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THE WATER FOOTPRINT OF BEEF CONSUMPTION IN BRAZILIAN REGIONS

Lenilton dos Reis Canto
Undergraduate Degree in Geography at Universidade Estadual in Amazonas (CESP-UEA)

Besides Silvia Marinho dos Santos
PhD in Sustainable Development (CDS-UNB), Master in Society and Culture in the Amazon (UFAM), degree in Geography, Associate Professor at Universidade Estadual in Amazonas (CESP-UEA)

Edinelza Macedo Ribeirio
PhD in Sustainable Development (CDS-UNB), Master in Administration, Degree in Literature, Adjunct Professor at the Universidade Estadual in Amazonas (CESP-UEA)

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Abstract: Brazil is the owner of the first commercial cattle herd in the world and together with this beef production there is a large volume of water used throughout the production chain that is not accounted for; mainly for watering beef cattle. Therefore, it is necessary to measure the consumption of fresh water by beef cattle in all Brazilian regions for the strengthening of scientific culture, and in the formation of a database on water management in the national territory. For this accounting, the environmental sustainability indicators were associated: Ecological Footprint (PE) and Water Footprint (PH). The work on screen aims to calculate the water footprint of beef consumption in Brazilian regions, for the year 2020. Being of a quantitative nature, based on a bibliographic and documentary research with the collection of secondary data at the Brazilian Institute of Geography and Statistics (IBGE) and the Brazilian Agricultural Research Corporation (EMBRAPA). The analysis method used was the water-ecological footprint. The methodology is based on Almeida (2010), Andrade (2006) and Santos (2013). The results point to the advance of livestock over the North region; with an increase of 2.4 million head in the last five years. In the Midwest there was also an evolution of the effective bovine herd of 1.5 million head. Possessing the highest total PE of 86,274.40 global hectare. Therefore, the tool demonstrates an environmental unsustainability; due to the appropriate area in global hectare to maintain the level of consumption, translated as the own footprint in the producing region.

Keywords: Water Footprint, Ecological, Cattle, Brazilian Regions.

INTRODUCTION

In chapter 04 of Agenda 21, it addresses the urgency of changing consumption patterns, in order to reduce the demand on finite resources in the production process. This aggravating factor present at all scales, whether local, national or global, requires a systemic reflection. Indicators are an important mechanism for measuring the levels of appropriation of natural resources linked to the carrying capacity that the planet can sustain without harming the natural ecosystem.

The National Water Agency (ANA, 2019) states that the consumption of water consumption consumes 80% of the water by the animal organism. And only 20% returns via excretion of solids and liquids and also through animal transpiration. In this sense, the water footprint (PE) method aims to demonstrate the volume of consumption by measuring environmental sustainability in each producing region.

The National Water Resources Policy No. 9,433/1997 determines in its art. 1st on the foundations on which the policy is based; lll – in a situation of scarcity, the priority use of hydrological resources must be for human consumption and for watering animals. The distribution of this resource in Brazilian territory is uneven, and there are already areas that deal with this scarcity. In agriculture, which is a sector that demands a very expressive volume of water. Along with this consumption of water provided by the agricultural advance on the last frontiers, it is linked to deforestation and the burning of native vegetation and incorrect water management.

In the great Brazilian regions there is a diversity of meat production system. In this production chain of beef cattle until its slaughter, it represents an appropriation of hydrological resources in the North, Northeast, Midwest, Southeast, and South regions. The work arises as a need to calculate the consumption of water in the animal watering of beef cattle, and considers that with the consumption of beef, virtual water is consumed. This way, the question is what is the water footprint of beef consumption in large regions of the country?

In order to solve this question about consumption. The objective of this work is to calculate the water footprint of beef consumption in Brazilian regions. Specifically quantify the water consumed in cubic meters and megaliters, and also compare the water footprint of the regions studied.

This work is the result of the methodology developed by Almeida et al. (2010), Andrade (2006), Hoekstra (2011), Santos et al. (2013) and Van Bellen (2002). That develop the concept of ecological footprint and its determination of the carrying capacity of the planet, now also associated with the water footprint as a new perspective in relation to water scarcity, dependence on water, its use in a sustainable way, and its implications for global management of the virtual water trade (MARACAJÁ et al., 2012).

The methodological procedures adopted in the research are characterized as exclusively quantitative, and are based on an exploratory, descriptive and documentary bibliographic survey for the evaluation of the studied system. Data were obtained through the Brazilian Institute of Geography and Statistics (IBGE) and the Brazilian Agricultural Research Corporation (EMBRAPA) of the respective Brazilian regions for the year 2020.

Thus, this work is divided into sections. Starting with this introductory part, followed by the theoretical contribution that describes the environmental indicators, Ecological Footprint (PE), Virtual Water and Water Footprint (PH). Then follows with the methodological considerations. In the fourth part, the result of the evaluation is presented, its analysis and discussions on the values of environmental appropriation found. In the last part, the final considerations about the research are made.

THEORETICAL CONTRIBUTION

ENVIRONMENTAL INDICATORS

The way human beings enter forests without a real understanding of the existence of a complex ecosystem in nature, often putting themselves in a position of vulnerability, evidences the *deficiency of perception* when it comes to the environment.

The recent covid-19 pandemic, still without many detailed studies on the origin of the virus, has triggered a series of questions about the stage in which the relationship between man and nature is, and also confirms problems already pointed out by authors such as Genebaldo Dias (2002).); In his book *Ecological Footprint and Human Sustainability,* he states that "cities are sick due to disorder coupled with predatory and autophagic models of development, extreme poverty, unemployment, disease, precariousness of the health system, unstructured industrialization, administrative incompetence, aggression and changes in the biosphere" (p. 35). These are some of the problems that humanity has been facing in recent centuries and has intensified with each passing year.

For years, natural resources have been plundered in a predatory way across the planet, configuring what must be called a new geological era called - *Anthropocene*. Where humanity is primarily responsible for this depredation of natural resources, finding itself at the center of the main debates related to the environmental issue as well placed the Living Planet Report (2018). As a reflection of this predatory action and mainly of environmental degradation, habitat destruction and forest transformation into agricultural areas have been observed in recent years without understanding the real impact it causes on climate regulation, carbon concentration, emergence of new diseases and floods (OLIVEIRA et al, 2020).

Therefore, it is important to emphasize the contribution of *Environmental Sustainability Indicators* in monitoring and communicating the pressure that humanity exerts on natural resources. For Hammond (et al., 1995 apud Van Bellen, 2002, p. 28) the term indicator is derived from the Latin - *indicare,* which expresses the person who discovers, points out, announces or esteems. Being responsible for communicating or reporting the progress of a system or phenomenon, for example, sustainable development that prioritizes the use of goals to be achieved; aiming to satisfy the needs and well-being of the present society and the supply of resources in quantity and quality for future generations.

With emphasis on Sustainable Development itself and its applicability in environmental indicators, it allows the use of an approach that values economic justice, social equity and ecological integrity (ANDRADE, 2006, p.28). With attention mainly to the role of the ecological dimension within these tools that contributes to the aid of decision making for the good political-administrative management of the environment.

As an effective measure of application of the term Sustainable Development, the importance of these indicators that serve as a warning in the sense of preventing and/or mitigating the economic, social and environmental impacts arising from the activities or lifestyle of a given specific population is highlighted, and its relation to a certain area (BARROS, 2014; p.22). Van Bellen (2002) endorses that the real objective of indicators is to aggregate and quantify information in a way that its significance becomes more apparent (p. 30).

This way, indicators are so important in periods like this. Where the covid 19 pandemic has sparked reflections on the future paths of humanity and of this place called *planet earth*; where we are all tenants. And about the gigantic metabolism present on planet earth driven by the capitalist system. In 2019 and the following years, it has experienced a loss in speed and urban dynamics visually expressed in the world's large cities, but the demand for water, food, and pharmaceutical ingredients has gradually increased.

ECOLOGICAL FOOTPRINT (PE)

In this context, present the *Ecological Footprint (EP)* as an indicator of environmental sustainability created by *Mathis Wackermagel* and *William Ress* and proposed from the publication of the book "*Our Ecological Footprint Method*" in 1996. Andrade (2006) suggests it as an indicator alternative method of measuring ecological sustainability and its differential is that the tool allows the comparison of the footprint of different locations and countries (p. 33-4). For Dias (2002) the tool is an indicator that clearly relates the dependence between human activities and the natural resources necessary for its maintenance and also responsible for the absorption of generated waste.

The ecological footprint is based on the concept of "determination of the area of land necessary to supply the needs of a given population, without harming the ecosystem, taking into account the area necessary to serve an urban population system, based on the levels of consumption, development of new technologies, import and export of products, elimination of competing species, production efficiency and management of natural resources" (CARVALHO & MARACAJÁ, 2010). In other words, this indicator works with the concept of carrying capacity of the natural environment responsible for ensuring this intense metabolism.

The ecological footprint in Santos (2013) and Santarém (2016); reveals that to measure the sustainability of an open system, the following question must be asked. What is the bioproductive area of land or sea responsible for supplying the lifestyle of a given population without harming the natural ecosystem? As opposed to questioning: how many people does a given area admit without compromising the sustainability of the natural environment?

Almeida (et al., 2010, p. 95) states that "the calculation of the ecological footprint identifies that for each item of material or energy consumed, there is a certain area of land necessary to provide such flows". Working with two categories of analysis: land and consumption. And subdividing the first into pasture, cultivation, forest, built and fishing areas. The second is divided into food, housing, consumer goods, services and energy (SANTARÉM JUNIOR, 2016). This way, the calculation evaluates the flow of the studied system in global hectares, considering the level of consumption in a static way, either monthly or annually, without extrapolating the final result.

For Andrade (2006) the methodology must use aggregated national data to identify the resources produced and required by the population, for example, the demand for food, paper, fuel (p. 37). Through the determination of consumption items required by the population, such as water used for urban supply, in agriculture and especially in Brazilian livestock.

VIRTUAL WATER

The concept of *Virtual Water* was introduced by John Anthony Allan in 1998. It is defined as water embodied in commodities. That is, the water involved in the production process of any industrial or agricultural good (BLENINGER & KOTSUKA, 2015). This tool considers the flow of water between countries, and considers the water trade through the import and export of agricultural products where water apparently has an invisible character, not being accounted for.

For Farias (et al., 2020, p. 520), in order to to return more elucidating the concept; says: a lettuce plant, for example, that costs R$ 3.00 if you count the water used to irrigate it in the production process, will it end up with the same value? Certainly, if we consider water as a raw material for the maintenance of the production cycle, it would add its cost to the total value of the product.

This way, it is not intended to water is a mere commodity linked to the capitalist system, but questioning the real value of water in the accounting of the final product. Considering that this most valuable good satisfies the needs of present nations, and must preserve its liquid state suitable for consumption and in sufficient quantity for future generations.

This conception considers that water participates in an indirect trade of the same, embedded in certain products and consists of understanding that the consumption of water is not limited to its direct use, but also the "virtual" water existing in the content of the consumed products, in the production, manufacturing and transport process, which must be accounted for and evaluated (HOESKSTRA & CHAPAGAIN, 2007, BLENINGER & KOTSUKA, 2015, CARMO et al., 2007)

Therefore, along with the exported products, there are tons of water being taken from our country, in the midst of containers full of coffee, soy, sugar, orange and especially beef. Our water resources leave the country through our ports towards the international market practically invisibly (BARBOSA, 2014, apud FARIAS, 2020, p. 518)3

WATER FOOTPRINT (PH)

In 2002 the researcher and water engineer Arjen Hoekstra introduced the concept of *Water Footprint (PH)* or "*Water Footprint"*; that you want to visualize the partial or total consumed water; whether through the production of a product, by an individual, state, region or country. Hoeskstra (1998) considers the water footprint to be "defined as the volume of total water used during the production and consumption of goods and services, as well as the direct and indirect consumption of water throughout the production process for the quantification of total water consumption". water throughout the production chain". It is worth noting, as Maracajá (2012, p. 115) puts it, the premise of this theme points out that the largest share of water that human beings consume is incorporated into the products and not the water consumed daily.

The water footprint has become a study instrument, being used as an environmental indicator to assess the degree of consumption of drinking water by public and private services. The PH classification is divided into three specific components: blue PH (blue water); green PH (green water); Gray PH (gray water). (GIACOMIN, et al., 2002)

According to Hoeskstra (et al., 2012) the *blue water footprint* of a product refers to the consumption of blue water (surface and underground) along its production chain. 'Consumption' refers to the loss of available water in the catchment. Water that evaporates, returns to another basin and not to the place of origin, or when it is incorporated into a product, is considered a loss. The *green water footprint* considers the consumption of green water (water from precipitation, as long as it does not run off). As for the *gray water footprint,* it refers to water pollution, that is, it is defined as the volume of fresh water needed to assimilate the load of pollutants.

In chapter - 3 of the book Animal Production and Water Resources, by Júlio Palhares (2019); expressed: *drinking water* is part of the concept of blue water, which is extracted from surface and underground sources and can be used to irrigate plant crops, water animals, wash facilities and equipment, etc. Therefore, it is classified as water for direct consumption.

According to the Manual of Consumptive Uses of Water in Brazil (National Water Agency - ANA) of 2019. The largest consumptive uses of water, on a global scale, are agricultural. In Brazil, which has one of the largest herds in the world, the demand for fresh water in the structures for drinking water, raising and raising animals is high (p. 24). Thus, the water footprint method was introduced with the purpose of illustrating the little-known relationships between direct or indirect human consumption and water use, as well as global trade and water resources management (SILVA et al., 2012, p. 101).

Van Bellen (2002) considers that the complex problems of sustainable development require interconnected systems, interrelated indicators or the aggregation of different indicators. Although few tools deal specifically with sustainable development, most of them on an experimental basis, and these systems were developed with the purpose of better understanding the phenomena in their scope and later communicating them to the scientific society.

METHODOLOGICAL CONSIDERATIONS: WATER FOOTPRINT - ECOLOGICAL

This chapter presents the methodological procedures that led to the research. This way, the research is especially quantitative, as it deals with the systematization of secondary data present in monographs, documents and data platforms.

The method adopted in the research

is the association of the water footprint with the ecological footprint as a basis for measuring the data obtained. The terms have similarities in applicability, being the ecological footprint (EP) evaluated in *hectare* and the water footprint (PH) in *volume* of fresh water consumed directly and indirectly (MARACAJÁ, 2012). It is proposed to extend the water footprint calculation to *global hectares* within the ecological footprint, as a standardization measure of the result of the evaluation of the studied area.

The data were obtained through the survey of secondary data for the year 2020, at the following institutions: National Institute of Geography and Statistics (IBGE) and at the Brazilian Agricultural Research Corporation (EMBRAPA). Therefore, characterized as a bibliographic and documentary research, it assumes an exploratory and descriptive character, a requirement of the analysis method itself (ALMEIDA et al., 2010).

The data were initially distributed in a federal unit in the quarterly time interval, being necessary to group the units in their corresponding geographic region, and the quarters were added to obtain the result for the year 2020. Following the criteria proposed in the research and shown in table 01.

The association between the tools is also possible by adopting the water consumption item within the ecological footprint. The consumption of blue water directly and indirectly in the water footprint and the concept of Virtual Water to envision the flow of water and also its indirect consumption through agricultural products. Thus; it is considered that the water used directly for drinking water in the different cattle breeding systems present in Brazilian geographic regions is also consumed indirectly by the final consumer, and we consider that a portion of this water is exported to other regions or countries.

At the beginning of the calculation, an average consumption for animal watering of beef cattle corresponding to the value of 45 *liters/day/animal is adopted* and corresponds to a consumption of *15,120 liters/year/animal* for all geographic regions of Brazil (SURDESHA Grant Manual – Paraná, 2006); (Table 02). According to the technical note of the National Water Agency (ANA) the minimum consumption value is 20 liters/day/animal and the maximum value is 80 liters/day/animal (Technical Note nº364/GEOUT/SOF-ANA, 2013 apud Palhares, 2019). We also point out that consumption indications in specific literature are scarce in Brazil, this is due to the lack of a scientific culture to generate this type of information and the lack of water management within the breeding system (PALHARES, 2019, p. 56).

The calculation process follows some conversion steps along the way. In view of this, the development of the calculation is presented based on the systematization made in Almeida (et al., 2010), Andrade (2006), Hoekstra et al. (2011), Santos (2013) and Van Bellen (2002).

1 – Stage: Survey of the population at IBGE (2020);

2 - Stage: Absolute water consumption, for the year 2020. Obtained through the total number of animals slaughtered in each region (IBGE, 2020, EMBRAPA, 2020); multiplied by the average annual consumption value (15,120 l/year/head);

3 – Stage: Based on the considerations of Chambers et al. (2000 apud ALMEIDA et al., 2010), where 1 liter of water corresponds to 0.001 m^3; and 1 megaliter is equivalent to 1,000.00 m^3, it is necessary to convert the value from cubic meters (m^3) to megaliters (mgl);

4 – Stage: The total carbon gas (CO_2) emitted is obtained through the

proposal by Chambers et al. (2000 apud ALMEIDA et al., 2010) which considers the process of capturing, treating, plumbing and distributing water in this case to the drinking fountains. Where the consumption of 1 megaliter (mgl) of water corresponds to the value of 370 kg of carbon gas (CO_2) emitted into the atmosphere. And 370 kg is equal to 0.37 tons;

5 – Stage: According to the report of the Intergovernmental Panel on Climate Change (UNEP, 2007 apud ALMEIDA et al., 2010) an area of 1 hectare can absorb 1 ton of CO_2 emitted into the atmosphere. Thus, the population's ecological footprint is obtained by dividing the total CO_2 emitted in the previous step (4) by 1 (ha), which corresponds to the total area required to absorb the total CO_2 emitted;

6 – Step: To obtain the ecological footprint *per capita* it is necessary to divide the PE of the population by the number of inhabitants in the area (step – 1);

7 – Step: In the case of the total ecological footprint in global hectare (gha) it is reached by multiplying the ecological footprint of the population (ha) (step – 5) by 1.37 (gha); which corresponds to the equivalence factor of the bioproductive forest area;

8 – Stage: The ecological footprint per capita in global hectare (gha) is reached through the total Ecological Footprint (gha) (stage – 7) by the number of inhabitants (stage – 1).

Based on the previous steps, it was possible to build the panorama expressed in the next chapter of this work. Where the values of water consumption in the watering of beef cattle within the various existing breeding system (whether extensive, intensive and confinement) in the 5 (five) regions of Brazil are demonstrated.

RESULTS AND DISCUSSIONS

BEEF CATTLE IN BRAZILIAN REGIONS

From the concept of region, where we can understand it in its broadest sense as a way developed by geography to understand the geographic space, through its fragmentation into particularities with relatively homogeneous and/or identifiable characteristics and also as a unit of territorial planning (BASCARIAL, 2014). Brazil is divided into 5 (five) major geographic regions; being: North region, Northeast region, Midwest region, Southeast region and South region. In these regions, there is a diversity of beef cattle production systems, ranging from farms with very simple breeding practices to the presence of very modern and technified levels of incorporation of technology (MALAFAIA, 2021).

Brazil is the owner of the second largest cattle herd in the world and the first commercial one, it exports a large amount of meat in tons to the international meat market and has a very high turnover, this is due to India occupying the first place in the ranking, but, does not commercially exploit its herd (Scenarios for Amazonian beef cattle, 2015). Which puts Brazil in the first position of the ranking.

The expansion of Agriculture in Brazilian territory is pointed out as one of the main causes for the deforestation of forests, lately it has advanced to the Amazon and over the savannah. Every year there has been an increase in the number of outbreaks of arson in the region, due to the limitations found by livestock in Amazonian soils that are naturally not very fertile and result in the burning of undergrowth for the establishment of pastures and is also result of the weakening of environmental policies in the current management government.

Lately, the problems arising from the deforestation of the forest to create a pasture area in the last borders of the North and Central-West regions of the country have intensified. What serves as a warning and the future impacts they may cause on the regulation of the local climate, its effect on the reduction of the rainy season and the increase in temperature.

A very important aspect has been neglected when thinking about Brazilian cattle farming, which is water in animal production; generally little mentioned in studies on Brazilian livestock. Where the average value of consumption for animal watering of dairy cattle can vary between 150 liters/day per animal in the lactation period and 40 liters/day for a dry cow, representing 60% of the total consumption, already in comparison with the beef cattle which, despite the relative average consumption between 20 to 80 liters/day/head depending on each system and region, is responsible for 80% of the absolute consumption by each animal (ANA, 2019, PALHARES, 2019).

In the last five years the bovine herd in some Brazilian regions has increased its effective size and with that the demand on the water resource in the production systems has intensified. In the case of the northern region of the country, which in 2015 had 47 million heads; presented for the year 2019 the value of 49 million heads, meaning an increase of 2 million heads in this short time span of just five years (IBGE, 2021).

Table 01 shows the increase in the bovine herd in some areas of the country and in others there was a decrease, such as in the Northeast, Southeast and South of the country. In the southeastern and southern regions, the herd reduction is due to the displacement of livestock to the North, and these regions have also experienced a valorization of the soil, and the promotion of the development of grain culture as in the case of soybeans (SANTARÉM JUNIOR, 2018).

The National Water Agency (ANA), in its manual of technical and administrative procedures, states that to carry out the assessment of water demand for animal consumption (sedentation) it is necessarily important to consider the physical characteristics of the breeding system; whether extensive, semi-intensive or intensive and confinement (PALHARES, 2019). Animal nutrition also plays a role in the level of water consumption and water demand in each location.

Production systems can be classified based on the technological level present in the system; in: a) extensive system – based on feeding exclusively on pasture; b) semi-intensive system – based on native and cultivated pasture, in addition to mineral supplementation; c) intensive system – it is characterized by more intensive feeding in the growing period and by the practice of semi -confinement when finishing males (MALAFAIA, 2014). Considering the production phases in each system, it is possible to understand the duration time from the 1st breeding, weaning and slaughter of the animal (Table 02).

WATER FOOTPRINT (PE) OF BEEF CONSUMPTION IN MAJOR BRAZILIAN REGIONS

Beef consumption has increased in some regions of Brazil. As well as the number of animals slaughtered in the regions, in the Midwest the slaughter was 11,256,617 million heads. Followed by the Southeast with a total of 6,260,350 million heads slaughtered, in the North region of the country the total number of cattle slaughtered was 5,957,202 million heads for the year 2020, see table 03. The

Federative Units (States)	→	**Great Geographic Region (RG)**
1º, 2º, 3º and 4º trimest	→	**Year (2020)**

Table 01: Grouping of data.

Org. Prepared by the authors.

1º	Daily consumption value (45 liters/day/animal)
2º	Multiplication by the number of days of the week of 7 days (7 days x 45 liters = 315 liters/week/animal)
3º	Multiplication by the amounts of weeks in a 4-week month (4 weeks x 315 liters/week/animal = 1,260 liters/month/animal)
4º	Multiplication by the total number of months in a 12-month year (12 months x 1,260 liters/month/animal = 15,120 liters/year/animal)

Table 02: Initial stages of water volume conversion (drying)

Source: PESSOA & SANTOS (2015 apud MATOS, 2018).

Org. Prepared by the authors.

Variable - Number of herds (Heads)					
Herd type – Cattle					
Brazil and Greater Region	**Year**				
	2015	**2016**	**2017**	**2018**	**2019**
Brazil	**215,220,508**	**218,190,768**	**215,003,578**	**213,809,445**	**214,893,800**
North	47,175,989	47,983,190	48,508,063	48,900,788	49,609,974
North East	29,092,184	28,393,671	27,791,097	27,837,112	28,593,389
Southeast	38,812,076	39,123,700	37,550,079	37,111,436	37,046,635
South	27,434,523	27,577,786	27,026,122	26,121,702	25,392,462
Midwest	72,705,736	75,112,421	74,128,217	73,838,407	74,251,340

Table 01 - Number of herds, by type of herd

Source: IBGE – Municipal Livestock Survey, 2021.

Org. Prepared by the authors.

System	Indicator (Age, months)		
	1st calf	weaning	slaughter
Extensive	45	7-8	>40
semi-intensive	36	7-8	25 to 40
Intensive	24	7-8	<24

Table 02: Synthesis of the Beef Bovine Production System in Brazil.

Source: MALAFAIA, 2014.

highest number of cattle slaughtered from of the sum of the 4 quarters of the year 2020 is in the Midwest region.

From the total number of animals slaughtered in each region, it was possible to draw an overview of water consumption for beef cattle in the respective regions. Taking into account the average water consumption in all geographic regions of 45 liters/day/head as a standardization measure in the calculation, this represents an average consumption per capita per year of 15,120 liters/year/head (Table 04). Although Brazil has water comfort in some regions to maintain this rate of consumption for a few more years, attention must be paid to the size of the beef cattle herd that continues to grow each year. However, more and more water will be needed for animal watering. Palhares (2019) Water is essential in animal production, and has always been present in the production chain of beef and dairy cattle, its management incorrectly results in waste and negative impacts on the environment.

The statement of the consumption value in liters in each region in the year 2020 is quite expressive. In the North region, consumption is 90,072,894,240 billion/liters for a bovine herd of 5 million/head. In the Northeast region, the value is 35,570,571,120 billion/liters for a herd of 2 million/head. In southeastern Brazil, the value is estimated at 94,656,492,000 billion/liters of water for a herd of 6 million heads. In the south of the country, the value is 62,589,345,840 billion/liters and the herd is 4 million head. For the Midwest region, the value is very high, it is estimated 170,200,049,040 billion/liters of water consumed by a herd of 11 million head. The highest consumption value in liters registered between the regions is in the Brazilian Midwest (Table 04).

The values in table (05) above draw attention to the use of water for animal watering in all regions. Both the increase in herd and water consumption tend to increase each year. It is interesting to think that countries with water scarcity in their territory import goods that demand large amounts of water in the production chain, this water in the virtual form exerts pressure on the locality especially when this international flow of water between nations is not accounted for, and even in the interior of the country there is this flow of virtual water. However, this system becomes a problem when producing regions suffer from the presence of an inefficient management mechanism, and start to exploit their hydrological resource, not allowing the regeneration capacity of water sources (GIACOMIN & OHUMA JUNIOR, 2012).

In studies carried out by Hoekstra and Chapagain (2007) it is shown that agriculture is the sector that uses the most water on the planet, corresponding to 70% of the demand for water for this sector alone. And 22% is destined for the industrial sector and the remaining 8% is for domestic use (HOEKSTRA; CHAPAGAIN, 2007). Thus, the methodological premise aims to circumvent the pressure on a given area, moving to another; with abundant water availability.

In recent years, there has been a great adoption of the food model based on *"fast food"* that promotes fast or more practical food to meet the fast speed of urban flows in cities around the world. In this model, the various hamburgers composed of bread and beef are prioritized (GIACOMIN & OHUMA JUNIOR, 2012). And when you think that along with this beef-based food, a large volume of water is incorporated into its production process that generally does not add value to the final product, starting with animal consumption itself. It only reinforces the need to reflect on current patterns of human consumption.

The calculation of the water footprint

Slaughter - Number of animals slaughtered, sum of the 4 quarters - 2020	
Variable: Animals slaughtered (heads)	
Type of bovine herd - Total	
Brazil / Major Regions	Total (1st, 2nd, 3rd and 4th quarter) -2020
North	5,957,202
North East	2,352,551
Southeast	6,260,350
South	4,139,507
Midwest	11,256,617
Brazil	29,966,227

Table 03: Number of animals slaughtered by geographic region.

Source: Brazilian Institute of Geography and Statistics – IBGE, 2021.

Org. Corner, 2021

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Brazil / Major Regions	Consumption *(Billions / Liters)*	*Per capita* consumption *(Liters/animal/year)*
North	90,072,894,240	15,120
North East	35,570,571,120	15,120
Southeast	94,656,492,000	15,120
South	62,589,345,840	15,120
Midwest	170,200,049,040	15,120
Brazil	453,089,352,240	15,120

Table 04: Water consumption in liters, 2020.

Source: Prepared by the authors, 2021.

	No. of Inhabitants (2020)	**Consumption (m^3)**	**Consumption (mg)**	**Total CO_2 emitted (t)**	**PE of population (ha)**	**PE per capita (ha)**	**total PE (gha)**	**PE per capita (gha)**
Phases	**(1)**	**(two)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
North	18,672,591	90,072,889.24	90,072.88	33,326.96	33,326.96	0.0017	45,657.94	0.0024
North East	57,374,243	35,570,571.12	35,570.57	13,161.11	13,161.11	0.0002	18,030.72	0.0003
Southeast	89,012,238	94,656,492	94,656.49	33,022.90	33,022.90	0.0003	45,241.37	0.0005
South	30,192,315	62,589,345.84	62,589.34	23,158.05	23,158.05	0.0007	31,726.53	0.0010
Midwest	13,698,112	170,200,049.04	170,200.04	62,974.01	62,974.01	0.0045	86,274.40	0.0062
Brazil	**211,755,692**	**453,089,352.24**	**453,089.3522**	**167,643.0603**	**167,643.0603**	**0.0007**	**229,670.9926**	**0.0010**

Table 03- The Water Footprint of the Great Regions of Brazil (2020).

Source: Prepared by the authors, 2021.

together with the ecological footprint reveals a consumption of fresh water in the watering of beef cattle in the North Region: with a population of 18,672,591 inhabitants, a consumption of 90,072,889.24 (m^3), 90,072.88 (mgl), emitting a total of 33,326.96 (t) of carbon gas (CO_2), and requiring an area for the absorption of this CO_2 of 33,326.96 (ha), and has a *per capita ecological footprint* of 0. 0014 (ha), has a total ecological footprint of 45,657.94 (gha) and a per capita ecological footprint of 0.0024 (gha).

In the Northeast region, with a population of 57,374,243 inhabitants, water consumption is 35,570,572.12 (m^3) for beef cattle, translated into megaliters this value is 35,570,572.12 (mgl), emitting the total of 13,161.11 (t) of CO_2 to the Earth's atmosphere. This emission requires an area in hectare for the absorption of carbon gas of 13,161.11 (ha), and a per capita ecological footprint of 0.0002 (ha), and a total ecological footprint of 18,030.72 (gha) and a per capita ecological footprint of 0.0003 (gha).

In the case of the Southeast region, which has the largest population in the country, with an estimated population of 89,012,238 people. Consumption in cubic meters is 94,656.49 (m^3), 94,656.49 (mgl), the total CO_2 emitted is 33,022.90 (t), and an area of appropriation for the absorption of carbon gas ($CO_{2)}$ emitted of 33,022.90 (ha), and a per capita ecological footprint of 0.0003 (ha), while the total ecological footprint in global hectares of 45,241.37 (gha) and a per capita ecological footprint of 0.0005 (gha).

As for the South region, with a population of 30,192,315 inhabitants, the consumption value is 62,589,345.84 (m^3) in the animal watering of beef cattle, the same consumption in megaliters is 62,589.34 (mgl), emits a total of 23,158.05 (t) of CO_2 into the atmosphere, and requires an area of 23,158.05 (ha) to absorb the carbon gas emitted. The ecological footprint *per capita* is 0.0007 (ha), it has an absolute ecological footprint of 31,726.53 (gha) and a per capita ecological footprint in global hectare of 0.0010 (gha).

For the Midwest region with 13,698,112 inhabitants. The absolute consumption of water is 170,698,112 (m^3), in megaliters the value is estimated at 170,200.04 (mgl), this consumption value emits 62,974.01 (t) of carbon gas ($CO_{2)}$ in tons and requires the same value in hectare for the absorption of CO_2 which corresponds to 62,974.02 (ha). The ecological footprint per capita of the region is 0.0045 (ha), in global hectare the value found in the total ecological footprint is 86,274.40 (gha) and a per capita ecological footprint of 0.0062 (gha) the largest among all regions of Brazil, see Table 01.

In this framework, we observe how much livestock activity has an impact on the water footprint in Brazilian regions. The Midwest region has a larger water footprint and smaller population, demonstrating not only the demand from national and international consumer markets but also the scarcity of technologies that point to reducing the impact of cattle ranching. The latter, a reality shared by the other regions.

FINAL CONSIDERATIONS

The overview of the water-ecological footprint in the respective geographic regions demonstrates how beef cattle demand a large amount of water to supply drinking fountains in production systems. The values of the total footprint in global hectares in the case of both the absolute ecological footprint and the per capita footprint represent the appropriate area to maintain this pattern of water consumption in animal watering in the regions and also the value to be replaced each year for the maintenance of constant production.

The Midwest is the region that has the largest ecological footprint (gha) with

86,274.40 (gha) PE total and 0.0062 (gha) PE per capita. Followed by the Northeast region with a total ecological footprint of 45,657.94 (gha) and a per capita footprint of 0.0024 (gha). This footprint is shared with other countries, this is due to the export of meat to the international market. Therefore, these values reinforce the need to continue monitoring and accounting for this consumption, whether through environmental indicators, such as the methodology used in this work, which, in addition to measuring the animal consumption of beef cattle, serves as a tool to raise awareness of the meat consuming population about the real values that are embodied in beef. This way, it serves as a warning in the quest to prevent its scarcity for future generations.

Therefore, the (ecological) water footprint method in the presentation of the results of the evaluation of beef cattle in the regions of Brazil, in no way tries to close the pertinent questions on the subject, mainly on the levels of water consumption. But it raises new reflections and leads to the thought that when beef will be consumed, water is also being consumed in the form of "virtual water".

The very high values of water consumption by beef cattle reinforces the extreme urgency in establishing the correct water management. The promotion of a culture of information on water management within each production system, its use always seeking to reduce waste, since agriculture is the economic sector responsible for the consumption of 70% of the water on the planet. Avoiding pollution, and strengthening environmental policies and water use control mechanisms within the national territory is very important, or beef cattle in the not-too-distant future will have to undergo harsh transformations in its production cycle. The present work sought to give the kick-off to contribute to the formation of a database on hydrological management in beef cattle in the national territory.

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