Journal of Scientific Research & Reports

18(1): 1-12, 2018; Article no.JSRR.39250
ISSN: 2320-0227

Virtual Water Consumption: A Case Study in a Higher Education Institution in Northeast Brazil

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Authors' contributions

This work was carried out with the collaboration of all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JSRR/2018/39250
Editor(s):
(1) Grigorios L. Kyriakopoulos, School of Electrical and Computer Engineering, National Technical University of Athens (NTUA), Greece.
Reviewers:
(1) Ahmed Karmaoui, Morocco.
(2) Francis K. Attiogbe, University of Energy and Natural Resources, Ghana.
(3) Dal Singh Kharat, India.
Complete Peer review History: http://www.sciencedomain.org/review-history/23196

Original Research Article

Received 7th November 2017
Accepted 16th January 2018
Published 15th February 2018

ABSTRACT

Water limitation has driven punctual global actions in search of efficient management strategies, to calculate the sustainability indices, as the water footprints can guide these efforts. With the aim of estimating the water footprint of the academic community of the Rural Health and Technology

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Center of the Federal University of Campina Grande, an exploratory study was carried out with sample groups of undergraduate and graduate courses of the unit. The exploratory research consisted of the application of questionnaires, the answers being processed in the calculator of the water footprint. The water footprint of the studied academic community is below the Brazilian average and higher than the global average, except for the degree course of the Masters in Veterinary Medicine, where the water footprint exceeded the national average. It was possible to reduce the twelve original variables into three latent variables, evidencing that the use of multivariate statistics was efficient in analysing the data of the water footprint.

Keywords: Water demand; index of sustainability; multivariate statistics; environment.

1. INTRODUCTION

Water scarcity has increasingly limited the use of natural resource water, reflecting negatively on economic development and the quality of life of civilisations [1]. This scenario makes evident the need to map the habits of individuals and establish the relationship between these habits and water consumption, notably to subsidise the development and implementation of popular awareness programs and multiplier agents, as well as find strategies for management and rational use of water [2].

The diagnosis of water consumption and the indices that compose this consumption can be estimated to guide the decision making in the establishment of strategic plans to reduce consumption. In this context [3] mention that water footprint (WF) assessment is an analytical tool that can assist in understanding how activities and products interact with water scarcity and pollution and their related impacts, as also in comprehending what can be done to ensure that activities and products contribute to the sustainable use of water resources.

The WF concept was demonstrated by the academic community in the year 2002 at an international meeting on virtual water trade [1]. Since then, there has been a significant quantitative increase in literature on the scarcity and virtual commerce of water (H_2O), denoting methodological advances regarding the definition of the methods of analysis of the WF, its accounting, evaluation of its sustainability, and formulation of answers to the questions raised about the theme [4,5,6,7].

The volume of fresh water used to obtain a specific product is given by the sum of the consumptions along the various phases of its production chain, which is the basis for understanding the concept of a water footprint [8]. In a complementary sense, the water footprint of an individual covers the water used in the home for cooking, personal hygiene, and washing of clothes, besides the virtual water contained in the products consumed.

Diagnosing the water footprint of people in academic environments can generate preponderant indicators for the massification of educational actions, with a high success rate, especially as this public is potentially a multiplier of relevant information about the subject. However, it is worth observing that the data generated from the subjectivity of the people who are part of the sample groups may present high dispersion and invalidate the statistical analysis method used to analyse these data, making it necessary to search for techniques that best describe the subjective data [9].

Taking into consideration the need for statistical solutions to better represent the data obtained in scientific research, it is postulated that use of the Principal Component Analysis (PCA) is efficient for data analysis, making the explanation of the studied phenomenon more unaffected [10]. In a complementary sense, cluster analysis (Cluster Analysis) assists in the visualization and interpretation of the results from the group structure [11]. These techniques have been applied successfully in qualitative research to establish the public opinion [12,13], seasonality of the agro-industrial crop production [14], and to discuss the best techniques of data analysis [15].

Thus, the aim of this study is to estimate the water footprint of the academic community of the Center for Health and Rural Technology of the Federal University of Campina Grande, aiming to establish the relationship between the values obtained in the global and Brazilian water footprint averages and to verify the need for educational actions with the sample groups that make up this community. The use of multivariate statistics is efficient to analyze the water footprint data obtained from sample groups.

2. MATERIALS AND METHODS

The study was carried out between April 26 and April 29, 2016, at the UFCG Rural Health and Technology Center (CSTR), located in the municipality of Patos - PB, in the Sertão mesoregion of Paraíba state, in the Caatinga biome. The municipality has a population of 106,314 in habitants, with a territorial area of 473,056 km^2. The local economy is based on agriculture, with emphasis on the cultivation of cotton and beans [16].

The exploratory research [17] consisted of the application of 140 questionnaires with structured questions to estimate the water footprint, according to a methodology adapted from [18]. Seven sample groups were evaluated, represented by undergraduate courses (Biological Sciences, Forest Engineering, Veterinary Medicine, and Dentistry) and postgraduate courses (MSc in Forest Sciences, MSc in Animal Science, and MSc in Veterinary Medicine), from CSTR. Each group had a sample size of n = 20. The variables considered in this study were represented by the components of the total water footprint (WF Tot), fractionated in domestic water footprint (WF Dom), industrial (WF Ind), and food (WF Food) — the latter being fractionated into cereal water footprint (WF Cer), meat (WF Mea), vegetables (WF Veg), fruits (WF Fru), dairy products (WF Dpr), beverages (WF Bev), fats (WF Fat), Sugars (WF Sug), eggs (WF Egg), and others (WF Oth).

The questionnaire responses were processed in the extended personal water footprint calculator [19]. The data obtained, after the processing, were submitted to analysis of variance by the F test at 5% probability and the means of the sample groups were compared by the Tukey multiple comparisons test, using the Computational System of statistical analysis [20].

In order to facilitate the explanation and visualization of results in a multivariate perspective, the data were submitted to standardization, to achieve the mean zero and unit variance. The multivariate structure of the results was evaluated by the principal component analysis (PCA) to condense the amount of relevant information contained in the original dataset into a smaller number of dimensions (main components) resulting from linear combinations of the original variables generated from the highest eigen values in the covariance matrix. For each main component (PC), a cluster analysis was performed using the hierarchical method, Ward's minimum variance, considering the relevant variables in the composition of each main component [21].

3. RESULTS AND DISCUSSION

Based on the results of the analysis of variance, it was possible to verify that there was a significant difference ($p < 0,01$) between the groups sampled, in relation to the total and food water footprints, while the domestic and industrial water footprints did not differ significantly ($p > 0,05$) as a function of the sample groups (Table 1).

Among the sample groups, it was verified that the academic community of the Masters degree in Veterinary Medicine (MVM) had a total water and food footprint superior to the community of the other courses that did not express divergent WF values among themselves. Percentage differences of 46% and 52% were calculated between the means of WF obtained in the MVM group and the average of the other courses for the total footprints and the food water footprints, respectively. Based on the values reported in literature, it was observed that all sample groups had mean values of WF higher than the global average of 1,240 m^3 hab^{-1} $year^{-1}$ [22] and lower than the Brazilian average of 2,027 m^3 hab^{-1} $year^{-1}$ [23] (Fig. 1A and Fig. 1B).

Table 1. Summary of analysis of variance for the components of the total water footprint (WF Tot), food (WF Food), domestic (WF Dom), and industrial (WF Ind) academic community of the UFCG Rural Health and Technology Center. Patos - PB, Brazil, 2016

Sources of variation	GL	Average squares			
		WF Tot	WF Food	WF Dom	WF Ind
Groups	6	5861456.39**	5320372.69**	41148.84^{ns}	9278.82^{ns}
Residue	133	1327648.70	1219848.85	28179.29	5006.48
CV (%)		62.70	76.32	52.21	110.15

***, ns: Significant at 1% and not significant by the F test; GL: Degrees of freedom; CV: Coefficient of variation*

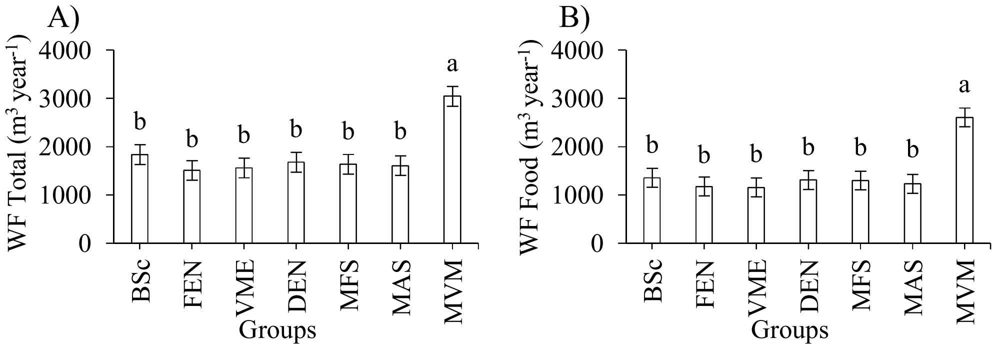

Fig. 1. Total water footprint (WF Tototal) (A) and food (WF Food) (B) of the academic community of the UFCG Rural Health and Technology Center. Patos - PB, Brazil, 2016. BSc: Biological Sciences; FEN: Forest Engineering; VME: Veterinary Medicine; DEN: Dentistry; MFS: Master's in Forest Sciences; MAS: Master's in Animal Science; MVM: Master's in Veterinary Medicine; BA: Brazilian average (2,027 m^3 hab^{-1} $year^{-1}$); GA: global average (1,240 m^3 hab^{-1} $year^{-1}$)

Source: Elaboration of the authors

Based on the results, the dietary habits of the academic community of the Master's Program in Veterinary Medicine can be inferred, as the most expressive values of WF were verified in relation to food, disaggregating the sample group (MAS) of the others. The results of this survey are of fundamental importance for making decisions about educational actions on the conscious consumption of water, especially because freshwater is one of the most valuable resources on the planet that cannot be replaced, being a vital element of sustaining life, even though it has increasingly become a scarce resource [24].

Thus, the separation of the WF profiles studied in this research may be preponderant for specific actions among the sample groups, as this sustainability indicator suggests the possibility that humanity demands for resources greater than the planet can provide in a sustainable manner. Such overconsumption tends to increase significantly due to rapid economic expansion as well as urbanization, migration, lifestyle changes, and other major social transitions in the world [8].

After decomposing the water footprint of its components, a significant difference was observed between the sample groups for the water footprints of meats, vegetables, fruits, fats, sugars and others, as summarized in the analysis of variance presented in Table 2.

Table 2. Summary of analysis of variance for the components of the water footprint decomposed in the water footprint of cereals (WF Cer), meats (WF Mea), vegetables (WF Veg), fruits (WF Fru), dairy products (WF DPr), beverages (WF Bev), fats (WF Fat), sugars (WF Sug), eggs (WF Egg), and others (WF Oth) from the academic community of the UFCG Rural Health and Technology Center. Patos - PB, Brazil, 2016

Sources of variation	**GL**	**Average squares**				
		WF Cer	**WF Mea**	**WF Veg**	**WF Fru**	**WF DPr**
Groups	6	26596.14^{ns}	3227521.41**	2487.79*	7114.36**	10074.02^{ns}
Residue	133	43898.45	606971.17	863.41	2315.18	8227.21
CV (%)		90.65	103.59	159.32	103.89	120.63
		WF Bev	**WF Fat**	**WF Sug**	**WF Egg**	**WF Oth**
Groups	6	3693.62^{ns}	0.49*	12.44**	588.37^{ns}	82196.40**
Residue	133	11377.74	0.22	3.63	2156.70	17159.34
CV (%)		101.48	123.54	51.85	96.56	88.09

***, *, ns: Significant at 1% and 5% and not significant by the F test; GL: Degrees of freedom; CV: Coefficient of variation*

The most significant value of the water footprint of the meat component (1654.65 m^3 $year^{-1}$) was verified in the sample group of the Veterinary Medicine Masters degree, while the other groups did not differ, with an overall mean of 601.65 m^3 $year^{-1}$ being calculated to represent these groups (Fig. 2A).

The course of Dentistry had a higher water footprint of vegetables (38.3m^3 $year^{-1}$), while courses for Forest Engineering, Veterinary Medicine, and Master's in Animal Science showed lower values of 7.65 m^3 $year^{-1}$, 9.85 m^3 $year^{-1}$, and 10.35 m^3 $year^{-1}$, respectively, for this variable (Fig. 2B).

For the water footprint of fruits, the Master's courses in Forestry Sciences and Veterinary Medicine obtained higher values, (70.65 m^3 $year^{-1}$) and (69.10 m^3 $year^{-1}$), respectively, differing from the Forestry Engineering course that obtained the lowest value (22.15 m^3 $year^{-1}$) of WF (Fig. 2C).

Although the results of the analysis of variance detected differences between sample groups for the water footprint of fats, no difference was detected between these groups when the mean comparison test was applied. Nevertheless, the Master's degree in Forest Sciences expressed slightly higher values than the other courses (Fig. 2D).

Increased consumption of water related to sugars was revealed in the Master's Degree Programs in Forestry Sciences and Veterinary Medicine, with WF values of 4.3 m^3 $year^{-1}$ and 4.6 m^3 $year^{-1}$, respectively, with differences of 46.5% and 50% in relation to the undergraduate course in Veterinary Medicine, where the lowest value (2.3 m^3 $year^{-1}$) of WF was found (Fig. 2E).

For other components of the food-water footprint, it was verified that the Master's degree in Veterinary Medicine obtained the expressive value of 291.9 m^3 $year^{-1}$, differing from other courses that, on an average, had a WF of 124.84 m^3 $year^{-1}$ (Fig. 2F).

Fractioning the food-water footprint into its components seems to be a promising strategy for understanding the share of each fraction in the total of this WF. In fact, animal production and the generation of products derived from it can be considered an excellent thermometer for the estimation of human water consumption, especially due to the increasing water demand in this sector [25,26]. In this respect, [1] reports that a significant error on the part of scholars in this area, is the omission of the volume of water demanded for the generation of certain products, as, such omission covers products with a high water footprint, for example, meat, which increases the scarcity of the natural resource water, converging to limit this resource on the planet, constituting a troubling environmental issue.

The variations in WF components among sample groups indicate the need to activate specific action plans for each group, with emphasis on specific products that integrate WF. This statement is confirmed by [23], when mentioning that the analysis of this indicator can favor the critical reflection on the individual and / or collective consumption of water, thus contributing to a rational use. These authors found the WF values of 807 m^3 $year^{-1}$ for meat, for teachers and employees and 404 m^3 $year^{-1}$ for students, being higher than those found in this research, except for the Master's degree in Veterinary Medicine, denoting the need for awareness to be instilled in this sample group.

The WF data of the plant, fruit, fat, sugar, and other food components found in the study by [23] corroborate with those evidenced in this study, with the differences among categories of people being studied attributed to food habits and purchasing power. [27], explain that WF increases according to family income and decreases according to eating habits. Thus, annual family income also interferes with the water footprint, given the virtual water accumulated in goods and services, which is directly proportional to the consumption habits of the population. Similar results were found by [28], who, when examining different categories, verified that the employees presented higher WF than the teachers and related these results to annual income, food habits, and level of consciousness.

In the evaluation and interpretation of the statistical results obtained through experimentation, it is advisable to explore all available information so that the researcher, in making his conclusions, is as safe and accurate as possible. Data analysis becomes more informative when, in addition to the average, some measures of dispersion or variability are obtained. Among these, the coefficient of variation has proved to be very useful for specifying the accuracy of experimental results with certain efficiency [29]. In this respect, it can be inferred that the data of this research show high dispersion and consequent low precision, as they show high coefficients of variation according to [30,31,32]. Given the above, the use of multivariate data analysis can reduce the original dimensions of the variables, focusing the study on the relevant portion of information needed to explain the phenomenon studied here.

Based on the principal component analysis (PCA), it was possible to condense the number of original variables into three main components (PC1, PC2, and PC3), which together hold 88.67% of the total cumulative variance. The choice of these PCs was based on eigen values ≥ 1.0. For the selection of variables, values ≥ 0.60 (in module) were adopted, according to [33] (Table 3).

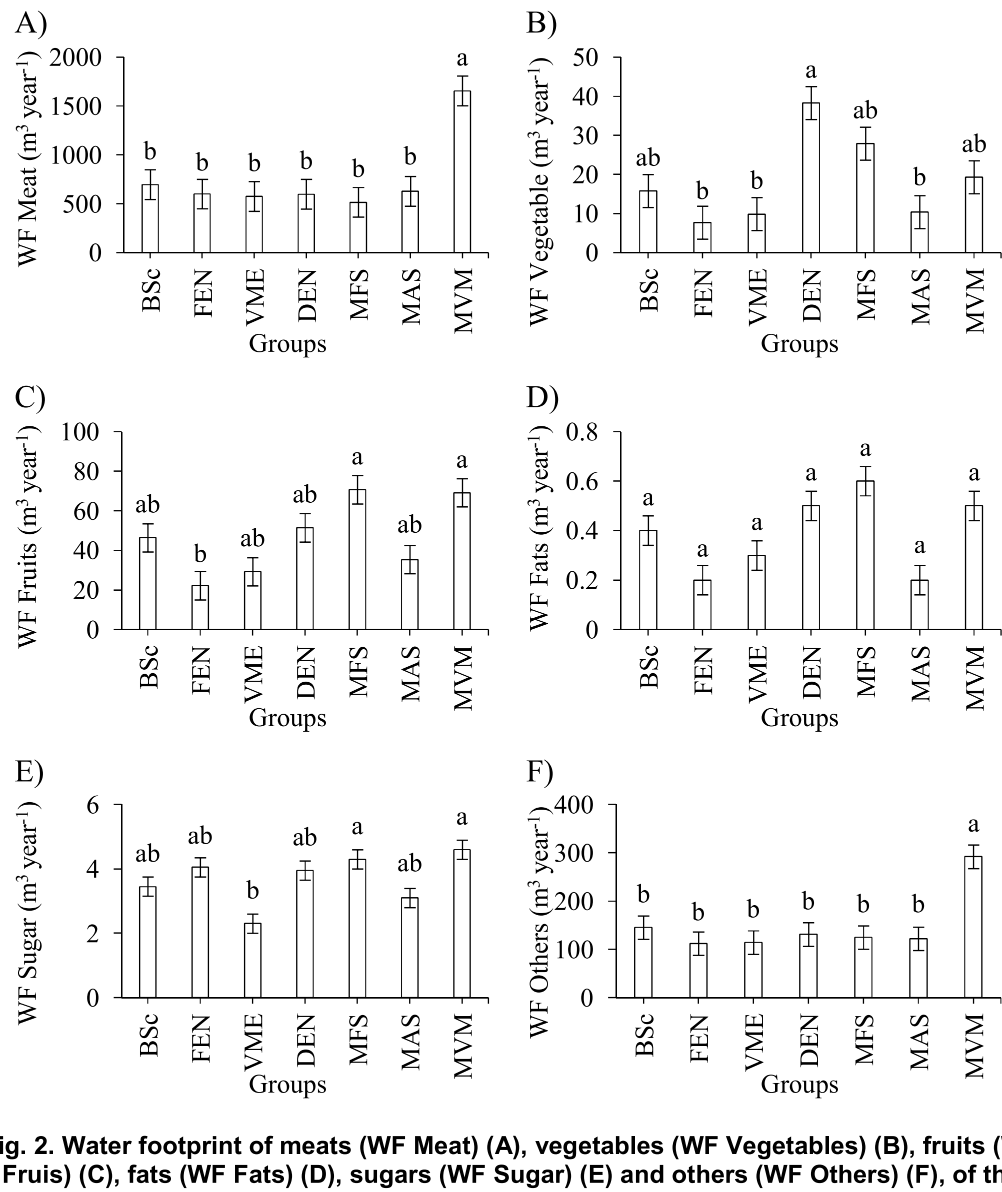

Fig. 2. Water footprint of meats (WF Meat) (A), vegetables (WF Vegetables) (B), fruits (WF Fruis) (C), fats (WF Fats) (D), sugars (WF Sugar) (E) and others (WF Others) (F), of the academic community of the UFCG Rural Health and Technology Center. Patos - PB, Brazil, 2016. BSc: Biological Sciences; FEN: Forest Engineering; VME: Veterinary Medicine; DEN: Dentistry; MFS: MSc in Forest Sciences; MAS: Master's in Animal Science; MVM: Master's in Veterinary Medicine

Source: Elaboration of the authors

Table 3. Relative variance and loads of the variables associated with the first three main components formed from 12 variables estimated in seven sample groups of the academic community of the UFCG Rural Health and Technology Center. Patos - PB, Brazil, 2016

PCs	σ²	Loads of water footprint variables											
		Hwf	Ind	Cer	Mea	Veg	Fru	Dpr	Bev	Fat	Sug	Egg	Oth
PC1	43.77	-0.71	0.17	-0.16	-0.87	-0.28	-0.77	-0.93	-0.81	-0.64	-0.53	-0.44	-0.92
PC2	29.53	-0.61	0.05	0.91	-0.21	0.74	0.57	-0.23	-0.47	0.63	0.67	-0.52	-0.11
PC3	15.37	-0.13	0.84	-0.28	-0.13	0.52	0.16	0.09	-0.17	0.28	-0.41	0.66	-0.08

PC: Main component; σ²: Relative variance; Hwf: Household water footprint; Ind: Industrial; Cer: Cereals; Mea: Meats; Veg: Vegetables; Fru: Fruits; Dpr: Dairy products; Bev: Beverages; Fat: Fats; Sug: Sugars, Egg: Eggs and Oth: Other components of the water footprint

The first major component (PC1) retained 43.77% of the relevant total variance. In this component, the sample group represented by the Master's course in Veterinary Medicine was divergent from the others, because it had specific properties, notably in relation to the components of the household water footprint, meat, fruits, dairy products, beverages, fats, and others. The second main component (PC2) accounts for 29.53% of the total variance, as this PC is important to discriminate the undergraduate courses in Veterinary Medicine (VME) and Master's in Forest Sciences (MFS), where the latter has a higher WF of cereals, vegetables, and sugars to the detriment of these variables in the VME course (Fig. 3).

In the third main component (PC3) 15.37% of the total variance was retained; where separated, the sample groups represented undergraduate courses of Forest Engineering (FEN) and Dentistry (DEN). Hence, this last mentioned course has an industrial water footprint and is superior when compared to the Forestry Engineering course, as can be observed in the vector projections of these variables, overlapping the relative position of the sample groups (Fig. 4).

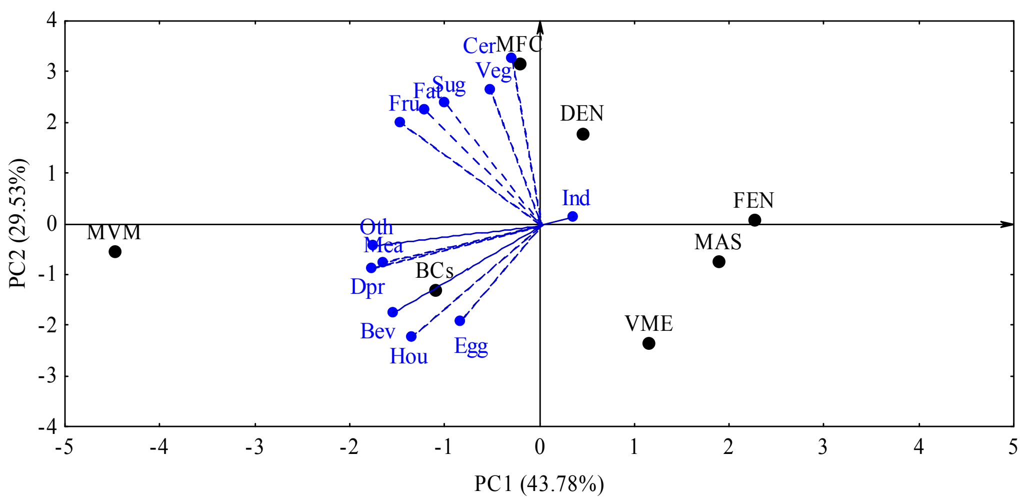

Fig. 3. Two-dimensional projection (Biplot) of the relative position of the sample groups and their respective variables in the first two main components (PC1 and PC2). BSc: Biological Sciences; FEN: Forest Engineering; VME: Veterinary Medicine; DEN: Dentistry; PFS: MSc in Forest Sciences; MAS: Master's in Animal Science; MVM: Master's in Veterinary Medicine. Hou: household water footprint; Ind: industrial; Cer: cereals; Mea: meats; Veg: vegetables; Fru: fruits; Dpr: dairy products; Bev: beverages; Fat: fats; Sug: sugars, and Oth: other components of the water footprint of the academic community of the Center for Health and Rural Technology of the UFCG. Patos - PB, Brazil, 2016
Source: Elaboration of the authors

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The calculation of the water footprint is distributed in three dimensions: industrial use, domestic, and food. For each category of respondents these dimensions varied, which can be attributed to diet style, level of awareness, and income [26]. Actually, these three dimensions were evidenced by the formation of three PCs from the original 12 variables, although the WF variable was correlated with some components of the WF of food and also the WF industrial variable, correlated with the WF component of eggs. These findings show that the use of principal component analysis can be used efficiently to discriminate sample groups as to the components of their total water footprints in the three dimensions. In fact, the APC has been beneficial in facilitating the understanding of complex phenomena related to water quality [34] and people's opinions [12,13].

From the three PCs formed, it was possible to illustrate the group structure contained in the courses based on the components of the water footprint, with expressivity in each main component. Thus, it was possible to form three groups from the variables (WF: household, meat, fruit, dairy, beverages, fats, and others) with loads higher than 0.6 in PC1, the first group (Group I) formed by the Masters degree in Forestry Sciences and Graduation in Dentistry, the second group (Group II) formed by Graduates in Veterinary Medicine and Forestry Engineering, in addition to the Masters degree in Animal Science. A third group (Group III) was formed from the dissimilarity between the Master's courses in Veterinary Medicine and undergraduate studies in Biological Sciences (Fig. 5).

Based on the second main component (PC2), formed from the WF components of cereals, vegetables, and sugars, it was possible to form two groups, the first being the Masters degree in Forestry Sciences and Graduation in Dentistry,

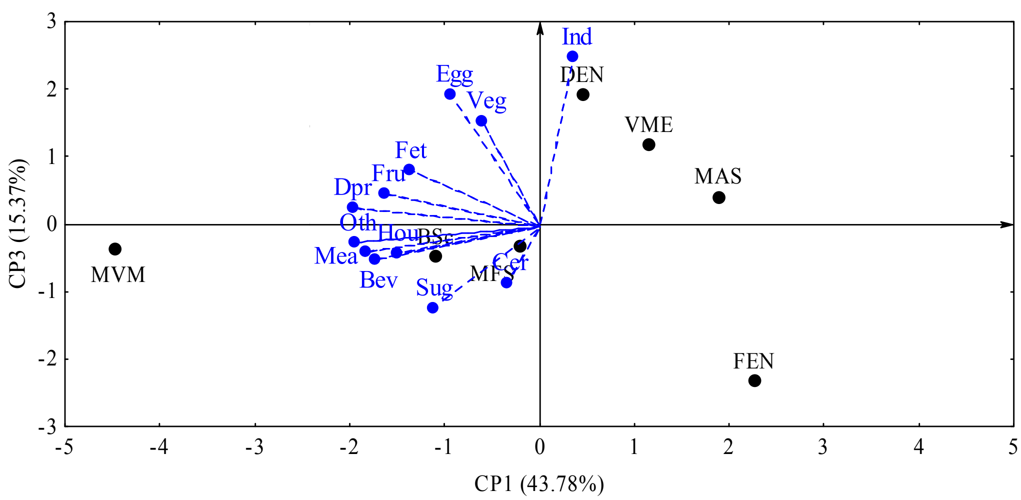

Fig. 4. Two-dimensional projection (Biplot) of the relative position of the sample groups and the respective variables in the first and third main components (PC1 and PC3). BSc: Biological Sciences; FEN: Forest Engineering; VME: Veterinary Medicine; DEN: Dentistry; MFS: MSc in Forest Sciences; MAS: Master's in Animal Science; MVM: Master's in Veterinary Medicine. Hou: household water footprint; Ind: industrial; Cer: cereals; Mea: meats; Veg: vegetables; Fru: fruits; Dpr: dairy products; Bev: beverages; Fat: fats; Sug: sugars and Oth: other components of the water footprint of the academic community of the Center for Health and Rural Technology of the UFCG. Patos - PB, Brazil, 2016

Source: Elaboration of the authors

while the second group was graduates in Veterinary Medicine, Engineering Forestry, and Dentistry, as well as the Master's in Veterinary Medicine and Animal Science (Fig. 6).

From the third main component (PC3), formed by the industrial water footprint and eggs, it was possible to agglomerate the courses into three groups, the first one being a Master's degree in Animal Science and an undergraduate course in Dentistry. The second group was formed by postgraduate and veterinary medicine courses, while the third group included the undergraduate courses in Forestry Engineering and Biological Sciences and the Masters degree in Forestry Sciences (Fig. 7).

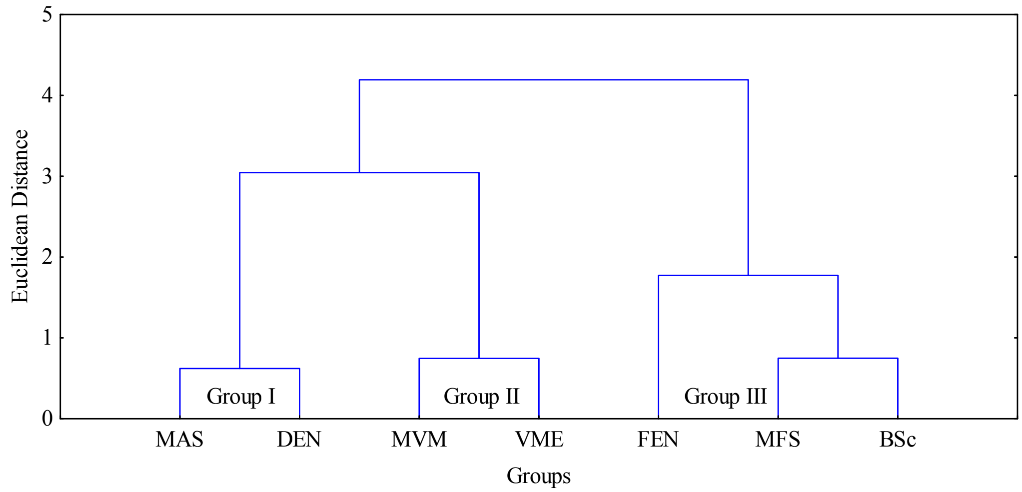

Fig. 5. Dendrogram of grouping of the sample groups constructed from the variables, with relevant contribution in the first main component (PC1). BSC: Biological Sciences; FEN: Forest Engineering; VME: Veterinary Medicine; DEN: Dentistry; PFS: MSc in Forest Sciences; MAS: Master's in Animal Science; MVM: Master's in Veterinary Medicine

Source: Elaboration of the authors

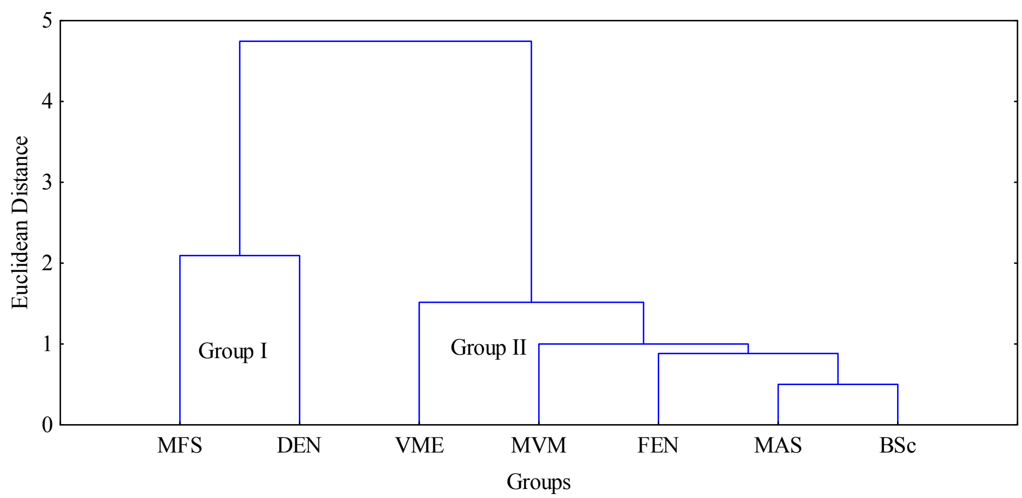

Fig. 6. Dendrogram of grouping of the sample groups, constructed from the variables with relevant contribution in the second main component (PC2). BSC: Biological Sciences; FEN: Forest Engineering; VME: Veterinary Medicine; DEN: Dentistry; PFS: MSc in Forest Sciences; MAS: Master's in Animal Science; MVM: Master's in Veterinary Medicine

Source: Elaboration of the authors

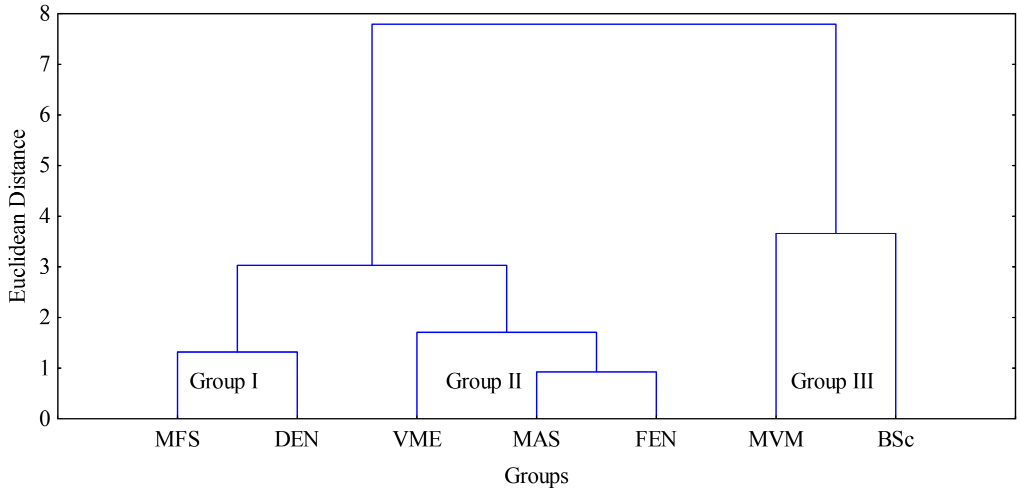

Fig. 7. Dendrogram of grouping of sample groups, constructed from the variables with relevant contribution in the third main component (PC3). BSC: Biological Sciences; FEN: Forest Engineering; VME: Veterinary Medicine; DEN: Dentistry; MFS: MSc in Forest Sciences; MAS: Master's in Animal Science; MVM: Master's in Veterinary Medicine

Source: Elaboration of the authors

The formation of these groups from specific components of the water footprint is of great significance for strategic planning, notably because it is possible to verify which groups have the highest water consumption and which items lead to this higher consumption, therefore, specific remedial solutions can be given to each group. In this sense, the clustering technique proved to be efficient, to form clusters of courses as a function of their WFs. In a study with questionnaires, the use of cluster analysis proved to be efficient to verify customer satisfaction [35], public opinion about cashew potentials [13], marketing and socio-environmental responsibility in companies [12], and perception of relationships in international trade [36], corroborating with the results of this research, denoting that new studies can make use of this technique with objectivity and ease of interpretation of results.

4. CONCLUSION

The water footprint of the academic community of the Rural Health and Technology Center of the Federal University of Campina Grande is below the Brazilian average and higher than the global average, except for the Master's degree course in Veterinary Medicine, where the water footprint exceeded the national average. There is a need for creation of awareness, with emphasis on the dietary habits of this sample group.

It was possible to reduce the 12 original variables in three latent variables with 88.67% of all relevant information in this study, allowing greater objectivity in the decision making, concerning the necessary actions in the priority sample groups, evidenced in the result of the cluster analysis.

The use of multivariate statistics was efficient to analyse the water footprint data obtained from sample groups represented by undergraduate and postgraduate courses at the Health and Rural Technology Center of the Federal University of Campina Grande.

ACKNOWLEDGEMENTS

The authors thank to Graduate Program in Agricultural Engineering of Federal University of Campina Grande – UFCG, to National Council of Scientific and Technological Development – CNPq, and to Coordination of Improvement of Higher Level Personnel – CAPES.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Hoekstra AY. A critique on the water-scarcity weighted water footprint in LCA.

Journal Ecological Indicators. 2016;66: 564-573.

2. Rondon GG, Marcondes MA, Souza VAF, Itaya NM, Gonçalves AMM. Implantation of rainwater harvesting system for non potable purposes in residences in the city of São Paulo. Environmental Health Acts – ASA. 2015;3(2):60-65.
3. Schneider VE, Carra SHZ. Water footprint of swine slaughtered in the region of Corede Serra, RS, Brazil. However. 2016; 11(1):211-224.
4. Castellanos MT, Cartagena MC, Requejo MI, Arce A, Cabelho MJ, Ribas F, Tarquis AM. Agronomic concepts in water footprint assessment: A case study in a fertirrigated melon crop under semiarid conditions. Journal Agricultural Water Management. 2016;170:81-90.
5. Manzardo A, Loss A, Fialkiewicz W, Scipioni A. Methodological proposal to assess the water footprint of direct water use at an urban level: A case study of the Municipality of Vicenza. Journal Ecological Indicators. 2016;69:165-175.
6. Wang X, Huang K, Yu Y, Hu T, Xu Y. An input-output structural decomposition analysis of changes in sectoral water footprint in China. Journal Ecological Indicators. 2016;69:26-34.
7. Zhuo L, Mekonnen MM, Hoekstra AY. Consumptive water footprint and virtual water trade scenarios for China - With a focus on crop production, consumption and trade. Journal Environment International. 2016;94:211-223.
8. Silva V de PR da, Aleixo DO, Dantas Neto J, Maracajá KFB, Araújo LE. An environmental sustainability measure: Water footprint. Brazilian Journal of Agricultural and Environmental Engineering. 2013;17(1):100-105.
9. Souza JL, Rodrigues FEF, Studart TMC, Souza Filho FA. Water footprint of a consumer community in Fortaleza / CE / Brazil: rapid and extended footprint analysis in the 'water footprint network' methodology. Journal of Economic Research. 2014;25(3):17-32.
10. Musingarabwi DM, Nieuwoudt HH, Young PR, Eyéghé-Bickong HA, Vivier MA. A rapid qualitative and quantitative evaluation of grape berries at various stages of development using Fourier-transform infrared spectroscopy and multivariate data analysis. Journal Food Chemistry. 2016;190(1):253-262.
11. Wang R, Zhou YQ, Qiao S, Huang K. Flower pollination algorithm with bee pollinator for cluster analysis. Journal Information Processing Letters. 2016; 116(1):1-14.
12. Silva SC da, Ferraz RL de S, Acre FG, Teixeira Neto J, Barbosa M de A. Ecologically correct packaging: Marketing strategies and socio-environmental responsibility in companies. Revista Ambiental Ambiental em Ação. 2015;14:1-12.
13. Fulco RJ, Ferraz RL de S, Batista JL, Barbosa M de A, Santos DM dos M. Potentialities of the castor bean from the perspective of the popular ones of the municipality of Matão SP. Revista Ambiental Ambiental em Ação. 2016;14: 1-15.
14. Fonseca G, Ferraz RL de S, Batista JL, Jardim CA, Barbosa M de A. Follow-up of castor bean production in the municipalities of São Paulo between 2005 and 2012. Revista Ambiental Ambiental em Ação. 2016;14:6-13.
15. Figueiredo Filho DB, Paranhos R, Da Silva Jr JA, Silva D. We need to talk about quantitative methods in Political Science. Latin American Journal of Social Research Methodology. 2016;11:21-39.
16. IBGE - Brazilian Institute of Geography and Statistics. Paraíba, Patos. Complete information; 2016.
    (Accessed 05 July 2016)
    Available:<http://cidades.ibge.gov.br/xtras/perfil.php?lang=&codmun=251080&search=||infogr%E1ficos:-informa%E7%F5es-completas>
17. Gil AC. How to elaborate research projects. 5th ed. São Paulo: Atlas. 2010;184.
18. Hoekstra AY, Chapagain A, Martinez-Aldaya, M, Mekonnen M. Water footprint assessment manual: Establishing the global standard. São Paulo: Institute of Environmental Conservation; 2011.
19. Hoekstra AY, Chapagain AK, Mekonnen MM. Personal calculator – extended; 2005.
    (Accessed 05 May 2016)
    Available:<http://waterfootprint.org/en/resources/interactive-tools/personal-water-footprint-calculator/personal-calculator-extended/>
20. Ferreira DF. Sisvar: A computer statistical analysis sustem. Sciences and Agrotechnology. 2011;35(6):1039-1042.

21. Hair JF, Black WC, Babin BJ, Anderson RE, Tatham RL. Multivariate analysis of data. 6th ed. Porto Alegre: Bookman. 2009;688.
22. Almeida RRP, Silva MA, Crispim DL, Carolino ECA, Machado ECM. The water footprint and the level of environmental awareness of three high schools in the municipality of Pombal-PB. Green Journal of Agroecology and Sustainable Development, Pombal. 2015;10(3):20-24.
23. Moreira R da S, Barros JD de S. Water footprint of consumer classes that compose the school Antônio Landim de Macêdo in Aurora - CE. However. 2015; 15(1):18-27.
24. Koehler A. Water use in LCA: Managing the planet's freshwater resources. The International Journal of Life Cycle Assessment. 2008;13:451-455.
25. Liu J, Savenije HHG. Food consumption patterns and their effect on water requirement in China. Hydrology and Earth System Sciences. 2008;12:887-898.
26. Ercin AE, Hoekstra AY. Water footprint scenarios for 2050: A global analysis. Environment international. 2014;64:71-82.
27. Maracajá KFB, Silva V de PR, Dantas Neto J. Water footprint of vegetarian and non-vegetarian consumers. Qualitas Revista Eletrônica. 2013;14(1):1-18.
28. Patrício MCM, Cabral A de A, Dantas JRAF, Pontes SH, Dantas Neto J. Comparison of the water footprint among consumer classes that compose the university campus of the Federal University of Campina Grande / PB. However. 2013; 12(2):1267-1279.
29. Garcia CH. Tables for the classification of the coefficient of variation. Piracicaba: Institute for Research and Forest Studies. 1989;10. (Technical Circular 171). (Accessed 05 July 2016)
Available:<http://www.ipef.br/publicacoes/ctecnica/nr171.pdf>
30. Pimentel Gomes F. Curso de Estatística Experimental. São Paulo: Nobel. 1985; 467.
31. Ferreira PV. Experimental statistics applied to agronomy. Maceió, EDUFAL. 1991;440.
32. CEP - Statistical Process Control. Coefficient of variation; 2009.
(Accessed: 05 July 2016)
Available:<http://www.datalyzer.com.br/site/suporte/administrador/info/arquivos/info39/39.html>
33. Kaiser HF. The varimax criterion for analytical rotation in factor analysis. Psychometrika. 1958;23(3):187-200.
34. Rocha CHB, Pereira AM. Multivariate analysis for selection of monitoring parameters in Juiz de Fora, Minas Gerais. However. 2016;11(1):176-187.
35. Rosario CR do, Kipper LM, Ferrão MF. Model for the application of multivariate analysis using statistical techniques PCA and HCA on questionnaire to evaluate customer satisfaction: Case study in a metallurgical company of metallic packaging. Journal of Technology. 2012; 16(1):30-39.
36. Silva JCGL da, Martins G, Hosokawa RT, Rochadelli R. The use of the correspondence and cluster analysis for the perception of relations in international trade: The case of the South-Brazilian furniture sector and the barriers to the FTAA. Journal of Management. 2008; 43(1):44-58.

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