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Water Footprint and its relationship with family income: a study applied to Brazil

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ABSTRACT
The urbanization process, accompanied by significant population growth, has promoted new consumption patterns that put pressure on natural resources. Faced with the challenges arising from unsustainable consumption, Sustainable Development Goal 12 of the 2030 Agenda seeks to promote sustainable methods of production and consumption, as well as the conscious use of natural resources. In this sense, this study aims to contribute to the debate on the relationship between the dietary patterns of the Brazilian population and family income by calculating the environmental indicator Water Footprint. To meet this objective, an appl0069ed research with a quantitative approach was carried out based on a bibliographical review carried out in the SCOPUS and Web of Science databases, from 2012 to May 2023. In addition, microdata from the latest Brazilian Institute of Geography and Statistics Household Budget Survey were employed, supported by the application of the multivariate statistical technique of Factorial Analysis. As a result, six main factors that characterize the main Brazilian dietary profiles were identified. The results confirmed that diets rich in animal protein tend to have a higher Water Footprint, the same as those found in the literature review. A strong correlation was also found between income and meat consumption, with higher income households consuming larger amounts of animal protein and, therefore, having a larger water footprint compared to those of lower per capita income households. The results prove the need to promote awareness about the environmental consequences of consumption and the importance of promoting healthy and sustainable eating habits.

KEYWORDS: Water Footprint. Income. Sustainable consumption.

1 INTRODUCTION

The ongoing unprecedented consumerism, driven by high urbanization and population growth, has contributed to the scarcity of natural resources. Discussions on new concepts of wealth and prosperity that promote population well-being through a lifestyle requiring fewer resources have led to the creation of the term sustainable consumption (BARBOSA, 2023).

There are various definitions of sustainable consumption. As clarified by Jackson and Michaelis (2003), some definitions are related to consumer behavior, while others are focused on more responsible consumption.

Unsustainable consumption can lead to various disastrous consequences, including water quality degradation. In this sense, Costa et al. (2021) underscore that Water Footprint (WF) has gained prominence in the scientific community.

It is important to take WF into account in research that addresses water consumption, sustainability, and water resource management is essential because, according to Hatjiathanassiadou et al. (2022), WF aims to show the connections between human consumption and water use, contributing to the assessment on the impact of consumption and production patterns on resources and can influence consumption trends, assisting in more sustainable management.

WF was developed by the Dutchman Arjen Y. Hoekstra and aims to estimate the volume of water used throughout the life cycle of a good or service, considering all stages of the production process and all production inputs (HOEKSTRA; HUNG, 2002).

Considering the concept of virtual water used in the production process or even in agriculture, Jacobi and Grandisoli (2017) draw attention to the importance of considering the water mobility in imports and exports.

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WF is divided into three components: green WF (rainwater); blue WF (surface or underground fresh water); and grey WF (freshwater needed to dilute pollutants). The sum of the water volume from these three components results in the WF of a product.

WF can be calculated to obtain the consumption pattern of an individual, with the aim of promoting the transition to sustainable, fair, and efficient use of freshwater resources worldwide (Water Footprint Network [WFN], 2021).

WF is calculated based on the level and composition of consumption and includes dimensions of food consumption, household consumption and industrial consumption, and can be measured in cubic meters per ton of production, per hectare of cultivated area, per unit of currency, or other units. The calculation metric is provided by the Water Footprint Network (WFN).

2 OBJECTIVE

The main objective of this paper is to discuss the relationship between the dietary patterns of the Brazilian population and family income by calculating their Water Footprints.

Water Footprint is a metric that estimates the total amount of water used directly and indirectly throughout the life cycle of a product or service.

By calculating the Water Footprints of different dietary patterns, it is possible to obtain a more precise understanding of how water consumption relates to dietary habits and family income. This analysis contributes to the discussion of responsible consumption, aligned with Sustainable Development Goal 12 (SDG 12) of the UN's 2030 Agenda, which seeks to promote sustainable consumption and production patterns.

3 WATER FOOTPRINT AND CONSUMER INCOME

The study of Water Footprint (WF) is particularly complex due to the objective of measuring the direct and indirect impact of consumption on water demand. In the literature there are studies that assess the WF of products or sectors, while others focus on the impact of consumption patterns of selected consumer groups. This research starts with the hypothesis that socioeconomic groups have different consumption patterns and, consequently, different water footprints.

To verify if there is empirical evidence to support this hypothesis, a search was conducted in the SCOPUS and Web of Science databases in May 2023 using the descriptors "Water footprint" AND "Income." The search was limited to articles published from 2012 to May 2023. The methodology for calculating WF was published in a manual in 2011 (HOEKSTRA et al., 2011) and was disclosed by WFN with the aim of promoting the application of WF, sharing results and contributing to the conscious use of water.

The search in the SCOPUS and Web of Science databases resulted in a selection of 105 articles and 116 articles, respectively. With the aid of the R software and the bibliometrix program (ARIA; CUCCURULLO, 2017), the selected results were gathered and duplicated articles were excluded. The final sample consisted of 144 articles (Figure 1).

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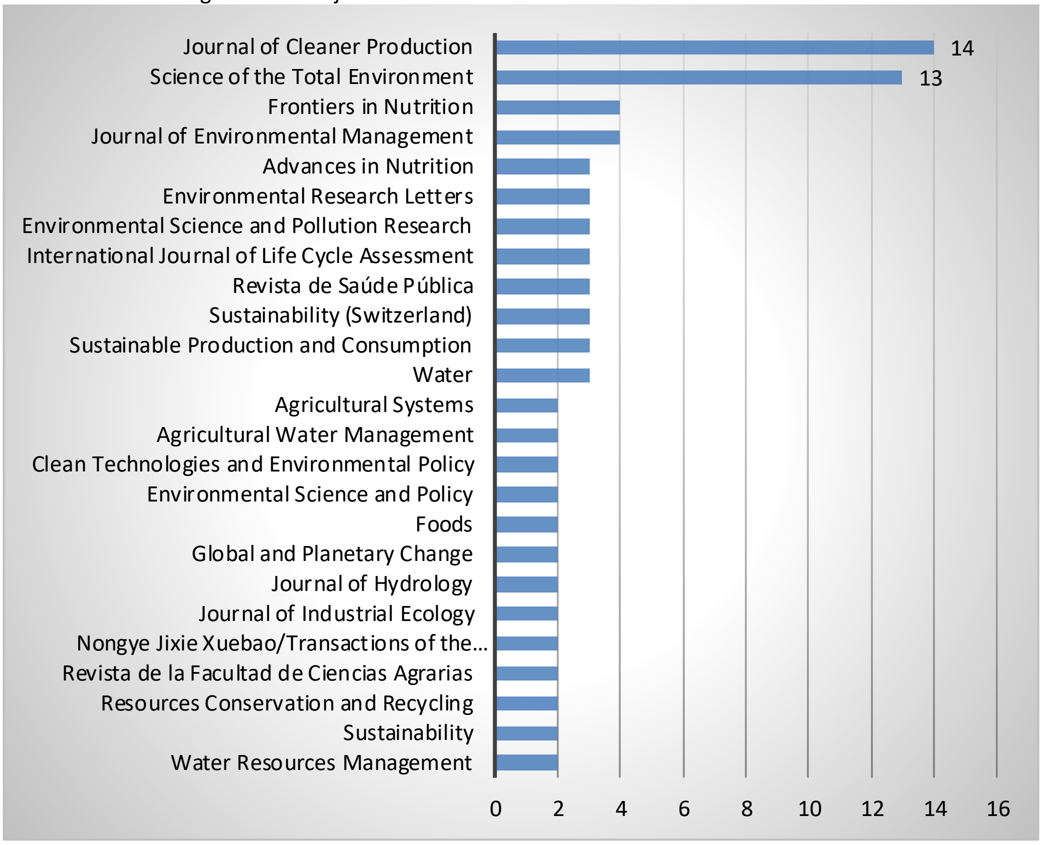
Figure 1 - Main journals found in the selected databases



Source: Elaborated by the authors.

The selected articles were published in 85 journals, with the journals Journal of Cleaner Production and Frontiers in Nutrition being jointly responsible for over 18% of the publications (Table 1). The 25 journals at the Figure 1 published 59% of the articles, while the remaining 59 journals published only one article on the subject during this period.

Table 1 - Main research institutions of the authors of the sample

Research Institute	Frequency
London School of Hygiene and Tropical Medicine	22
China Agricultural University	19
Icar-Central Soil Salinity Research Institute	12
Icar-Indian Agricultural Research Institute (Iari)	9
Johns Hopkins University	9
Federal University of Rio Grande do Norte	**7**
International Livestock Research Institute (Ilri)	7
Texas Aandm University	7
University of São Paulo	**7**
Federal University of Campina Grande	**7**
Federal University of Rio de Janeiro	**7**
University of Maryland	7
Other Institutions	24
Total	**144**

Source: Elaborated by the authors.

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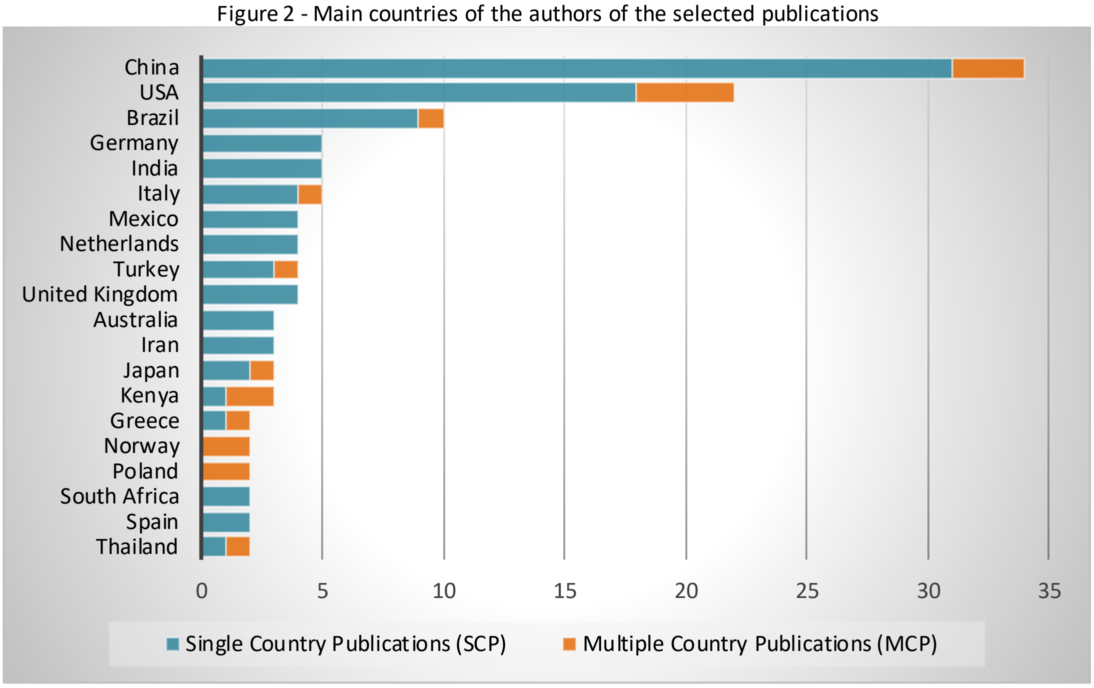
At the Table 1, the presence of four Brazilian universities can be observed. Figure 2 highlights the countries of origin for the authors of the selected publications.

Figure 2 - Main countries of the authors of the selected publications



Source: Elaborated by the authors.

Figure 2 shows a significant concentration of authors from China, followed by the United States, and a clear prevalence of single country publications, except for Norway and Poland.

Figure 3 highlights the thematic clustering within the selected sample. The link between Water Footprint, Income and Consumption is a theme with an above-average relevance level, while its development is within average (blue cluster).

The groupings described at the Figure 3 confirm the importance of discussing WF along with income.

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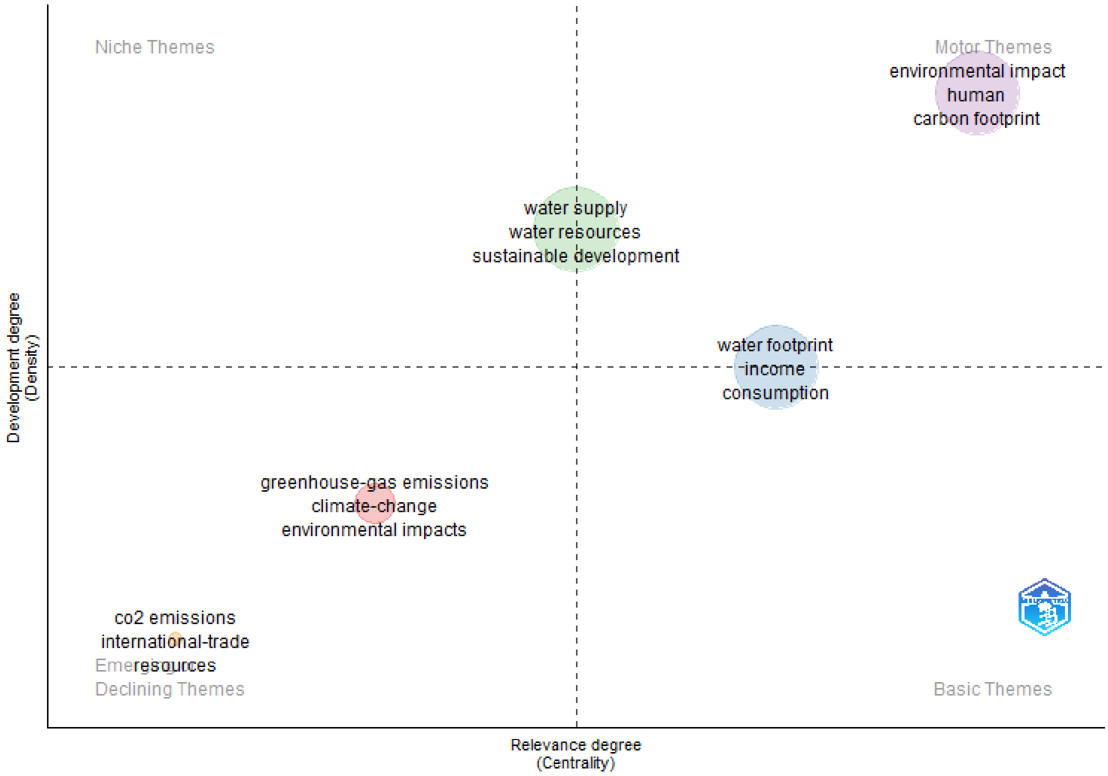
Figure 3 - Clusters of themes found in the selected sample



Source: Elaborated by the authors.

Considering only the Brazilian context, the abstract search resulted in a selection of twelve articles. However, after a thorough reading of the texts, eight of them were excluded for dealing with the topic of Water Footprint and income but with an emphasis on productive activities.

The study by Hatjiathanassiadou et al. (2022) analyzed the Water Footprint (WF), Carbon Footprint, and Ecological Footprint of Natal residents through a questionnaire applied to 411 adults and seniors. The results revealed that male, adult participants from higher income groups had the highest WF. One of the explanations provided by the researchers for these results is related to the economic difficulties faced by families. These difficulties may limit the ability to acquire more expensive foods, such as beef, which has a higher environmental footprint. Additionally, frequent consumption of meals outside the home, which is also associated with a higher WF, may be affected by financial constraints. The authors concluded that the diet with the lowest environmental impact is not necessarily the most sustainable, as they observed that the lowest impact was associated with the diet of inhabitants with worse socioeconomic conditions. In other words, the authors emphasized that access to a quality diet may increase the consumption of meat and other animal products, resulting in a higher environmental impact. This means that as socioeconomic conditions improve and people have more resources available, they may have access to a greater variety of foods, including animal products, the production of which usually has a significant environmental footprint.

This statement is based on the common association between a high-quality diet and the consumption of animal protein. However, other studies, such as the one by França et al.

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(2022), demonstrate that it is possible to have a high-quality diet based on plant-based protein. In a study with 91 adolescent athletes from Rio de Janeiro, França et al. (2022) identified that the greatest impact, measured by the Water Footprint (WF), is associated with the diet of male adolescents from middle-income families. The authors established five classes of family income, measured in minimum wages, and observed that the association between income levels and environmental footprints is not linear. Specifically, the environmental footprint increases as income levels increase up to the middle class, decreases in the upper-middle class, and then increases again in the highest income class.

The complex relationship between income and the environmental impact of consumption habits guided the study conducted by Garzillo et al. (2022), where they developed a linear regression model to estimate the relationship between the amount of meat consumed and various explanatory variables, such as gender, age, education, per capita family income, region, and area of residence. The results obtained by the authors provided empirical evidence that beef consumption increases with income, especially in the Midwest regions and urban areas, where the WF associated with meat consumption is higher.

In the study conducted by Silva et al. (2022), a survey was conducted with 625 inhabitants of the Agreste region of Pernambuco. The aim was to estimate the water footprint associated with food, domestic use, and industrial use, and to discuss the relationship between the water footprint and the Human Development Index (HDI). Through regression analysis between the water footprint and income, the researchers found a relatively low correlation ($R^2 = 0.228$ and $R = 0.472$). One of the main conclusions of the study is that the water footprint decreases with dietary habits, especially with the reduction of beef consumption.

Silva et al. (2013) evaluated, through a case study, the Water Footprint of vegetarian and non-vegetarian consumers in the municipality of Caicó, Rio Grande do Norte, in 2011. The objective was to compare the Water Footprints between the two groups, considering different levels of family income. Nine groups of ten people with different dietary habits were evaluated, according to levels of meat consumption. The main results of the study indicated that the Water Footprint of vegetarians was 58% of that of non-vegetarian consumers. Furthermore, the authors found that the water footprint increased with family income due to the virtual water content in the products and services consumed. Non-vegetarian consumers with higher income had a water footprint three times higher compared to those with a maximum income of one minimum wage.

Beux (2014) assessed the Water Footprint in the subnormal agglomeration of the Rocinha neighborhood in the city of Rio de Janeiro in 2013. The research was carried out through a random sample of residents using interviews and questionnaires. The author estimated an average water consumption of 1,715 m³ per year per capita. The results showed that individuals in the sample with higher expenses had a higher industrial Water Footprint (related to the goods consumed) and total Water Footprint (including industrial, food, and domestic water footprints). In addition, the author found that domestic water consumption in the sample of Rocinha consumers was approximately three times higher than the average water footprint of low-income consumers found in the literature on the subject. This result allowed identifying a water wasteful behavior, although the Water Footprint of this sample was lower than the Brazilian average of 2,027 m³ per year per capita.

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The study conducted by Utikava (2016) presents the estimation of food consumption patterns and their water footprints based on the Household Budget Survey (Pesquisas de Orçamentos Familiares - POF) carried out by the Brazilian Institute of Geography and Statistics (IBGE) in the years 2002-2003 and 2008-2009. Applying statistical methods such as factorial analysis and multiple linear regression, the author identified food patterns characterized by protein consumption levels and estimated the corresponding Water Footprints. A dietary pattern that included red and processed meats was associated with a water footprint three times higher compared to fish and vegetable-based dietary patterns. The study also pointed out a relationship between the increase in the Water Footprint and the increase in family income.

4 METHODOLOGY

This research is applied with a quantitative approach, using statistical techniques such as Factorial Analysis, to identify food consumption patterns and their relationship with per capita income in Brazilian Federal Units.

To describe the food consumption pattern, the quantities of food purchased for home consumption were used, detailed in the microdata of the latest POF (IBGE, 2022).

The selected food groups compatibilize the POF information with the information from the Water Footprint Statistics (WaterStat) database to estimate the amounts of green, blue, and gray water per kilogram of acquired product and, finally, estimate the water footprint of food consumption.

Graph 1 illustrates the total Water Footprint, in ascending order, of the selected food groups. Among the foods with the highest total Water Footprint are red meats, especially processed and non-processed beef, which reach about 30,000 and 20,000 liters per kilogram, respectively, and cocoa, which has the highest Water Footprint among all surveyed foods, reaching about 31,000 liters per kilogram. However, potatoes have the lowest Water Footprint, approximately 256 liters per kilogram.

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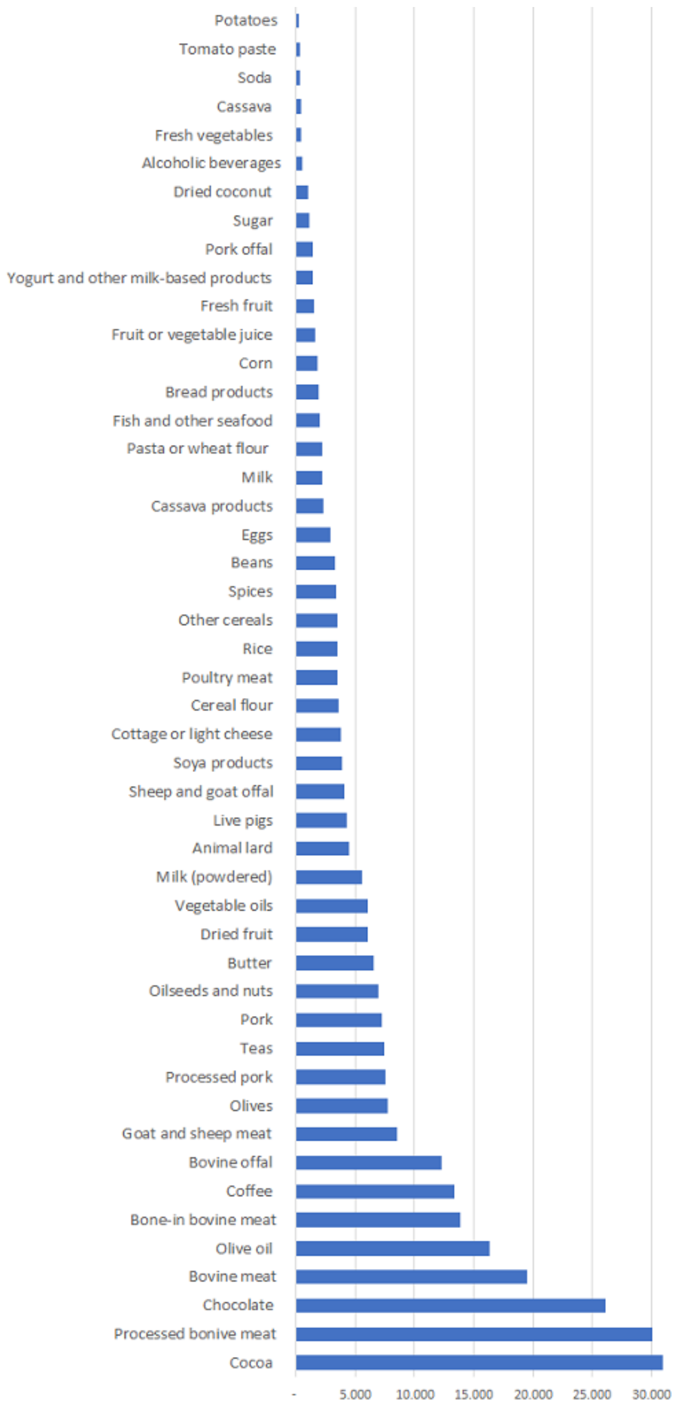
Graph 1 - Total Water Footprint of selected food groups



Source: Elaborated by the authors.

The products for which Water Footprints were identified in the WaterStat database totaled 6,935 (83%) items, while 1,062 (13%) had no Water Footprints available in the mentioned database. The food products cataloged in the POF were grouped according to similarities in their characteristics, forming the 24 food groups described in Table 2.

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Table 2 - Formation of food groups

Food Groups	Main Products
Sugar	Variety of sugars including natural, refined, cane molasses and others.
Rice	All types of rice, including husked rice, paddy rice and rice grits.
Alcoholic beverages	Alcoholic beverages in general, including beers and wines.
Cocoa and derivatives	Cocoa (fruit), cocoa paste, chocolates, chocolate-based products and derivatives.
Coffee and teas	All varieties of coffees and teas.
Bovine meat	All types of bovine meat, including fresh meat, bone-in and boneless, processed and offal.
Poultry meat	Meats of different poultry species, including fresh, processed and offal.
Spices and condiments	Variety of spices and condiments, including shoyo, ketchup, tomato paste and extract and all types of seasoning.
Beans	All types of beans.
Fruits	Fresh and dried fruits.
Fats	Vegetable and animal fats, comprising different types of vegetable oils, including olive oil, as well as animal lard and butter.
Vegetables and leguminous	A wide variety of vegetables and leguminous, including soybeans and derivatives.
Dairy products	Milk, milk powder, cheese, yogurt and other milk-based products.
Corn and derivatives	Corn, corn flour, corn starch, corn gum and other derivatives.
Other red meat	Pork, goats and sheep meat, including fresh, boneless and processed meat, offal and live animals.
Other cereals and derivatives	A variety of cereals, including oats, barley, rye, flours and derivatives.
Eggs	Chicken, duck, turkey, quail and other eggs.
Bakery products	All varieties of breads.
Seafood	Fish, shrimp, squid, octopus, crab, shellfish and other seafood.
Soft drinks	All types of soft drinks, including light and diet, flavored waters, mixed drinks and their variations.
Oilseeds and coconuts	Coconut and dried coconut, all types of seeds and oilseeds, including peanuts, sesame, linseed and nuts.
Juices	Juices of all kinds of fruits and vegetables, natural or industrialized.
Wheat and derivatives	Wheat flour and all varieties of pasta.
Tubers, roots and derivatives	Variety of potatoes, sweet potatoes and cassava, including starches and derivatives.

Source: Elaborated by the authors.

5 RESULTS

Using the Statistical Package for the Social Sciences (SPSS), product clusters that share common variance, resulting in food patterns based on strongly correlated factors, were identified. The selected sample was evaluated using the Kaiser-Meyer-Olkin test - KMO (value 0.803) and Bartlett's sphericity test (p-value close to zero). Both tests confirm that the sample is suitable for analysis using Factorial Analysis (FÁVERO; BELFIORE, 2017).

Six factors that explain 46.3% of the total sample variance were selected. The selected factors define the following food profiles (or Food Patterns - FP) with their respective explanatory share of the total sample variance:

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• FP1 - Typical Brazilian food pattern without animal protein. It includes sugar, rice, coffee and teas, spices and condiments, beans, fats, corn and derivatives, and wheat and derivatives (responsible for explaining 13.6% of the total variance).
• FP2 - With two foods, alcoholic beverages, and other cereals (8.2%).
• FP3 - Food pattern predominantly associated with the consumption of fruits and vegetables (7%).
• FP4 - Food pattern that includes all types of meat (6.35%).
• FP5 - Food pattern that includes bread, milk, cocoa and derivatives, and juices (5.7%).
• FP6 - Food pattern characterized by the consumption of fish (5.3%).

Based on the study conducted by Lares-Michel et al. (2022), the calculation of the top three deciles, corresponding to the 30% with the highest adherence to the food patterns (FP-30), was used.

According to data from the 2017-2018 POF, the average per capita income in Brazil was R$ 2,238 (IBGE, 2021). Table 3 presents the food pattern associated with the average per capita income.

Table 3 - Frequency of incomes

Food Patterns	Income per capita (R$)	Income above brazilian per capita average (%)
FP1-30	2.273	1,6
FP2-30	2.365	5,7
FP3-30	3.119	39,4
FP4-30	2.606	16,4
FP5-30	3.130	39,9
FP6-30	2.433	8,7

Source: Elaborated by the authors.

It can be observed that FP5-30 is associated with the highest average per capita income, almost 40% higher than the national average. A similar result is observed for FP3-30, which is the food pattern with the highest content of fruits and vegetables, while the lowest income is associated with FP1-30, which is the typical Brazilian food pattern without animal protein.

Canuto et al. (2019) and Costa et al. (2021) observed a higher frequency of traditional food patterns similar to FP1 among people with lower purchasing power. Canuto et al. (2019) emphasize that food patterns similar to FP5, with higher frequency of consumption of bakery goods and dairy products, are commonly found among people with higher income.

In this research, fish consumption (FP6) was found to be more frequent among people with incomes close to the average per capita, while Costa et al. (2021) observed a more frequent consumption of a similar food pattern (with a focus on fish) in populations with lower income.

Table 4 presents the average per capita incomes for each Brazilian Federal Unit, based on data available in the 2017-2018 POF. Each row identifies the highest and lowest consumption frequency of food patterns in the Federal Units (FUs).

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Table 4 - Relationship between per capita incomes and food patterns, by Brazilian Federal Units (FUs)

FU	Income per capita (R$)	FP1-30	FP2-30	FP3-30	FP4-30	FP5-30	FP6-30
DF	4.291,71	23,0	37,7	32,1	24,6	32,8	29,1
SP	2.917,54	27,6	30,1	33,2	31,4	39,9	21,5
RS	2.715,19	32,7	30,6	33,0	37,3	40,7	22,5
RJ	2.417,71	31,7	29,5	26,1	28,1	32,6	21,6
SC	2.375,57	32,7	32,5	36,9	33,4	45,9	27,1
MS	2.285,60	28,5	35,3	28,2	35,4	26,4	22,9
PR	2.212,16	30,9	36,6	29,6	31,7	38,0	19,9
MT	2.073,50	28,1	39,7	26,3	29,9	26,2	23,0
ES	2.022,51	26,0	32,0	23,0	23,5	25,9	19,4
MG	2.000,66	28,9	28,3	31,6	27,6	34,6	21,7
GO	1.936,21	29,8	33,2	32,4	31,7	23,9	24,8
AC	1.634,28	24,7	29,4	20,1	32,0	17,4	50,8
SE	1.629,72	26,4	23,5	41,4	33,9	16,9	52,7
RR	1.494,96	40,9	30,4	19,2	27,4	13,5	37,5
RO	1.485,85	33,2	36,2	20,0	27,9	21,0	31,0
BA	1.478,88	29,8	25,0	33,3	28,9	20,3	39,8
RN	1.457,81	33,6	28,6	32,2	27,3	20,6	42,2
PI	1.417,90	41,1	34,8	30,4	28,0	10,1	49,7
PE	1.378,73	27,4	25,6	33,0	25,6	21,5	38,4
AP	1.361,70	33,3	18,0	22,0	42,8	35,6	79,0
AM	1.294,09	26,3	18,8	18,4	37,7	17,9	57,7
PB	1.287,26	27,6	22,8	26,6	24,7	20,0	38,3
CE	1.246,80	31,5	21,0	24,3	25,0	19,5	37,5
TO	1.233,77	36,5	58,7	12,7	21,9	7,6	26,0
AL	1.085,11	29,2	32,8	28,5	24,3	12,5	39,5
MA	1.013,71	41,8	42,0	20,2	27,1	7,1	55,0
PA	1.005,95	29,3	30,5	18,5	35,7	17,7	63,6

Legend:
- Highest frequency in each FU
- Second highest frequency in each FU
- Lowest frequency in each FU

Source: Elaborated by the authors.

The analysis of Table 4 reveals that most Federal Units with per capita incomes higher than the average of R$ 2,238 share the lowest frequency of the food pattern characterized by fish consumption (FP6-30) and the highest frequency of FP5-30. On the other hand, FP1-30 is more frequent among FUs with per capita incomes below the national average. It is interesting to observe that the Federal District, which has the highest per capita income, stands out for the lowest frequency of FP1-30, while presenting a higher frequency of FP2-30 and FP5-30.

When estimating the Water Footprints of the main food patterns, it was found that FP4, characterized by a higher presence of meat in the diet, has the highest water footprint, followed by FP1, which represents the typical Brazilian food pattern without animal protein. On the other hand, the food patterns FP2, characterized by the presence of cereals and alcoholic beverages, and FP6, with a prevalence of fish consumption, stand out for presenting the lowest water footprints. These results are in line with the study conducted by Utikava (2016), which also identified similar patterns regarding the Water Footprints of different food patterns.

6 CONCLUSION

The relationship between food patterns, family income, and water footprint contributes to the discussion of the environmental impacts associated with food consumption and, consequently, to the discussion of sustainable consumption aligned with SDG 12.

Food patterns with elevated consumption of animal protein tend to have larger water footprints, due to the high water requirement in meat production. Therefore, it is common to find a correlation between higher family income and higher water footprints, as animal protein consumption tends to be higher in groups with higher purchasing power. Recommendations to reduce beef consumption can contribute to the mitigation of climate impacts in the country, although Brazil is the main supplier of beef in the international market.

The relationship between food patterns, family income, and water footprint is quite complex as it is influenced by regional and cultural differences. Additionally, other factors such as access to food, individual preferences, water resource availability, and agricultural production practices may contribute to explaining the observed differences.

In summary, estimating the Water Footprints of the food patterns of the Brazilian population contributes to the analysis of the complex relationship between food consumption, family income, and water resource use. This analysis helps to understand the environmental impacts associated with different consumption patterns and can support the development of strategies and policies aimed at guiding more sustainable consumption decisions.

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BIBLIOGRAPHIC REFERENCES

ARIA, M.; CUCCURULLO, C. bibliometrix: An R-tool for comprehensive science mapping analysis. **Journal of Informetrics**, v. 11, n. 4, p. 959-975, 2017. DOI: 10.1016/j.joi.2017.08.007

BARBOSA, A. M. **Padrões de consumo alimentar, pegada hídrica e sustentabilidade**. 2023, 90p. Dissertação (Mestrado em Sustentabilidade) - Pontifícia Universidade Católica de Campinas, Campinas, 2023.

BEUX, F. **Pegada hídrica de aglomerados subnormais:** o caso do Bairro Rocinha / Rio de Janeiro 2014. 131p. Dissertação (Mestrado) - Centro de Ciências e Tecnologia - Faculdade de Engenharia, Universidade Estadual do Rio de Janeiro Rio de Janeiro, 2014.

CANUTO, R.; FANTON, M.; LIRA, P. I. C. Iniquidades sociais no consumo alimentar no Brasil: uma revisão crítica dos inquéritos nacionais. **Ciência & Saúde Coletiva**, v. 24, n. 9, p. 3193-3212, 2019. DOI: 10.1590/1413-81232018249.26202017

ISSN 1980-0827 – Volume 20, Number 1, Year 2024

COSTA, D. V. P.; LOPES, M. S.; MENDONÇA, R. D.; MALTA, D. C.; FREITAS, P. P.; LOPES, A. C. S. Diferenças no consumo alimentar nas áreas urbanas e rurais do Brasil: Pesquisa Nacional de Saúde. **Ciência & Saúde Coletiva**, v. 26 (Supl. 2), p. 3805-3813, 2021. DOI: 10.1590/1413-81232021269.2.26752019

FÁVERO, L. P.; BELFIORE, P. **Manual de análise de dados**: Estatística e modelagem multivariada com Excel, SPSS e Stata. 1 ed. Rio de Janeiro: Elsevier, 2017.

FRANÇA, P. A. P.; LIMA, C.K. A. Z. G.; OLIVEIRA, T. M. de; FERREIRA, T. J.; SILVA, R. R. M. da; LOUREIRO, L. L.; PIERUCCI, A. P. T. R. Effectiveness of current protein recommendations in adolescente athletes on a low-carbon diet. **Frontiers in Nutrition,** p. 1-12, 2022. DOI 10.3389/fnut.2022.1016409

GARZILLO, J. M. F.; POLI, V. F. S.; LEITE, F. H. M.; STEELE, E. M.; MACHADO, P. P.; LOUZADAI, M. L. C.; LEVY, R. B.; MONTEIRO, C. A. Ultra-processed food intake and diet carbon and water footprints: a national study in Brazil. **Revista de Saúde Pública**, v. 56, n. 6, p. 1-9, 202. https://www.revistas.usp.br/rsp/article/view/195089

HATJIATHANASSIADOU, M.; SOUZA, C.V.S. de; VALE, D.; DANTAS, N.M.; BATISTA, Y.B.; MARCHIONI, D.M.L.; LIMA, S.C.V.C.; LYRA, C. de O.; ROLIM, P.M.; SEABRA, L.M.J. Dietary Environmental Footprints and Their Associationwith Socioeconomic Factors and Food Purchase Practices: BRAZUCA Natal Study. **Foods,** v. 11, p. 1-20, 2022. DOI:10.3390/foods11233842

HOEKSTRA, A. Y.; HUNG, P. Q. Virtual water trade: a quantification of virtual water flows between nations in relation to international crop trade. **Value of Water Research Report Series**, n. 11, IHE Delft Institute for Water Education, 2002. Available at: <https://ihedelftrepository.contentdm.oclc.org/digital/collection/p21063coll3/id/10327/>. Access: 05 nov. 2022.

HOEKSTRA, A.Y.; CHAPAGAIN, A. K.; ALDAYA, M. M.; MEKONNEN, M. M. **The Water Footprint Assessment Manual**. Londres: Earthscan, 2011.

IBGE. Instituto Brasileiro de Geografia e Estatística. **POF** - Pesquisa de Orçamentos Familiares. Available at:: <https://www.ibge.gov.br/estatisticas/sociais/populacao/24786-pesquisa-de-orcamentos-familiares-2.html?=&t=o-que-e>. Access: 03 jan. 2022.

JACOBI, P. R.; GRANDISOLI, E. **Água e Sustentabilidade:** desafios, perspectivas e soluções. São Paulo: IEE-USP e Reconectta, 2017.

JACKSON, T.; MICHAELIS, L. **Policies for Sustainable Consumption**: A Report to the Sustainable Development Commission. Londres: Environmental Change Institute Oxford University, 2003.

LARES-MICHEL, M.; HOUSNI, F. E.; Cervantes V. G. A.; REYES-CASTILLO, Z.; NAVA, R. M. M.; CAÑEDO, C. L.; LARIOS, M. J. L. The water footprint and nutritional implications of diet change in Mexico: a principal component analysis. **European Journal of Nutrition**, v. 61, p. 3201–3226, 2022. DOI: 10.1007/s00394-022-02878-z

SILVA, V. P. R. da; MARACAJÁ, K. F. B.; ARAÚJO, L. E. de; DANTAS NETO, J.; ALEIXO, D. O.; CAMPOS, J. H. B. C. Pegada hídrica de indivíduos com diferentes hábitos alimentares. **Revista Ambiente & Água,** v. 8, n. 1, p. 250–262, 2013. http://dx.doi.org/10.4136/ambi-agua.967.

SILVA, M. C. O.; SILVA, M. M da; SANTOS, S. M.; BEZERRA, S. T. M.; SILVA, G. L. da; GONÇALVES, E. A.P. Estudo da Pegada Hídrica Populacional em Região Semiárida. **Revista Brasileira de Geografia Física**, v.15, n. 1, p. 297-311, 2022.

UTIKAVA, N. **Evolução da associação entre padrões alimentares brasileiros e pegada hídrica na primeira década do século XXI**. 2006, 133p. Dissertação (Mestrado) – Faculdade de Saúde Pública, Universidade de São Paulo, São Paulo, 2016.

WFN. Water Footprint Network. **Personal Water Footprint Calculator, Personal calculator - extended**. Available at: <https://waterfootprint.org/en/resources/interactive-tools/personal-water-footprint-calculator/personal-calculator-extended/>. Access: 06 jun. 2021.