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Ecological footprint of beef consumption in the state of Rio de Janeiro - Brazil

J.B. Cunha[1], D. Cecchin[1,*], P.I.S. Amaral[2], F.C. Silva[1], A.R.G. Azevedo[3], I.L. Salcedo[1], C.M. Hüther[1], F.A. Sousa[4] and D.F. Carmo[1]

[1]Federal Fluminense University (UFF), Department of Agricultural Engineering and Environment, Street Passo da Pátria, n.156, Boa Viagem, Niterói-RJ, Brazil
[2]José do Rosário Vellano University (UNIFENAS), Department of Veterinary Medicine, Rodovia Mg-179 km 0, s/n - Bairro Trevo, BR 37130-000 Alfenas-MG, Brazil
[3]North Fluminense State University (UENF), Civil Engineering Department, Campos dos Goytacazes, Rio de Janeiro, Brazil
[4]SEMAG/Aracruz, Av. Morobá, n.20, BR 29192-733 Bairro Morobá-ES, Brazil
[*]Correspondence: daianececchin@id.uff.br

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Abstract. The beef production chain can cause considerable impacts on the environment depending on how it is carried out. The need to discuss the impact of the consumption of this food in a country whose production base is mainly agricultural and livestock is relevant in view of the environmental degradation and scarcity of resources. In this work, the ecological footprint of beef consumption was evaluated using the state of Rio de Janeiro as a case study. Data were collected such as population, productive capacity, annual consumption, cattle weight, grazing equivalence factor. Calculations of livestock density, consumption per capita, productivity, number of oxen, area per capita, and total area required were also carried out. The value found for Total Ecological Footprint was 1,117,995.22 gha and for Ecological Footprint per capita was 0.065 gha. It was found that the ecological footprint per capita is higher than the area destined for each inhabitant of the State which is 0.019 ha. It can be inferred that the consumption of beef as it is currently carried out harms the ecosystem in which production is inserted.

Key words: livestock, sustainability, indicator.

INTRODUCTION

The food sector is characterized worldwide by the extension of its production chain and its potential for environmental degradation, starting with the producers performance, from large to small, in agriculture or livestock. From this point on, it continues to pass through transporters, traders, distributors, waste companies, and consumers (Pena, 2012).

Almost 75% of the Latin American population, 81.23% of Brazilians (IBGE, 2017), live in big cities, with no direct relationship, control, or specific knowledge about the production of the food they consume (MMA, MEC, IDEC, 2005). Therefore, a considerable part of modern consumers buy food directly from supermarkets and,

generally, without access or concern about information such as the place of origin, production model, and socio-environmental impacts caused in the production of that commodity (MMA, MEC, IDEC, 2005).

The concern with those impacts is relevant since, if negative, they may make production in the short, medium, or long term unfeasible, for several reasons, such as increased production costs, minimizing resources until its scarcity, among others (Yifan, 2009).

The planet carrying capacity is limited and corresponds to 51 billion hectares, but not everything is available for use (Santos et al., 2013). According to the Living Planet Report from the World Wild Fund For Nature – WWF (2014), only 12 billion hectares can be considered bioproductive land, which is less than what is demanded by the current population's consumption style. Thus, assessing the impact of activities that require large extensions of productive areas is relevant and has fostered the development of this study.

Brazilian legislation defines environmental impact as any change in the environment (physical, chemical, biological properties) that may affect 'the health, safety, and welfare of the population; social and economic activities; the biota; the aesthetic and sanitary conditions of the environment and the quality of environmental resources' (Brasil, 1986). Those changes can be beneficial or adverse, small or large. It is also a fact that in all economic activities, the related environmental impacts are driven by consumption (Tukker et al., 2008). In this way, consumers start to act as protagonists in directing new trends and production needs. A change in consumption habits represents an opportunity to minimize and mitigate the impacts generated in this production chain (Weber & Matthews, 2008; Carlsson-Kanyama & González, 2009; Hertwich & Peters, 2009; Pena, 2012).

Consumption's environmental impact is divided into three main categories of services/products: food, transport, and housing. In these three categories, greenhouse gases can be indicators of the impacts caused on the environment. In this context, Europe presents 31% of greenhouse gas (GHG) emissions only for the food sector, while Brazil has a percentage of 43% of its emissions for this category (Pena, 2012, and Hertwich & Peters, 2009). It should be noted that in Brazil, according to the Greenhouse Gas Emission Estimation System - SEEG (2018), beef cattle is one of the main responsible for the emission of these gases. In this context, for the same amount of GHG emissions, about ten times more vegetable protein is produced than bovine animal protein (Leitzmann, 2003). Thus, it is clear that knowledge about possible food choices and their respective impacts on the environment can be decisive in changing consumers' eating habits, directly contributing to environmental conservation and the establishment of production models that are in agreement with sustainable development.

Brazil has incredible agricultural potential due to its extensive land area, which benefits the establishment of several types of production systems, especially animal production systems (Ferraz et al., 2019, p.704). Thus, in a mostly agricultural country like Brazil, knowledge about the number and extent of impacts that the meat production chain can cause to the environment and human health is relevant to the current scenario. The Ecological Footprint is a tool that can be used for such measurement, which allows estimating the requirements in resources and assimilation of waste from a given population or activity in terms of a corresponding productive area (Wackernagel & Reed, 1996). Achieving the smallest ecological footprint in production processes is one of the goals for finding an environmentally friendly pathway (Dunmade, 2020).

As in other countries, beef consumption has a trend that is dictated by the income of families that is, the higher the family income, the higher the consumption. Brazil has shown over the decades, a growth concerning meat consumption, which accompanied the country's development. However, according to data from the Brazilian Agribusiness Association (2016), the consumption of beef in the country has been decreasing more and more in 2015, the lowest value in 14 years, a fact that can be explained by the increase in prices and by the economic crisis faced internally.

According to the Household Budget Survey (IBGE, 2010), the per capita beef consumption in Brazil is worth 23.06 kg per year, higher than the consumption of poultry, fish, and pork. Thus, the higher the meat consumption, the higher the impact on the environment.

This study aimed to evaluate the ecological footprint of beef consumption, using the state of Rio de Janeiro, Brazil, as a case study. The State of Rio de Janeiro was chosen as a case study because it is the second largest metropolis in the country, it is one of the main economic centers, and it is responsible for a high demographic concentration. Therefore, it is also responsible for a high demand for food consumption and, consequently, for beef.

MATERIALS AND METHODS

Characterization of the study site: State of Rio de Janeiro

Rio de Janeiro is located in the southeastern region of Brazil and is the second largest metropolis in the country. It is considered one of the main economic, cultural, and financial centers. The state has the second-highest GDP, and it is only surpassed by São Paulo. The population of Rio de Janeiro estimated for 2018 is 17,159,600 inhabitants, with a demographic density of 365.23 inhabitants per square meter, ranking second in the country. The state has the fourth-highest human development index in Brazil, at 0.761. Compared to the rest of the country, Rio de Janeiro is a small state, with a territory of only 43,750.423 square kilometers and is bordered by Minas Gerais, Espírito Santo, São Paulo, and the Atlantic Ocean (IBGE, 2010).

Livestock still plays an important role in the state economy, with greater potential in the northern region of the state, with emphasis on the municipality of Campos dos Goytacazes, which leads the state's production ranking.

Calculation of livestock's environmental footprint

The methodology used was that established by Wackernagel & Reed (1996) with adaptations proposed by Santos et al. (2013). This study seeks to answer the question ‘What is the bioproductive land area necessary to supply a given population without prejudice to the natural ecosystem?’ in a way applied to the beef consumption in the State of Rio de Janeiro. Thus, the calculation of the case study covers the category that relates to the land area, more specifically applied to pasture areas that are used in beef production of meat that will be consumed.

Each of the productive territories considered in the global Ecological Footprint calculation has a different equivalence factor, which is necessary for converting the calculations to Global hectare (gha), which is equal to one hectare with the same average productivity as the 11.2 billion bioproductive hectares in the land. The equivalence factor represents the world average productivity for a given type of bioproductive land, divided

by the world average productivity for all kinds of bioproductive land. For pastures, this value is 0.46 gha ha^{-1}, according to the World Wild Fund For Nature - WWF - Brazil (2010) and Global Footprint Network (2010) (Santos, 2012).

The Ecological Footprint of beef production can be calculated by the estimating the natural productive area needed to maintain livestock and consequently sustain the populations's consumption. For that, the proposed calculation for the Ecological Footprint of consumption in Rio de Janeiro followed several stages. At first, the data that would be needed for the calculation were collected (Table 1).

Table 1. Steps and methods of obtaining data for calculation

Stages	Method of obtaining
Population RJ	Estimated for the year 2018, according to IBGE (2010).
Beef Consumption	Available in the Family Budget Survey (IBGE, 2010).
Average cattle weight	obtained from the Matogrossense Institute of Agricultural Economics - IMEA (IMEA, 2014.)
Per capita consumption	Obtained by dividing the annual consumption by the population of State.
Annual beef consumption	Available in the Family Budget Survey (IBGE, 2010).
Cattle density	Calculated by dividing the number of cattle in the State (IBGE, 2010), by the total area occupied by agricultural enterprises in the State (IBGE, 2010).
Productivity	Obtained by multiplying the cattle density by the average weight of the local cattle; this value is divided by the necessary amount of hectares for an ox (4), according to Dias (2002).
Quantity of oxen consumed in Rio de Janeiro	Calculated by dividing the total annual consumption by the local average of the kilo of the ox.
Per capita area (EFM)	Obtained by dividing consumption per capita by productivity (kg ha^{-1}).
Total area (EFM)	Obtained by multiplying the area per capita by the population of Rio de Janeiro.

Then, to calculate the Ecological Footprint (gha) per capita, the equivalence factor is multiplied by the area per capita (EFM). Finally, for the Total Ecological Footprint (gha), the Ecological Footprint (gha) is multiplied per capita by the population of Rio de Janeiro.

RESULTS AND DISCUSSION

Beef production aims to meet demand. Table 2 indicates the values that were used to calculate the ecological footprint of beef consumption in the state of Rio de Janeiro.

The Ecological Footprint is an indicator that has been increasingly disseminated and used to compare different countries, states and cities about their level of sustainability globally or for a particular activity. The calculation made for the Ecological Footprint of beef production in Rio de Janeiro points to a value of 1,117,995.22 gha, which represents a considerable environmental impact concerning other locations. This value is justified by factors such as high demographic concentration and high income of the population, that has more access to this type of food.

Table 2. Calculation of the Ecological Footprint of beef consumption in Rio de Janeiro.

Calculating the Total Ecological Footprint		Source used
Population RJ (inhabitants)	17,159,600.00	IBGE (2010)
Beef Consumption (kg year^{-1})	154,300,168.04	IBGE (2010)
Average cattle weight (kg)	238.05	IMEA (2014)
Per capita consumption (kg inhab^{-1})	8.99	Calculated
Productivity (kg hectare^{-1})	63.49	Calculated
Cattle density	1.07	Calculated
Number of hectares for the oxen	4.00	Days (2002)
Quantity of oxen consumed	648,183.86	Calculated
Per capita area (hectare)	0.142	Calculated
Total area (hectare)	2,430,424.39	Calculated
Equivalence factor (gha ha^{-1})	0.46	GNF (2010)
Ecological Footprint per capita (gha)	0.065	Calculated
Total Ecological Footprint (gha)	1,117,995.22	Calculated

Santos (2012) performed the Ecological Footprint calculation for different cities in different states of the country, finding the values shown in Table 3.

Table 3. Calculation of EF (gha) of beef consumption (Santos et al., 2012)

Place	Population	Area of consumption per capita (EFM)	Global Hectare per capita (gha)	Total Global Hectare (gha)
Fortaleza - Brazil	2,582,820	0.53	0.254	656.036
Brasília - Brazil	738,571	0.48	0.230	169.961
Londrina - Brazil	433,369	0.23	0.110	47.670

Santarém Junior (2016) performed the same calculation applied for the State of Amazonas. Table 4 presents the results found in this study.

Table 4. Calculation of EF (gha) for beef consumption (SANTARÉM JUNIOR, 2016)

Place	Population	Area of consumption per capita (EFM)	Global Hectare per capita (gha)	Total Global Hectare (gha)
Amazonas - Brazil	3,480,937	0.60	0.276	960,739

To show a comparison, Table 5 presents the results found in this study for the State of Rio de Janeiro.

Table 5. Calculation of EF (gha) for beef consumption (Author himself)

Place	Population	Area of consumption per capita (EFM)	Global Hectare per capita (gha)	Total Global Hectare (gha)
Rio de Janeiro - Brazil	17,159,600	0.142	0.065	1,117,995

The values found for Hectare Global Total, in gha, indicate the pressure the beef consumption in each of the locations. The per capita Ecological Footprint found for Rio de Janeiro is not the highest of all, but the high demographic density of the place, that is, the large number of people who inhabit the space makes the Total Ecological Footprint

considerably higher than all other locations assessed, thereby exerting higher pressure on natural resources. It is also worth mentioning that the State of Rio de Janeiro has a consumer profile and that the productive area is unable to supply domestic demand in the state.

In the State of Rio de Janeiro, the area per capita is 0.019 ha, considerably less than the area of beef consumption per capita found in the study, 0.065 ha. This indicates that only the consumption of this kind of food already exceeds the available hectares to each inhabitant within the State.

The habit of consuming beef is characterized as an unsustainable consumption pattern for the population not only in the long run but in the short run. It is responsible, alone, for exceeding the area destined to each inhabitant in the State of Rio de Janeiro, not counting the other activities that are carried out and that also exert pressure on the ecosystem and the environment.

CONCLUSIONS

The study site concentrates a considerable part of the country's income and consumption, and it is considered one of the largest metropolises, with high demographic density. The value found for the Total Ecological Footprint is 1,117,995.22 gha. The value for the Ecological Footprint per capita is 0.065 gha, which is higher than the area per capita destined for each inhabitant of the State, which is 0.019 ha. Only this consumption exceeds the maximum value for an inhabitant.

It is clear that the production and consumption of beef as it is currently carried out harms the ecosystem in which production is inserted. That is due to the ecological pressure that this type of activity generates on the environment and raises the need for searches for better production models that are in line with sustainable development and also for awareness about food choices and their effective impact on the environment.

The indicator used in this study is an analytical and educational tool, and it is important because it can be used to compare different locations and situations. Thus, it also acts as a vector in the awareness of good practices, better consumption habits, and a guide for future public policies that act to defend more ecological and sustainable habits.

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