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Water footprint of Brazilian food patterns: impacts on water resources

Pegada hídrica dos padrões alimentares brasileiros: impactos sobre os recursos hídricos

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Abstract: The preservation of the environment is essential to ensure life, especially in relation to water resources. The lack of knowledge of the consequences of individual consumption decisions on water resources contributes to the adoption of unsustainable living patterns. One subsidy for consumer awareness is to estimate the Water Footprint, that is, to measure the amount of water needed according to different lifestyles. In order to evaluate the food consumption patterns of the Brazilian population and highlight their impacts through the Water Footprints a quantitative research was carried out applying Factorial Analysis to POF microdata from 2016/17. The results allowed us to identify spatial differences, however, the pattern associated with the typical Brazilian diet, without animal protein, is the most homogeneous among the regions.

Keywords: Water Consumption; Food Patterns; Factorial Analysis.

Resumo: A preservação do meio ambiente é essencial para garantir a vida, especialmente em relação aos recursos hídricos. A falta de conhecimento das consequências das decisões individuais de consumo sobre os recursos hídricos contribui com a adoção de padrões de vida insustentáveis. Um subsídio para a conscientização do consumidor é estimar a Pegada Hídrica, ou seja, aferir a quantidade de água necessária de acordo com diferentes estilos de vida. Com o intuito de avaliar os padrões de consumo alimentar da população brasileira e destacar seus impactos por meio da Pegada Hídrica foi realizada uma pesquisa quantitativa aplicando a Análise Fatorial aos microdados da POF de 2016/17. Os resultados permitiram identificar diferenças espaciais, porém, o padrão associado à dieta típica brasileira, sem proteína animal, é o mais homogêneo entre as regiões.

Palavras-chave: Consumo de água; Padrões Alimentares; Análise Fatorial.

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1. Introdution

Sustainable development requires the participation of all sectors of society to change habits and create a new reality that promotes social well-being, environmental protection and economic growth. This involves adopting consumption patterns that are more friendly to natural resources. Scientific studies and discussions about consumption are essential to implement strategies, whether public or private.

In ancient times, consumption was limited to basic needs, without mass production or major environmental impacts. On the contrary, people produced in small quantities, hand made and to order, with limited impact on environmental resources (MIRANDA, 2023).

However, with the advent of the Industrial Revolution there was an increase in the consumption of products and services, driven by large-scale production and the creation of artificial needs. The abundant supply of industrialized products, combined with sales techniques and the search for status, led to an exponential increase in consumption (VEBLEN, 1987).

Through advertising, companies began to increasingly influence consumer behavior. With the aim of promoting sales, companies create new needs, promote the obsolescence of products and encourage the constant replacement of goods, leading to unrestrained and unsustainable consumption (SENNETT, 2001).

Chapter 4 of Agenda 21 proposes changes to consumption and production patterns to reduce environmental pressures and meet society's basic needs, developing a better understanding of the role of consumption and implementing more sustainable patterns. It is urgent that countries review their consumption patterns, with the richest leading actions and helping the poorest countries with knowledge and technical support. While other countries must avoid the high levels of consumption of the richest (UNCED, 1992).

The 2030 Agenda establishes 17 Sustainable Development Goals (SDGs), among which SDG 12 defines that countries must ensure sustainable production and consumption patterns, proposing the goal of "ensuring that people, everywhere, have relevant information and awareness about sustainable development and lifestyles in harmony with nature" (UN, 2015, p. 27).

Considering the importance that consumption patterns have on the social, economic and environmental dimensions of sustainability, lifestyle plays a fundamental role in decisions and as a consequence can harm or preserve the Planet. Water is an essential natural resource for the survival of all living beings, as well as for the production of food and the functioning of industries. All these needs, added to pollution, indiscriminate use of surface and underground water, unsustainable consumption of goods and services, and poor management of water resources and the increase in population, culminate in increasing pressure on this natural resource.

In this context, the present study aims to discuss the level of sustainability of the main food consumption patterns of the Brazilian population, highlighting their impacts through their food Water Footprints.

This article is divided into three sections, in addition to this introduction and final considerations. The theoretical foundation section contains a synthesis of the theory that supports the Water Footprint and studies of the Water Footprint of food consumption. Next, the methodology used is detailed and then the results are analyzed.

2. Theoretical foundation

Among the natural resources essential for life, water occupies a prominent place. Considering the importance of water resources for humanity, as well as the risk of scarcity increased by the use of water in the production of goods and services, the assessment of sustainable consumption must include the impact of consumption patterns on water demand. The Water Footprint is an indicator that measures the total volume of fresh water needed to produce a good or service, considering the entire production process or the entire production chain. The Water Footprint is a way of assessing the impact of human consumption on the use of water resources.

The Water Footprint was created by Arjen Hoekstra in 2002 with the aim of promoting the sustainable use of water in order to raise awareness among consumers about the volume of water needed to sustain the lifestyle. For this reason, the Water Footprint does not only include the amount of water used directly by the consumer, but all the water required in the production processes of the goods consumed.

The concept of Water Footprint is associated with quantifying the negative impacts of human activities on water use, both in terms of quality and availability in the biosphere. This concept aims to measure globally available water, combining the notion of virtual water with the concept of ecological footprint. Dong *et al*. (2019) and Northey *et al*. (2016) define the

Water Footprint as the volume of water that a population needs to consume or produce a specific quantity of goods or services.

When calculating the Water Footprint, Hoekstra *et al*. (2011) identified three components that provide a comprehensive view of the use of water resources, helping to understand the origin of the water consumed. These components include: (i) green component, which corresponds to water from precipitation stored in the soil and used by vegetation; (ii) blue component, which consists of fresh water, surface or underground; and (iii) gray component, which represents the volume of fresh water necessary to dilute the pollution resulting from the production process.

The Water Footprint is an indicator that contributes to the assessment of the sustainability of consumption patterns, given the importance of water resources in the production of all products. Global water scarcity, highlighted by studies from the World Resources Institute (WRI), affects around a quarter of the world's population, with regions such as the Middle East being most affected. Although Brazil has the largest freshwater reserves in the world, some areas, including the states of Rio Grande do Norte, Piauí, Ceará and Bahia, and the metropolitan regions of São Paulo, Rio de Janeiro, Brasília, Vitória, Ribeirão Preto and Campinas, suffer from similar levels of scarcity, according to data from WRI Brasil (2023).

In this sense, it is necessary to have information on the Water Footprint associated with the consumption of Brazilian families, in order to evaluate the sustainable consumption of specific groups of consumers. This data can help guide actions that promote population awareness through the dissemination of knowledge about consumption patterns that are more aligned with sustainability concepts.

From a search carried out on the CAPES Journal Portal and the Digital Library of Theses and Dissertations, it was possible to verify a small number of Brazilian academic studies relating to the Water Footprint of food consumption. However, the identified publications make important contributions to understanding the impact of different food consumption patterns on the environment, more especially on water resources.

Some Brazilian research stands out that studied the Water Footprint (WF) regarding food consumption.

• WF of vegetarian consumers in the municipality of Caicó in Rio Grande do Norte (SILVA *et al*., 2013a): the authors concluded that the WF of vegetarians is equivalent to around 58% of the WF of non-vegetarians, and that the WF increases with family income.

• WF in the subnormal agglomeration of the Rocinha neighborhood in the city of Rio de Janeiro (BEUX, 2014): the result of the study indicated that the WF of residents is three times higher than the average of low-income consumers, which would be caused by behavior of waste.

• Food WF in a university restaurant in Porto Alegre-RS (STRASBURG; JAHNO, 2015): it was found that animal protein represents around 80% of the total WF of meals, which requires planning collective menus to reduce its impacts.

• Brazilian food WF using the IBGE POF (2002-2003 and 2008-2009) (UTIKAVA, 2016): the study identified that food patterns with the most frequent consumption of red meat have a WF three times higher than the WF of food patterns based on consumption of fish and vegetables, as well as a tendency towards higher WF with increased income.

• WF of students at Faculdades Integradas de Aracruz (GIACOMIN; OHNUMA JÚNIOR, 2017): it was found that food had a greater weight in the WF (76%) of students with assessed consumption, with products of animal origin having the greatest impact on their WFs.

• WF of adolescents with microdata from the National School Health Survey (VALE *et al*., 2021): the results of the study showed higher WFs in the urbanized regions of the South and Southeast, with emphasis on the impact resulting from fast food meals.

• WF of students from the Accounting Sciences Course at UNEMAT in Tangará da Serra-MT (SILVA *et al*., 2020): the study showed that the general individual water footprint found was 6,137 m³ of water per year, which was 200.22 % above the national average, mainly due to the consumption of meat, cereals and domestic use. The study also found that in general, females have higher WFcompared to males.

• WF of inhabitants of the Agreste region of Pernambuco (SILVA *et al*., 2022): when evaluating water consumption and its relationship with social indicators, the results demonstrated a WF per capita of 1128.19 m³/year, (below the WF per capita on the planet 1385 m3/year and the Brazilian average 2027 m3/year), with food corresponding to 62.6% of the WF in the region. The population with greater purchasing power consumes more products, which consequently produces higher WF values.

• WF - an exploratory study in Brazil (MARACAJÁ, 2019): the Midwest, Southeast and South regions had the largest water footprints, in contrast to the North and Northeast regions.

• WF in a university restaurant (HATJIATHANASSIADOU *et al*., 2019): the study observed that between two types of menus offered in a restaurant at the Federal University of Rio Grande do Norte, the conventional standard had a higher water footprint due to the use of products of animal origin in its composition.

The studies mentioned reinforce the importance of Water Footprint assessments so that consumers, as well as governments and the private sector, can make more conscious choices in order to contribute to reducing direct and indirect water consumption.

The Water Footprint, as a sustainability indicator, makes it possible to monitor the impact of human action on the consumption and production of goods and services. Furthermore, the Water Footprint provides relevant information to measure the pressure on water resources and, consequently, on the environmental dimension of sustainability (SILVA *et al*., 2013b).

In this sense, the Water Footprint was used as an evaluation indicator to identify the food consumption patterns of the Brazilian population and understand their risks and contributions to sustainable development. For this purpose, public information on family budgets released by IBGE was used.

3. Metodology

The nature of the research is applied, considering its intention to generate knowledge that can be used in a practical way by those interested in its results (GIL, 2008).

The purpose of the research is explanatory in nature, considering the need to seek facts through database evaluation, which were analyzed and interpreted, aiming to identify the level of adherence to sustainability concepts existing in different food consumption patterns. According to Severino (2007), explanatory research analyzes and records the phenomena, objects of study, exploring the causes based on qualitative or quantitative methodologies.

Regarding the approach, a quantitative evaluation of information available in databases on the food consumption of the Brazilian population was carried out, with the construction of statistics that allow the interpretation and generation of knowledge about the differences in consumption patterns of different groups of individuals. Lakatos and Marconi (2003) emphasize that the quantitative approach considers the precision of information and statistical controls to enable the interpretation of hypotheses.

3.1. Factorial analysis

The statistical technique used is Factorial Analysis, which aims to structure the correlations between a large number of variables and summarize the original set of variables through a smaller number of dimensions (or factors) in order to minimize the loss of information in the variable reduction process (HAIR *et al*., 2009).

Factorial Analysis (FA) is a multivariate statistical technique used to identify the relationship between a set of observed variables and explain them in terms of a smaller number of unobserved variables, called factors. The objective is to simplify the analysis of large data sets, reducing the number of variables to be considered and identifying patterns or relationships between variables that would not be evident otherwise (HAIR *et al*., 2009; LATTIN; CARROLL; GREEN, 2011 ; BEZERRA, 2017; MATOS; RODRIGUES, 2019).

The application of AF made it possible to identify groupings of products that share common variance. These factors are classified as “food consumption patterns”, that is, combinations of strongly correlated products.

The Statistical Package for the Social Sciences (SPSS) software, version 20.0, was used to process POF microdata and Factorial Analysis.

Factor Analysis involves extracting factors that are linear combinations of the original variables, with the aim of explaining most of the total variance in the data. In this research, the application of Factorial Analysis made it possible to identify groupings of products that constitute food consumption patterns.

3.2. Database

To carry out the research, two databases were used: a) Family Budget Survey (POF), b) Water Footprint Statistics (WaterStat).

The POF used in this study is the latest available, applied between July 2017 and July 2018 (IBGE, 2017). The information available in the microdata made it possible to identify the quantities consumed per consumption unit (family) classified by place of residence (urban or rural), Federation Unit (State), and income.

In POF 2017/2018, information was collected for a total of 8,357 food items. However, in this research 360 items (approximately 4%) were disregarded because they were aggregated or travel products, which made it impossible to estimate the Water Footprint.

The Water Footprint Network publishes, among others, estimates of the Water Footprint of most foods, both globally and by country or region. In this research, data from the Water Footprint of food products for Brazil were selected (MEKONNEN; HOEKSTRA, 2010a, 2010b).

Of the products selected based on POF, the WaterStat database made it possible to identify the Water Footprints of 6,935 (83%) items, while 1,062 (13%) had no information available. For food groups, such as fish and soft drinks, without information available in the WaterStat database, estimates from Utikava (2016) were used. The reference values used in these estimates were extracted from studies carried out by other authors who evaluated the WF of these foods.

Then, the selected products were grouped into the following 24 food groups (Table 1).

Table 1 – Food Groups.

Sugar	Dairy products
Rice	Corn and derivatives
Alcoholic beverages	Other red meat
Cocoa and derivatives	Other cereals and derivatives
Coffee and teas	Eggs
Bovine meat	Bakery products
Poultry meat	Seafood
Spices and condiments	Soft drinks
Beans	Oilseeds and coconuts
Fruits	Juices
Fats	Wheat and derivatives
Vegetables and leguminous	Tubers, roots and derivatives

Source: The authors (2023).

Using information from these databases, the annual quantities consumed per capita and the corresponding Water Footprints were calculated for each of the selected food product groups.

The quantities of food purchased for consumption at home, detailed in the POF microdata, were used to describe food consumption patterns.

Subsequently, using WaterStat data, it was possible to estimate the Water Footprint associated with different food consumption patterns.

4. Analysis of Results

The method used to identify food patterns was Factor Analysis (FA) with the support of SPSS software. Using this technique, it was possible to identify food patterns based on common unobservable factors. The results of the Factor Analysis are presented below.

The estimated KMO statistic obtained for the data in this research was 0.803. According to Fávero and Belfiore (2017), KMO values between 0.8 and 0.9 indicate that Factor Analysis is suitable for the selected data.

In turn, the Bartlett test presented a p-value (or significance level - Sig.) close to zero, allowing us to reject the hypothesis that the correlation matrix is equal to an identity matrix, that is, the correlations found were significant. in statistical terms, confirming that the variables are sufficiently correlated to justify Factorial Analysis.

The Kaiser criterion is one of the ways to determine the number of factors to be retained in the Factor Analysis. This criterion suggests that only factors with an eigenvalue greater than 1 be retained, which means that they explain more variance than an individual variable. Based on this criterion, the results of the analysis showed that the first six factors have eigenvalues greater than 1. However, together, these factors explain around 46.25% of the total variance of the analyzed data (Table 2).

Table 2 – Total variance explained (six main factors).

Factor	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loading		
	Total	Var. (%)	Cumul. (%)	Total	Var. (%)	Cumul. (%)	Total	Var. (%)	Cumul. (%)
1	4.216	17.566	17.566	4.216	17.566	17.566	3.274	13.640	13,640
2	2.067	8.614	26.180	2.067	8.614	26.180	1.975	8.228	21.868
3	1.492	6.217	32.397	1.492	6.217	32.397	1.679	6.996	28.864
4	1.270	5.290	37.687	1.270	5.290	37.687	1.523	6.346	35.210
5	1.042	4.341	42.029	1.042	4.341	42.029	1.384	5.766	40.976
6	1.013	4.220	46.249	1.013	4.220	46.249	1.265	5.273	46.249

Note: Var.: Variance
Cumul.: Cumulative variance

Source: The authors (2023).

In order to identify the characteristics of the main factors, an analysis of the rotated components was carried out, according to the matrix presented in Table 3. From this analysis, the correlations between the food groups and each of the main factors were calculated, which made it possible to characterize the six Food Patterns (FPs) identified with the application of Factorial Analysis.

Table 3 – Matrix of rotated components.

Food Groups	Main Food Patterns (FPs)					
	FP1	FP2	FP3	FP4	FP5	FP6
Sugar	.719	-.016	.030	.042	.098	.044
Rice	.713	.003	-.018	.081	-.084	.009
Alcoholic beverages	.583	.034	.107	.084	.165	.022
Cocoa and derivatives	.544	.020	.011	.152	.019	.083
Coffee and teas	.664	.024	.097	.072	-.116	.072
Bovine meat	.678	.035	.112	.166	.129	.001
Poultry meat	.363	.000	.206	-.158	.077	.148
Spices and condiments	.566	-.020	.074	.133	.218	-.016
Beans	.025	.982	.057	.088	.073	.010
Fruits	.030	.983	.056	.080	.056	.009
Fats	.018	.049	.694	.108	.146	.077
Vegetables and leguminous	.125	.046	.636	.175	.125	.063
Dairy products	.087	.017	.565	-.016	.009	.008
Corn and derivatives	.180	-.036	.235	.505	-.096	.197
Other red meat	.150	.093	.197	.588	-.130	.134
Other cereals and derivatives	.158	.046	.020	.608	.124	-.044
Eggs	.033	.122	-.118	.504	.374	-.060
Bakery products	.157	.041	.157	.021	.504	-.063
Seafood	.250	-.016	.330	.110	.411	-.123
Soft drinks	.091	-.027	.273	.300	.417	.003
Oilseeds and coconuts	-.004	.052	.007	-.051	.528	.061
Juices	.045	.029	.079	.072	-.082	.599
Wheat and derivatives	-.042	.007	-.173	-.068	.354	.654
Tubers, roots and derivatives	.231	-.031	.182	.116	-.143	.590

Source: The authors (2023).

The characteristics of the food profiles of the six FPs generated are as follows.

• FP1: represents 13.64% of the sample's total variance, with a strong correlation between eight food groups, such as sugar, rice, coffee, beans, fats, among others. It reflects a basic food pattern of the Brazilian family.

• FP2: explains 8.23% of the variance and only includes alcoholic beverages and other cereals and derivatives.

• FP3: accounts for 7% of the variance and is associated with fruits, vegetables, legumes and eggs.

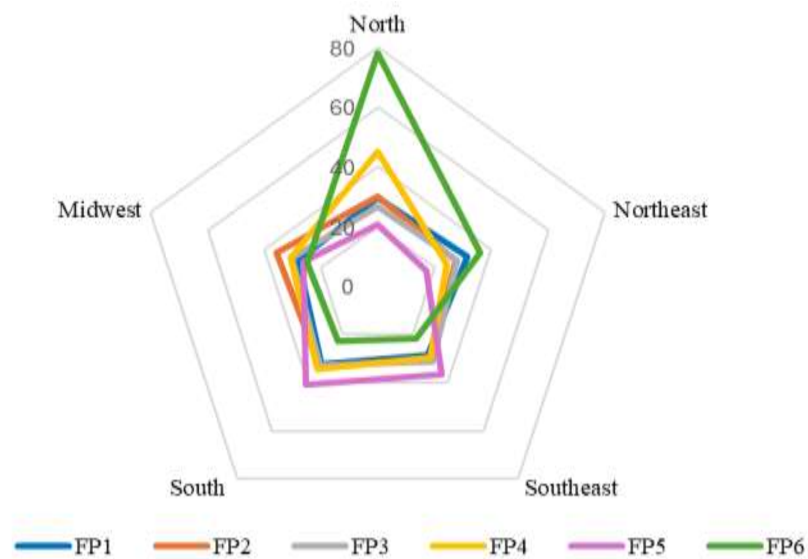
• FP4: represents 6.35% of the variance and is concentrated in meat, such as poultry, beef and other red meat, and soft drinks, representing the majority of animal proteins.

• FP5: with 5.77% of the variance, concentrated in cocoa, dairy products, bakery products and juices.

• FP6: explains 5.27% of the variance, focusing on seafood, oilseeds, coconuts, tubers and roots.

Based on the Water Footprints of the food groups, the most representative patterns were identified in each Brazilian region when calculating the three upper deciles, corresponding to the 30% that have greater adherence to the identified food profiles. This approach was adopted by Lares-Michel *et al*. (2022), who categorized food groups using the top three deciles, aiming to describe and interpret them, considering that the greater the percentage of association of variables (foods) with each food pattern, the greater the adherence to the groups.

Graph 1 shows the frequency of food patterns in Brazilian geographic regions. It is observed that FP1, which corresponds to the traditional Brazilian diet without meat, is the food pattern that presents the greatest homogeneity between regions. On the other hand, FP6, characterized by the presence of fish, tubers and roots, is the food pattern that presents the greatest variability between Brazilian regions, being more relevant in the North region.



Graph 1 – Food patterns in Brazilian regions.
Source: The authors (2023).

It is important to highlight that, although FP1 is the most homogeneous pattern across the country, it has a greater occurrence in the South and Northeast. FP2 is more common in the Midwest, while FP3 stands out in the South and Southeast, and FP4 is significantly more frequent in the North region. FP5 consumption is prominent in the South and Southeast, with low frequency in the Northeast. As mentioned previously, FP6 is the food pattern with the greatest variability among the FUs, being more frequent in the North and Northeast. Geographical differences in food patterns are illustrated in Figure 1.

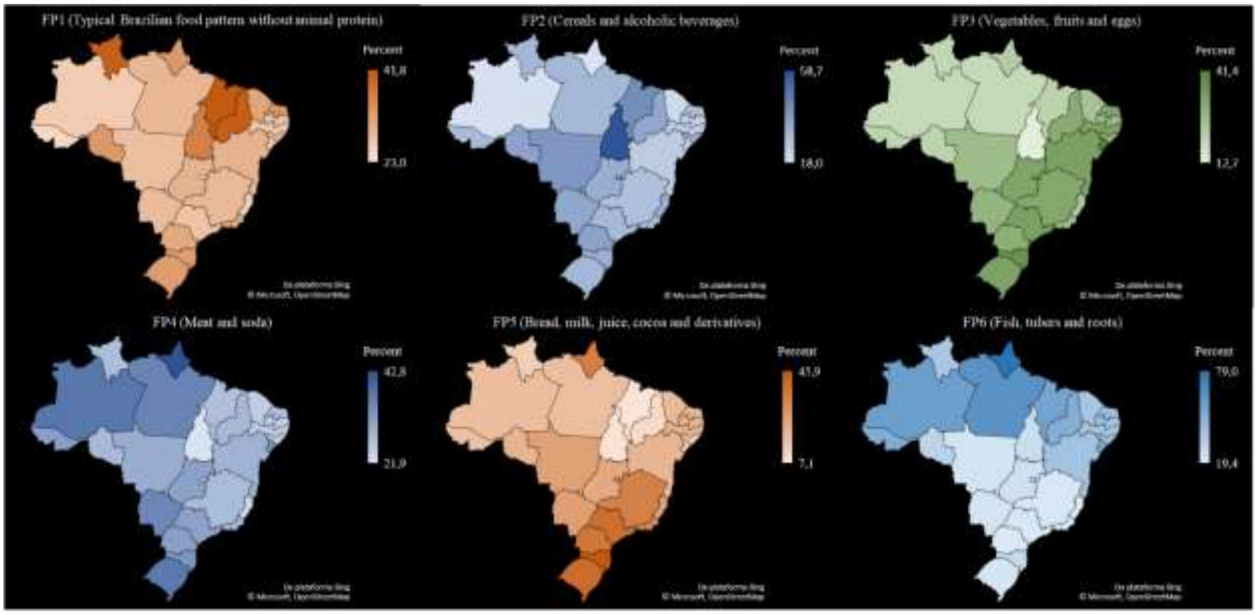


Figure 1 – Consumption per UF.
Source: The authors (2023).

The analysis of Figure 1 indicates that Maranhão, Piauí and Roraima lead in consumption of FP1, while the Federal District has the lowest relative frequency of this food pattern. The least frequent consumption of FP2 is observed in Amapá, while Tocantins leads among the other FUs. However, Tocantins has the lowest consumption of FP3 and FP4, while Sergipe and Santa Catarina stand out in the frequency of FP3.

Amapá presents the greatest emphasis on FP4 consumption, followed by Amazonas, Rio Grande do Sul, Pará and Mato Grosso do Sul, which also have a high frequency. Santa Catarina, Rio Grande do Sul, São Paulo, Paraná, Amapá and Minas Gerais stand out with the highest frequency of FP5 consumption. Finally, Amapá, Pará, Amazonas, Maranhão, Sergipe and Acre are the states that stand out with the highest consumption of FP6.

Previous studies that focus on the spatial comparison of the water footprint present partially different results in relation to those found in this study, as evidenced in Vale *et al*. (2021) and Macarajá (2019). These discrepancies can be attributed to substantial methodological differences. In the case of Vale *et al*. (2021), analyzing the consumption of urban adolescents, found that WF was higher for residents of the South and Southeast regions. The authors attributed this result to the frequent consumption of fast food, a type of food not considered in the current study due to the complexities in correctly estimating the water footprint, given the variety of food products combined in different ways. In turn, Maracajá (2019) estimated a greater water footprint associated with food consumption by residents of the Midwest, South and Southeast regions. This study used aggregated data from IBGE and defined three food patterns (vegetarian, high consumer of red meat and medium consumer of red meat). The differences found in these studies highlight the importance of making WF estimates with disaggregated data and, at the same time, point out the need to overcome the obstacle in estimating foods prepared or consumed outside the home, a consumption pattern that is currently very widespread.

Based on the data from the rotated components matrix, obtained through Factorial Analysis, the Water Footprints of the main food patterns evaluated in this research were calculated, which are presented in Table 4. The calculation was performed with the average of the total WF values of the main foods that make up the food groups, which were added to total the WF of each food pattern.

Table 4 – Water footprints of the main food patterns.

Food Groups	Main Food Patterns (FPs)					
	FP1	**FP2**	**FP3**	**FP4**	**FP5**	**FP6**
Sugar	785	-17	33	46	107	48
Rice	2,473	12	-64	281	-290	32
Alcoholic beverages	6,045	347	1,114	867	1,712	224
Cocoa and derivatives	1,002	37	21	280	34	153
Coffee and teas	2,166	79	317	235	-380	234
Bovine meat	22,660	1,169	3,728	5,533	4,322	19
Poultry meat	634	0	360	-275	135	259
Spices and condiments	1,216	-44	159	286	468	-35
Beans	12	494	29	44	37	5
Fruits	105	3,461	198	282	197	31
Fats	66	184	2,623	409	554	293
Vegetables and leguminous	501	183	2,543	700	501	252
Dairy products	254	49	1,651	-46	26	23
Corn and derivatives	627	-127	817	1,756	-334	685
Other red meat	11,357	7,006	14,889	44,501	-9,803	10,106
Other cereals and derivatives	5,201	1,503	663	20,012	4,086	-1.447
Eggs	11	41	-40	171	127	-20
Bakery products	4,475	1,169	4,471	602	14,393	-1,800
Seafood	3,248	-202	4,282	1,431	5,342	-1,599
Soft drinks	169	-51	511	561	779	6
Oilseeds and coconuts	-6	83	12	-81	836	96
Juices	89	58	155	142	-162	1,182
Wheat and derivatives	-171	28	-706	-276	1,446	2,668
Tubers, roots and derivatives	228	-30	179	114	-141	582
WFTotal	**63.150**	**15.433**	**37.948**	**77.580**	**23.997**	**12.001**

Source: The authors (2023).

Analysis of the Water Footprint (WF) estimates of the main food patterns shows that the highest WF is associated with the consumption of animal protein (FP4), followed by the traditional Brazilian diet (FP1), while FP6 and FP2 have the lowest WFs. The difference between the highest and lowest WF is significant, with FP4 being 646.4% higher than FP6. These results corroborate the conclusions of the study by Utikava (2016), which also identified that the food pattern with the highest presence of red meat had the highest WF compared to other food groups, while two patterns with the highest frequency of fish consumption had the highest lower WFs, similar to FP6 in this research.

The high WF values of the diet including animal protein corroborate the results found in Silva *et al*. (2013a) in the case study of a municipality in Rio Grande do Norte. Limiting the study to food consumption in university restaurants, Strasburg and Jahno (2015) in the city of Porto Alegre-RS, Giacomin and Ohnuma Júnior (2017) for students in Aracruz and Hatjiathanassiadou *et al*. (2019) at the Federal University of Rio Grande do Norte proved that menus with products of animal origin have a higher WF.

4. Final considerations

The research results made it possible to understand the food patterns of the Brazilian population, the Water Footprint involved and the relationship between these patterns and consumption in different geographic regions.

The pressure that the consumer society exerts on the finiteness of natural resources, increased by the increase in population, shows the need for changes in the habits of the entire society in search of sustainable development that promotes the preservation of the environment.

The research made it possible to identify the main food patterns with the products that stand out most in their composition, whose data evaluated through Factorial Analysis showed the patterns that are most frequent and least common in each State and in each geographical area. This information constitutes the main contribution of this research, as together with the Water Footprint of foods made available by WaterStat, allow the results to be used in the development of strategies to encourage the adoption of food patterns that are less aggressive to the environment, depending on water demand. involved in the production processes of the evaluated items.

Considering that the Water Footprint is an indicator used to identify the level of sustainability of products and services, the results on the WF of the main food patterns of the Brazilian population contribute with relevant aspects for sustainable consumption, as the knowledge of the impact on water resources favors decision-making about changing habits, including a possible reduction in consumption, as it can strengthen consumers' critical view of the issue and their search for products with less negative impact on the environment.

Additionally, the results obtained can also contribute to raising awareness among consumers in the search for more sustainable lifestyles and in harmony with nature, in line with the guidelines of goal 12.8 of SDG 12.

Among the difficulties encountered in the research, the limited number of academic publications that associate the Water Footprint with Brazilian consumption habits stands out. Therefore, more studies on this topic are necessary given the scarcity of water resources and the need for their preservation.

The limitations of the research include aspects related to the concept of Water Footprint, which also provides for the calculation of water consumption in domestic activities and the acquisition of products and services, however, considering that this information is not available in the POF, the research was focused on identifying the Water Footprint of food, without considering other aspects of consumption by the Brazilian population. Therefore, for future studies to include the other components of the Water Footprint, it would be necessary to provide greater detail in the POF data or to resort to alternative data sources, such as ad hoc research, aiming to provide an overview of the level of sustainability of the population's lifestyle, according to different geographic areas, places of residence, family income and other particularities.

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