Analysis of food nutrients availability based on food composition information and food consumption to support land use scenarios in Brazil

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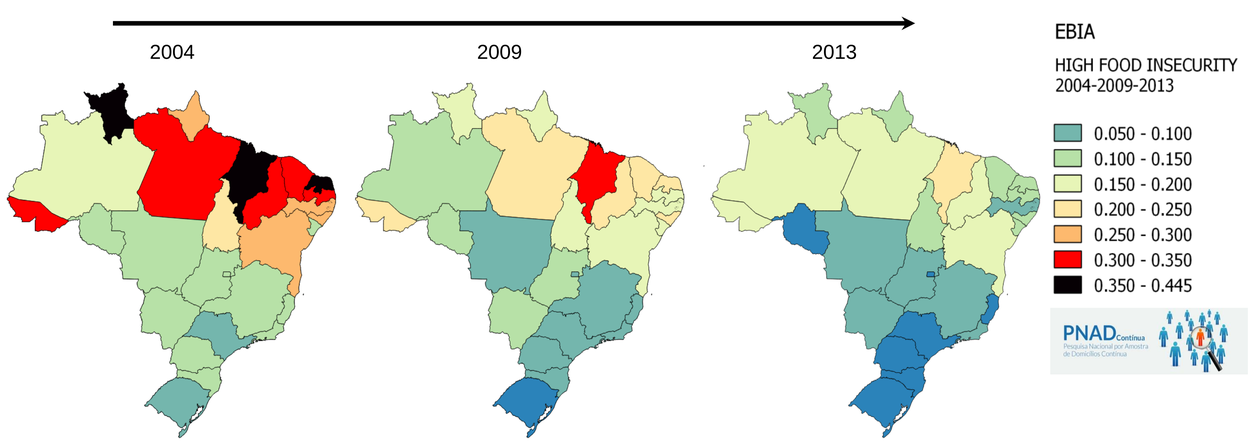
Aim and Scope

- Food and Agriculture Organization of the United Nations (FAO) estimates > 600000 inhabitants will be undernourished by 2050 if nothing is done.
- Evaluating the adequacy of food nutrient supplies allow the understanding on how micro/macronutrients deficiencies/surpluses in the Brazilian population shall require policies that promote either agricultural intensification or smarter food choices, or both.
- Our objective was to estimate the availability of macro and micro nutrients per food type according to Food Balance Sheets (FBS) retrieved from FAO database [1]. Preliminary results focus on bovine meat were adopted to support land demand scenarios linked to food insecurity secular trend (Figure 1) and regional level indicators in Brazil [2,3].



High food insecurity definition – Reduced food availability and/or changes in food choices among children no able to access food. Hunger, i.e. no meals during a day due to poverty.

Figure 1 – Temporal dynamics of the Brazilian Scale of Food Insecurity (EBIA)

Food data and land demand scenarios

- FAO food types available in the Food Balance Sheets (FBS) were associated to food types available in the food acquisition module of the Household Budget Survey, conducted in 2008/2009 by the Brazilian Institute of Geography and Statistics (POF / IBGE).
- After comparing FBS/FAO and POF/IBGE data, for each food type received a nutritional composition content retrieved from the Brazilian Food Composition Table (TACO) [4]. Food types with missing data in TACO were retrieved from the United States Department of Agriculture (USDA).
- Preliminary analyses of the data assembled allow the evaluation of nutrition the excesses or deficiencies of micro and macro nutrients available to the Brazilian population, focused first on bovine meat (Table 1).
- Outcomes where taken into account together with food acquisition scenarios (Figure 2) to develop scenarios of land demand under different premises of meat consumption.
- Associated percentage of undernourished population and proxies of land demand (area or yield) were modelled using FEEDME model [5], according to food and nutrient content availability.

Food type categories
cereals
starchy roots
cassava
pulses
nuts
soybean
coconut
vegetable oils
soybean oil
vegetables
fruits
stimulants
spices
sugar & sweetners
non-alcoholic beverages
alcoholic beverages
meat
bovine meat
poultry meat
offals
fishs & seafood
eggs
milk
animal fats
micelaneous

	B	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ
1		amount consumed by weight	proportion of total consumed	TACO Energy (kcal)	TACO Energy (kJ)	TACO Carbohyd rate (g)	TACO Fiber (g)	TACO Protein (g)	TACO Fat (g)	TACO Satd FA /100g fd (g)	TACO poly /100g food (g)	TACO Mono FA /100g food (g)	TACO Sodium (mg)	TACO Potassiu m (mg)	TACO Calcium (mg)	TACO Magnesi um (mg)
2	Meat, beef, strip loin, with fat, raw	0,819	0,107	22,089	92,322	0,000	NA	2,273	1,373	0,600	0,021	0,590	4,718	30,560	0,429	1,93
3	Meat, beef, strip loin, without fat, raw			0,000	0,000	0,000	NA	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,00
4	Meet, beef, coxão duro, without fat, raw			0,000	0,000	0,000	NA	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,00
5	Meet, beef, coxão mole, without fat, raw	0,645	0,084	14,271	59,703	0,000	NA	1,790	0,735	0,329	0,008	0,312	5,151	28,289	0,253	1,77
6	Meat, beef, tenderloin, without fat, raw	0,133	0,017	2,490	10,413	0,000	NA	0,376	0,098	0,050	0,003	0,033	0,853	5,607	0,052	0,36
7	Meat, beef, flanco, without fat, raw			0,000	0,000	0,000	NA	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,00
8	Meat, beef, skirt steak, with fat, raw			0,000	0,000	0,000	NA	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,00
9	Meat, beef, eye round, raw	0,234	0,031	4,136	17,279	0,000	NA	0,628	0,159	0,070	0,003	0,070	1,654	11,090	0,092	0,61
10	Meat, beef, trip tip, raw			0,000	0,000	0,000	NA	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,00
11	Meat, beef, sirloin, without fat, raw	0,866	0,113	18,481	77,212	0,000	NA	2,449	0,884	0,385	0,011	0,374	4,875	33,901	0,340	2,26
12	Meat, beef, patinho, without fat, raw	0,444	0,058	7,731	32,437	0,000	NA	1,261	0,262	0,116	0,012	0,110	2,848	18,485	0,174	1,16
13	Meat, beef, picanha, with fat, raw			0,000	0,000	0,000	NA	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,00
14	Meat, beef, picanha, without fat, raw			0,000	0,000	0,000	NA	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,00
15	Meat, beef, strip loin cape, with fat, raw			0,000	0,000	0,000	NA	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,00
16	Meat, beef, strip loin cape, without fat, raw	0,112	0,015	1,921	8,036	0,000	NA	0,315	0,063	0,028	0,001	0,028	1,158	4,766	0,088	0,29
17	Meat, beef, strip loin ribeye, raw			0,000	0,000	0,000	NA	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,00
18	Meat, beef, muscle, without fat, raw	0,361	0,047	6,711	27,980	0,000	NA	1,021	0,260	0,104	0,005	0,123	3,119	13,990	0,189	0,80
19	Meat, beef, pallet, with fat, raw			0,000	0,000	0,000	NA	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,00
20	Meat, beef, chest, without fat, raw	0,217	0,028	7,358	30,825	0,000	NA	0,500	0,580	0,233	0,014	0,261	1,818	6,847	0,114	0,42
21	Meat, beef, acém, ground, raw	0,822	0,108	14,744	61,451	0,000	NA	2,088	0,635	0,291	0,011	0,258	5,273	25,506	0,323	1,50
22	Meat, beef, acém, without fat, raw	0,715	0,094	13,480	56,447	0,000	NA	1,947	0,571	0,262	0,019	0,215	4,681	21,905	0,468	1,21

Table 1 – Calculated nutritional content (average by weight) of different types of bovine meat available in Brazil according to nutrients and consumed amount data.

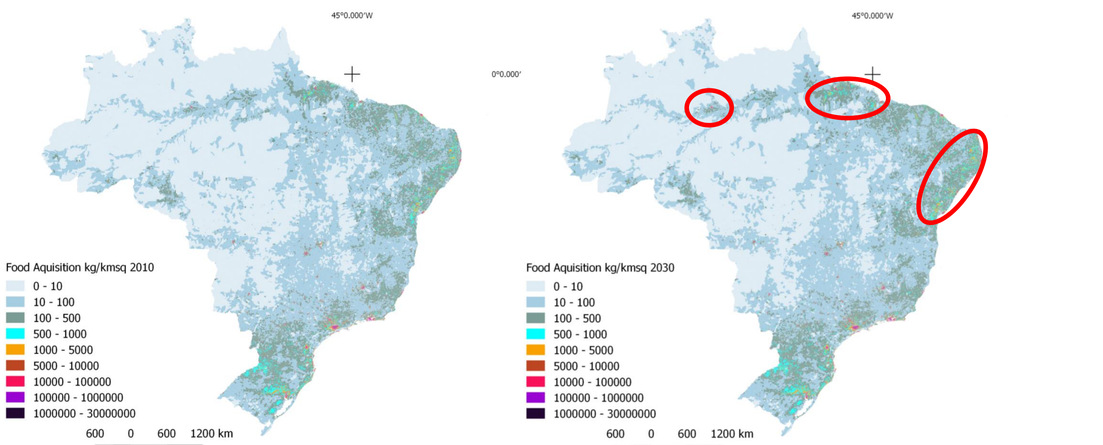
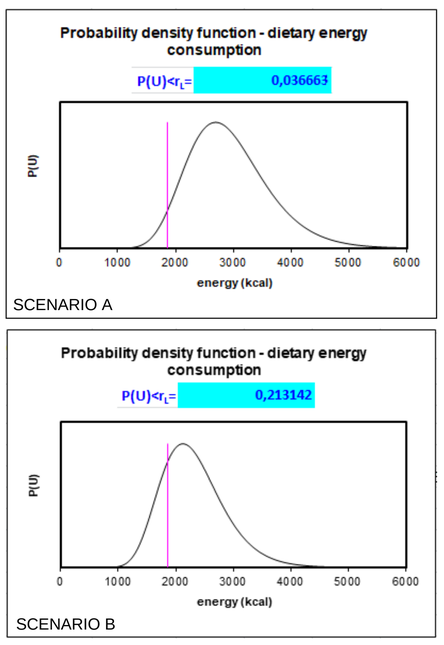


Figure 2 – Bovine meat acquisition scenarios 2008-2030

2010 - 2013 mean	1000 tonnes	1000 tonnes	1000 tonnes	1000 tonnes	1000 tonnes	1000 tonnes	1000 tonnes		1000 tonnes	1000 tonnes	1000 tonnes	kg	kcal/capita	g/capita/	g/capita/
subject	Production	Import Quantity	Stock Variation	Export Quantity	Domestic supply	Feed	Seed	Processing	Losses	Other uses (non-food)	Food	Food supply	Food Supply	Protein supply	Fat supply
	Production quantity (1000 tonnes)	Import quantity (1000 tonnes)	Stock variation (1000 tonnes)	Export quantity (1000 tonnes)	Domestic supply (1000 tonnes)	Feed quantity (1000 tonnes)	Seed quantity (1000 tonnes)	Food Manufacture (1000 tonnes)	Waste quantity (1000 tonnes)	Other Uses quantity (1000	Food quantity (1000 tonnes)	Food/capita/year (Kg)	Calories/capita/day	Proteins/capita/day (g)	Fat/capita/day (g)
Grand Total													3.244,01		
Vegetal Products													2.445,01		
Animal Products													799,00		
Cereals - Excluding Be	84.288,00	10.332,50	149,00	#######	73.877,50	#######	734,50	2.268,50	8.457,50	1,50	#######	115,41	961,50	22,48	2,79
Wheat	5944,50	7450,00	-275,00	1342,50	11776,50	400,00	208,00	0,00	598,50	1,50	10568,50	53,44	386,00	10,27	1,13
Rice (Milled Equivaler	7668,50	724,00	421,50	623,00	8192,00	0,00	132,50	643,50	924,50	0,00	6491,50	32,83	333,50	6,59	0,56
Barley	298,50	1371,00	0,00	13,50	1656,00	105,00	9,00	1523,00	19,00	0,00	0,00	0,00	0,00	0,00	0,00
Maize	67951,00	744,50	0,00	18855,00	49840,50	37326,00	363,00	102,00	6864,00	0,00	5186,00	26,20	224,00	4,96	0,90
Rye	3,50	0,00	0,00	0,00	3,50	0,00	0,00	0,00	0,00	0,00	3,50	0,02	0,00	0,01	0,00
Oats	437,00	0,50	0,00	5,50	431,50	0,00	19,00	0,00	13,00	0,00	399,50	2,02	10,00	0,41	0,16
Millet	0,00	3,50	0,00	0,00	3,50	3,50	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Sorghum	1802,50	9,00	2,50	1809,00	1762,00	10,50	0,00	0,00	36,50	0,00	0,00	0,00	0,00	0,00	0,00
Cereals, Other	182,50	30,00	0,00	0,50	212,00	29,00	3,00	0,00	2,00	0,00	178,50	0,91	8,00	0,26	0,05
Starchy Roots	27381,50	618,50	0,00	41,50	27958,00	11923,00	310,50	0,00	2674,00	1405,50	11648,00	58,93	128,50	1,73	0,33
Cassava	23096,50	107,00	0,00	33,00	23170,00	11644,00	0,00	0,00	2310,00	1305,00	7821,00	39,50	92,50	0,62	0,24
Potatoes	3559,00	511,50	0,00	2,50	4068,00									1,06	0,08
Sweet Potatoes	487,00	0,00	0,00	3,00	484,00									0,03	0,01
Yams	239,00	0,00	0,00	2,00	237,00									0,02	0,00
Roots, Other	0,00	0,00	0,00	1,00	-1,00									0,00	0,00
Sugarcrops	728365,50			0,00	728365,50									0,05	0,09
Sugar Cane	728365,50	0,00	0,00	0,00	728365,50									0,05	0,09
Sugar Beet	0,00	0,00	0,00	0,00	0,00									0,00	0,00
Sugar & Sweeteners	40.280,50	60,50	599,50	########	12.686,00									0,03	0,03
Sugar, Non-Centrifuga	472,50	0,00	0,00	0,00	472,50									0,03	0,03
Sugar (Raw Equivalent	39683,00	13,00	599,50	28213,00	12081,50									0,00	0,00
Sweeteners, Other	89,00	47,50	0,00	23,00	113,50									0,00	0,00
Honey	36,00	0,00	0,00	17,50	18,50									0,00	0,00
Pulses	3059,00	308,50	175,00	19,50	3523,00									9,98	0,73
Beans	3047,50	242,50	175,00	18,50	3446,50									9,75	0,71
Peas	5,50	43,00	0,00	0,00	48,50									0,15	0,01
Pulses, Other	6,00	23,00	0,00	1,00	28,00									0,08	0,01

Model	Active		
	Current 2010-2013	Scenario A - lowpro	Scenario B - middle
CROP	% of crops for food	% of crops for food	% of crops for food
WHEAT	100	100	110
MAIZE	100	100	110
SOYBEAN	100	80	120
NO CHANGE	100	120	100
Population (https://www.ibge.gov.br/apps/pop	197453384	232933276	232933276
Agricultural Land Use Change	100,00	100,00	100,00
MEAT	40	40	100
AQUATIC	100	100	100
calories-1	2644,314117	2.542,74	
calories-1LUC	2644,314117	2.542,74	
calories-2 (with export compensation)	2804,45554	2.815,34	
calories-3 (with feed compensation)	2660,377207	2.650,35	
calories-4 (with export and feed compensation)	2820,128078	2.910,46	
MDER (kcal/person/day):	1860		
Gini coefficient of variation:	0,242		

Table 2 – FEEDME model spreadsheets for Brazil using 2010-2013 FBS estimates, with illustrated demand proxies (in red box) for scenario A (< 30% meat consumption) and scenario B (no change in meat consumption, less grain exports) in 2050



Timeslice		SCENARIOS 2050	
Model	Status (2010)	A - LOWPRO - STEADY EXPORTS	B - BBQ + DECREASE EXPORTS
calories-3 (available per capita)	2.543,00	2.933,67	2.313,65
MDER (kcal/person/day):		1840	1840
Gini coefficient of variation:		0,25	0,25
undernourished probability (%)	0,1168	0,0382	0,116800
population_undernourished (inhab)	20543394,75	8655539,062	26437409,96

Figure 4 –Probability density functions of dietary energy consumption of the Brazilian population illustrated on the left indicating its % under the risk of undernourishment in 2050 according to scenario A (up) or scenario B (down) retrieved using FEEDME. Scenarios outputs regarding % and total number of people that might be under risk of undernourishment by 2050, according to given premises

Discussion and conclusions

- According to data from the FBS / FAO in 2013 Brazil produced **7,863,000 tons** of beef available for internal consumption (excluding Exports).
- This quantity allows an average of **21.8 g** of available protein per capita per day to the population coming from bovine meat production.
- Food acquisition scenarios indicate the growing Brazilian population will demand higher beef availability in the North and Northeast regions, increasing the need of pasture area in Cerrado region by 149% until 2050 in scenario B and 94% in scenario A (both under poor yield increase).
- In Scenario A of **low meat consumption**, compensated by higher vegetables and grain consumption, only **3%** of Brazilian population would be **under risk of high food insecurity** while in scenario B with current trends of meat consumption around **21%** of people could starve.

References
[1] The United Nations Food and Agriculture Organization (FAO). FAOSAT. Food Balance Sheets 2000, 2010, 2013.
[2] Gubert, M. B., et al. (2017). "A Municipal-level analysis of secular trends in severe food insecurity in Brazil between 2004 and 2013." Global Food Security. A segment of the Brazilian population lives in households experiencing severe food insecurity (SFI).
[3] Pesquisa Nacional de Amostra por Domicílio (PNAD), IBGE 2004, 2009, 2013.
[4] NEPA. Tabela Brasileira de Composição de Alimentos, 2011.
[5] Dawson, T. P., et al. (2016). "Modelling impacts of climate change on global food security." Climatic Change **134(3): 429-440.**

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