation total losses among forest and non-forest vegetation summed 24,2 Mha in the same period [7]. Therefore, tracing a parallel timeline on land use/cover changes (LUCC) in Brazil, such changes can be hardly attached to the implementation of food security policies, but instead to neoliberal policies to supply national and rather international demand for food and animal feeding markets plus other non-food agricultural/livestock commodities [8].

Food (in)security scenarios are usually assessed using socioeconomic variables such as poverty indexes, income per capita, nutritional availability of internal food stocks, imports and exports, final destination of agricultural products and wasted food. FEEDME model represents the state of the art in food security scenarios as, besides the aforementioned variables, it considers the amount of land use/cover availability allowing a more in-depth analysis and more conclusive outputs when dealing with climate and hunger relationships [9]. In this context, this work aims to analyze UnP scenarios assessed through FEEDME model run using oficial land cover change figures provided by PRODES Brazil. At last, land use/cover change scenarios under different diets are projected to Cerrado based on outputs provided by UnP models

2. MATERIAL E METHODS

2.1. Study area

In Brazil, agricultural expansion in the last 30 decades has occurred mostly over the expenses of forest and savannah removal in the Brazilian Amazon and in the Cerrado region, until recently poorly monitored when compared to the Amazon. The climatic and socioenvironmental relevance of the Amazon added to the biodiversity and water stocks relevance of the Cerrado are together keen to guarantee food security at the national and global levels. The fast pace of vegetation removal in Cerrado have built its spatial configuration of agricultural production systems, today characterized by large cropping farms along trading routes through roads or waterways, similar to cattle ranching areas all permeated by a mosaic of land use types within small (<100 ha) to medium-sized farms (100-500 ha), together with increasing urban areas and forest/savannah fragmented/degraded spots [7,10]. In the Atlantic Forest and

Pampas biomes, the agricultural frontier is not relevant in terms of opening new areas, but fragmentation of remnants is a big concern as most of their natural vegetation has been already converted into antropic land. In Pantanal biome cattle grazing occurs in a dynamic process and interaction to natural pastureland, so land intensification is the issue rather than expansion. Due to limited text space, in this work we will only present scenarios to the Cerrado biome, but this work is under development for all Brazilian biomes.

2.2. FEEDME model

Changes in national food supplies are simulated in the FEEDME (Food Estimation and Export for Diet and Malnutrition Evaluation) model [9], ensuring changes in percentage of undernourishment prevalence at national level. The FEEDME model simulates climate change impacts on food systems through changes in crop yields, and allows proxies to calculate the additional amount of cropland required to avoid further UnP. Figure 1 illustrates the FEEDME model scheme.

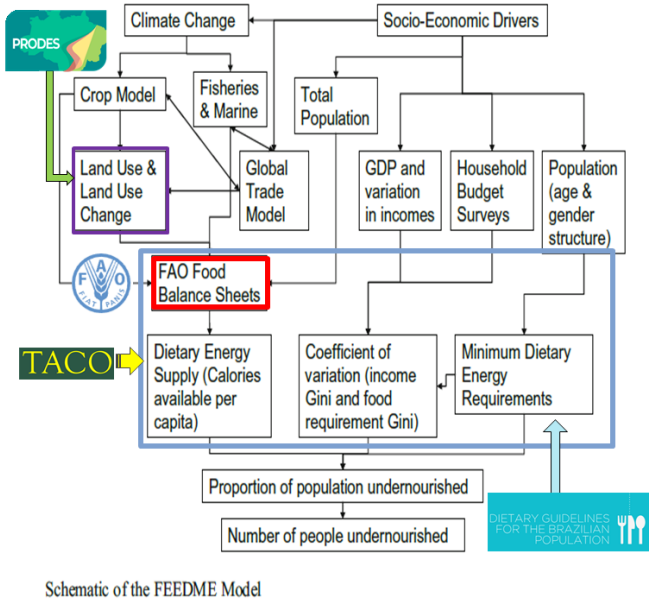


Figure 1. Methodological scheme of FEEDME model highlighting in the colored boxes the main input data that require detailed analysis and data preparation.

Land use/cover maps retrieved from remote sensing data to models of UnP at different scales.Land cover change figures to the whole country are based on PRODES Brasil [7]. Food balance sheets in FEEDME are originally given from FAOSTAT accessed at https://www.fao.org/faostat/en/, but were adjusted based on the Brazilian historical series of commodities imports and exports (accessed at http://comexstat.mdic.gov.br/pt/home) and on diagnostic maps of food demand for beef, pulses and cereals (see section 2.3.1). Minimum Dietary Energy Requirements were retrieved from the Dietary Guidelines for the Brazilian Population [11], and the Dietary Energy Supply from the Brazilian Table of Food Composition [12].

2.3. Scenarios development

2.3.1. Diagnostic maps of food demand

The first step of our methods was to build spatial explicit current and future diagnostic maps of food demand at local level in Brazil using census survey and household level data from IBGE [13]. Methods adopted here were developed by [14,15]. Such diagnostic food maps allow food supply assumptions to be projected to 2030 and 2050, based on population growth and crop/livestock intensification. Changes observed in food demand maps in pulses, cereals, vegetables and beef consumption per capita are simulated in the FEEDME where two scenarios of land use change are given considering different dietary choices regarding beef consumption, commodities exports and climate change impacts on crops production. Also different compliances to the Forestry Code, pasture land recovery and intensification of sustainable agriculture are taken into account.

2.3.2. Land use and land cover change scenarios

Land use and land cover change scenarios were developed based on the amount of change required to achieve dietary requirements of two scenarios: 1) Intensification of food security policies with current beef and decreased pulses/cereals consumption, with land high competition to crops for non-edible commodities; 2) Intensification of sustainable agriculture, low beef and high cereals/pulses consumption, with food security policies that guarantee small farming food production to local markets. Policies of sustainable agriculture stand for the increase in consortium areas of pasture, agriculture and forest, known as Low Carbon Agriculture (LCA) within the Brazilian National Plan on Climate Change.

3. RESULTS AND DISCUSSION

Estimated values of diagnostic food demand maps are given in acquisition per census tracts (given as food acquisition per square kilometer) for beef, pulses and cereals (Figure 2). Projections indicate that beef consumption is the most significant animal protein consumed in all regions. Increasing beef consumption is higher in the Center-West, North and less in the Northeastern regions. Aging of the Brazilian population by 2040 causing emptiness of Southern cities shall cause a decrease in beef consumption there.

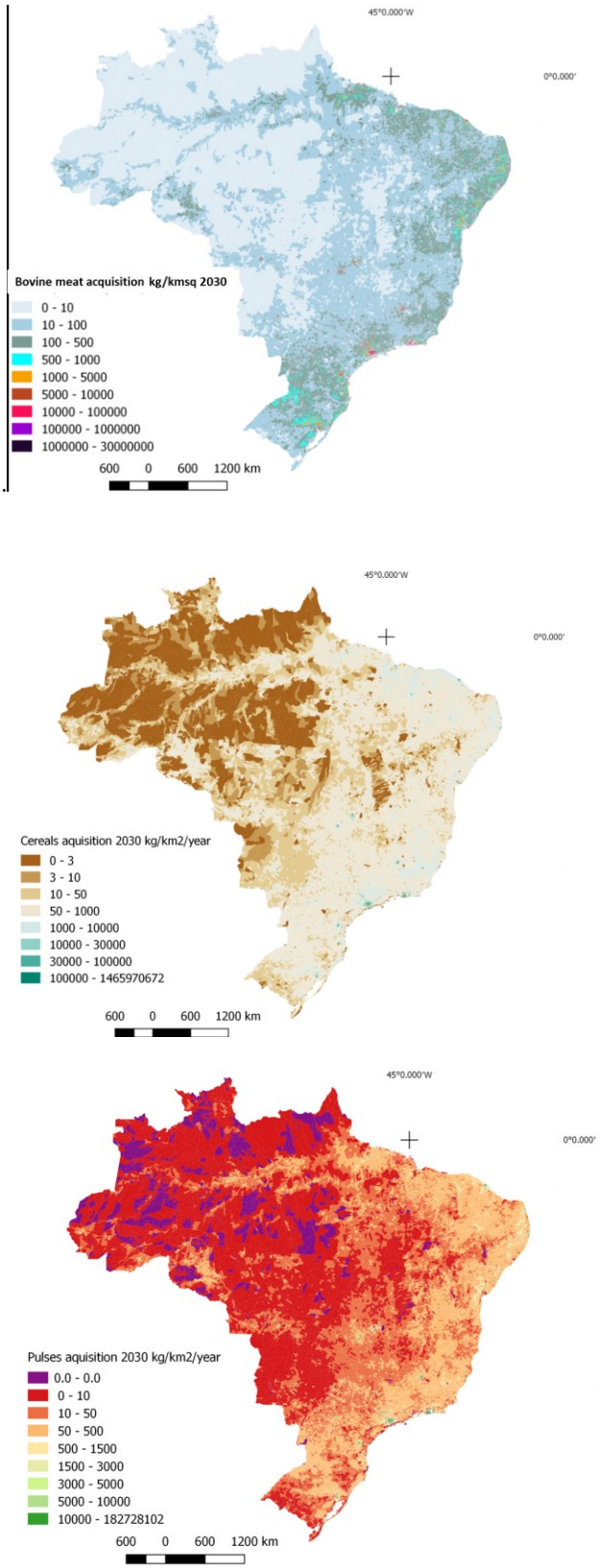
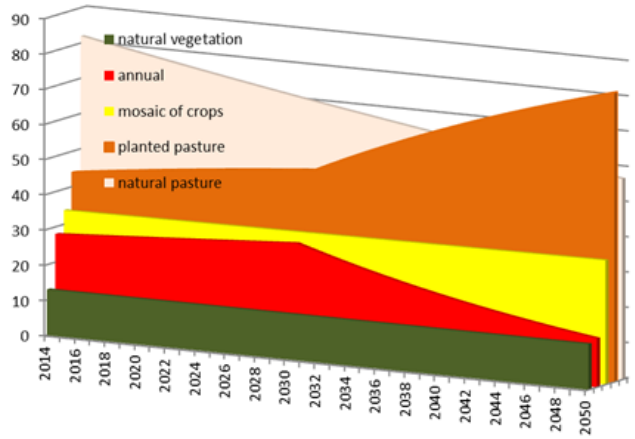


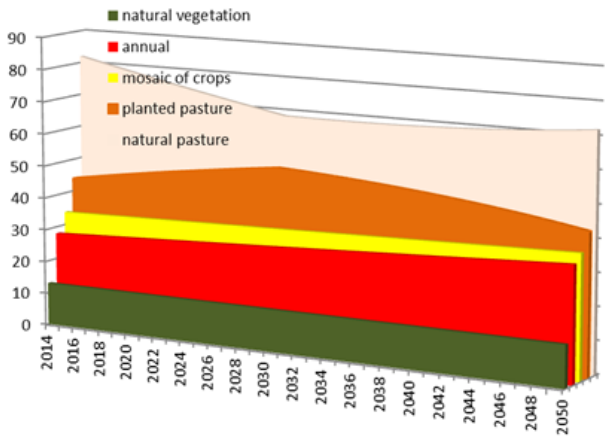
Figura 2. Diagnostic maps of food demand of beef, pulses and cereals at the census tract level projected to 2030.

Diagnostic maps of food demand indicate that food insecurity in Brazil is still characterized by the lack of food accessibility in the poorest urban areas mostly due to low income, whereas in rural areas inadequate transport and market infrastructure play similar roles, which is also indicated in the literature [3-5].

Projections of the scenarios of land use and land cover change to Cerrado are given in Figure 3. They are based on dietary requirements and attached land availability provided by FEEDME, according to scenario boundaries conditions presented in section 2.3.2. As FEEDME allows inferring required cropland to avoid high UnP, results indicate that Brazil must tackle increasing gaps between the amount of food produced regionally and the share actually available to low income population under high food insecurity.



(a)



(b)

Figura 3. Scenarios of land use and land cover change to Cerrado based on dietary requirements and land availability. (a) current beef/ decreased pulses/cereals consumption, with high land competition to non-edible commodities; (b) low beef consumption, high cereals/pulses consumption, land sparing.

4. CONCLUSIONS

Despite achieving key targets in tackling food insecurity in 2011, the estimates for hunger and starvation have risen considerably in the last decade. Beyond reimplementing the political agenda of food access for starving people and income distribution, Brazilians food security is better guaranteed with crops for food and land availability policies. Implications on land availability indicate reasonable pathways to meet the balance between crops/livestock production and conservation, but law enforcement, health and environmental education, participative governance and land tenure issues can hinder sustainable pathways, especially for the Cerrado region. Under the current Brazilian diet and expected population growth, the amount of land required to decrease UnP back to remove Brazil from the hunger world map, can be hardly met only by increasing protecting areas, but instead require large-scale implementation of climate change mitigation actions, such as the implementation of Low Carbon Agriculture.

In future research, we suggest the use of innovative approaches to Artificial Intelligence and Big Data to deal with large amounts of geographical and remote sensing data. This could facilitate data retrieval of the hunger state of people and also help rural producers to take decisions on crops that balance their revenue, promote conservation and attend to people's demands for edible nutritious food.

5. ACKNOWLEDGMENTS

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