International Journal of
Agriculture, Environment and Food Sciences

JAEFS

www.jaefs.com

E-ISSN : 2618-5946 DOI: 10.31015/jaefs.2021.4.4

Research Article Int J Agric Environ Food Sci 5 (4):456-463 (2021)

Distribution of Water Footprint Components of University Students and Detecting the Factors that Affect Those Components

Emine Elmaslar Özbaş[1,*] **Tülin Sütırmak Pehlivan[2,*]** **Hüseyin Kurtuluş Özcan[1]**

Atakan Öngen[1] **Serdar Aydın[1]** **Sinan Güneysu[1]**

[1]Affiliation: Istanbul University-Cerrahpasa, Engineering Faculty, Environmental Engineering Department, Istanbul, Turkey
[2]Affiliation: Istanbul University-Cerrahpasa, Institute of Graduate Studies, Istanbul, Turkey

[*]Corresponding Author: elmaslar@iuc.edu.tr

Abstract

20% of world population face the risk of disease and death due to the lack of access to healthy drinking water. A certain portion of water resources can no longer be used because of being polluted while some other parts pose danger for public health because of substructure incapacity. Water footprint is a remarkably crucial concept in terms of sustainable water management. Within the context of this study, consumption habits of university students and related changes in water footprint values have been investigated. Water Footprint Survey has been administered to participant university students and water footprint profiles of the students have been designed based on water footprint values computed according to survey results. At the end of the conducted analyses in Istanbul University-Cerrahpasa Avcilar Campus, mean annual rate of water footprint per person has been computed as 1848.78 m^3 for students. Components of this water footprint has been designated as; green water footprint 1329 m^3/per person/year, blue water footprint 199 m^3/per person/year, grey water footprint 320.78 m^3/per person/year. In addition, by transferring the data attained from surveys to IBM SPSS environment, presence and/or absence of a significant relationship between variables has been analyzed. It was then observed that parallel to the rise in students' income level a corresponding climb emerged in general water footprint.

Keywords: Life habits, University campus, SPSS, Water consumption, Water footprint

Introduction

Water resources are being depleted by every new day and there has been a resultant increase in the number of societies facing water scarcity. Under these circumstances "Ecologic Footprint", "Water Footprint" have gained wider acclaim as the concepts vital to prevent uncontrolled consumption of natural resources critical for living beings and essential to form a sustainable environment approach. In Turkey, available annual water quantity roughly equates to 112 billion m^3. Turkey is situated in a "semi-arid" location with high ratios of temperature. Falkenmark Water Scarcity Index reveals that to make a country water rich, annual volume of per person fresh water resource should exceed 1700 m^3. As of 2017-dated statistics issued by the State Hydraulic Works in Turkey, per person rate of fresh water resource is estimated around 1386 m^3. According to this Index,
Turkey is a country challenged with water stress. Besides, under the heading of "Water Stress", it is projected that with a population expected to reach 100 million until 2023 there will be 1120 m^3/per year left per person; hence by the year 2050 Turkey will be a country facing "water scarcity"(TKSB, 2019).

Water footprint concept is an indicator of fresh water quantity consumed or polluted by unit of time and it is rooted back to ecological footprint. It was first discussed in the 2002-dated experts meeting named Potential Water Trade in the Netherlands. Next World Water Forums were held in 2003 in Japan and in 2006 in Mexico, the same topic has been discussed in various international conventions.

Cite this article as:
Elmaslar Özbaş, E., Sütırmak Pehlivan, T., Özcan, H.K., Öngen, A., Aydın, S., Güneysu, S. (2021). Distribution of Water Footprint Components of University Students and Detecting the Factors that Affect Those Components. International Journal of Agriculture, Environment and Food Sciences, 5(4),456-463.
Doi: https://doi.org/10.31015/jaefs.2021.4.4
Orcid: Emine Elmaslar Özbaş: 0000-0001-9065-6684, Tülin Sütırmak Pehlivan: 0000-0001-6462-0098 , Hüseyin Kurtuluş Özcan: 0000-0002-9810-3985, Atakan Öngen: 0000-0002-9043-7382 , Serdar Aydın: 0000-0002-0626-5224 , Sinan Güneysu: 0000-0002-4875-101X
Received: 07 July 2021 **Accepted:** 28 September 2021 **Published Online:** 05 December 2021
Year: 2021 **Volume:** 5 **Issue:** 4 (December) **Pages:** 456-463
Available online at : http://www.jaefs.com - http://dergipark.gov.tr/jaefs

Water footprint concept has surfaced because of higher pressures on the local or basin-based water resources and emergent problems in water management. In relation with higher pressures on water resources, water utilized in the production of goods and services attracted greater value. In addition to the kind of goods, that demand heavy consumption of water in production stages it was recognized that local fresh water resources employed in their production moved beyond geographical boundaries. Thus, it was mandated to perform water footprint computations. The said concept was, for the very first time, introduced in 2002 by Prof. Dr. Arjen Hoekstra and further developed by Water Footprint Network (WFN) and Twente University. Water footprint is defined as a measure of the cumulative virtual water content required for human consumption (Aldaya et al, 2012; Wang and Ge, 2020).

Water footprint is an indicator of direct and indirect water use in relation to consumer goods. Water footprint can provide links between use of water resources and consumption of goods (Hoekstra, 2003; Mirzaie-Nodoushan et al., 2020). It is possible to measure water footprint of an individual, a product, a business branch or a country. Water footprint of an individual refers to the total volume of water utilized for the consumed service and produced goods and products per person. It is computed by multiplying “virtual water contents” of generated service, goods and products by consumption volumes. Water footprint not only displays the volume of consumed water but also reveals when and where the said water was utilized and to which category it belongs; green, blue and grey water footprints (Mekonnen and Hoekstra, 2011).

The blue water footprint concept refers to the total amount of surface and underground freshwater resources required to produce any good or service. This concept refers to consumption volume that occurs when water extracted from groundwater resources or surface water resources evaporates and is utilized in production; hence, extracted water fails to return to its original water resource. Water utilized in agriculture, water used in production lines of plants and domestic use is categorized as blue water footprint (Hoekstra et al., 2011; Pellicer-Martínez and Martínez-Paz, 2016).

Green water footprint calls for the volume of total rainwater used in the production of any good or service. These resources are primarily used in gardening, agriculture and forestry operations. It is evident in cases when rainfall per unit area fails to penetrate into ground waters and remain on the surface or absorbed by plants use. This phenomenon is a measure of evaporated volume of water and amount of water used by plants. Green water footprint primarily comes to the scene in the stage of producing agricultural products (Hoekstra et al., 2011; Pellicer-Martínez and Martínez-Paz, 2016). Green and blue water footprint indicates fresh water consumption whilst grey water footprint is in indicator of pollution (Hoekstra and Chapagain, 2008; Hoekstra et al., 2009). Grey water footprint concept, on the other hand, refers to the sum of fresh water volume required to designate a specific criteria of water quality by lowering contaminant concentration directly discharged to water resources or indirectly released into wastewaters to threshold values through administering dilution method (Pellicer-Martínez and Martínez-Paz, 2016). In relevant literature, there is a scarcity of studies conducted to determine campus water footprint. One of the few studies was conducted by (Natyzak et al., 2017) and in this study water footprint of the University of Virginia (UVA) was computed as the sum of direct water consumption and virtual water consumption. By analyzing in tandem with Water Footprint Statistics (Water Stat) public services, food, transportation, paper, research animals and facility management water bills within the premises of university as well as purchase records that entailed purchases for the hospital were reported and water footprint could thus be estimated. 10.06% of total water footprint consisted of direct water consumption, 45.77% consisted of public service industry, 23.34% consisted of food production industry, 16.88% consisted of health sector and 3.95% consisted of paper, transportation and research animals’ domains. Footprint due to direct water consumption was roughly computed as 1.7 million m^3 and virtual water footprint was computed as 15.2 million m^3.

In the study of Emory University (Allison et al., 2018), to achieve a campus-wide innovative water treatment, a re-use system also known as WaterHubt was operated. By this system, daily 151 liters of recovery was enabled thus two third of wastewater production of the university was recycled to its equivalent and campus water footprint could then be lowered as low as 40%.

In 2019 a research was conducted in Keele University to measure the total energy footprint, carbon footprint and water footprint values and in this particular study total water footprint of Keele University was computed as 532,415 m^3 (Gu et al., 2019).

Likewise, in another 2019-dated study, the water footprint of Valaya Alongkorn Rajabhat University due to electric-use was examined and it was concluded that vehicle fuel consumption was the reason for the highest level of water footprint (Kandananod, 2019).

In this particular study water footprint of university students was computed. In this case the aim was to determine water footprint components of same-age youngsters living in the same environment despite being raised in different cities and have different cultural formations. It was also aimed to unveil the factors affecting these components.

Materials and Methods

In this study, while water footprint values were designated (URL1), questions posted in a water

 DOI: 10.31015/jaefs.2021.4.4

footprint calculation motor were printed in a document. This Survey document was shared with the participants and each of the responses was singly entered to this calculation motor in order to compute their footprints. Survey questions are as listed in Table 1. During 2018-2019 academic year this research was conducted among 559 students, studying in 3 faculties respectively listed as Faculty of Engineering, Veterinary School and Faculty of Sports Sciences located in Istanbul University-Cerrahpasa Avcilar Campus. In this study, the incomes of the participants are given in Turkish Lira (TL). When this study was done, 1 US Dollar was 6.96 TL. SPSS 15.0 software was used to explain statistical significance of digital data.

Results and Discussion

In this research, firstly, participants were categorized into groups based on their age. It was detected that age range of the participants was 18 – 24. Water footprints of the participants based on age are as shown in Figure 1 (Green, blue, grey water footprints and total water footprints). As displayed in Figure 1, an increase in age corresponded to higher ratio of total water footprint whereas green, blue and grey water footprints failed to perform a directly proportional rise. Maximum mean water footprint value (2572 m^3/year) and maximum green water footprint value (1878 m^3/year) were reported to belong to age 24. Maximum blue water footprint value (306 m^3/year) belonged to age – 21 group and maximum grey water footprint value (524 m^3/year) belonged to age-23 group (Figure 1).

Upon analyzing the connection between Age and Water footprint, water footprint components were explored by considering participants' income levels. Connection between income level-water footprint was examined with respect to each faculty and in a general context. As the connection between income level-water footprint components was examined with respect to each of the three faculties, obtained results are as exhibited in Figures 2, 3 and 4.

Water footprint results of the Faculty of Engineering students with respect to income level can be viewed in Figure 2. As it can be observed one unit rise in income level corresponded to a climb in water footprint components (green, blue and grey water footprint) and total water footprint values. It was realized that total water footprint value of the participants whose monthly income levels were above 10 thousand TL corresponded to the top rank in all income groups (3142.5 m^3/year) (Figure 2).

Water footprint results of Veterinary School students with respect to income level can be viewed in Figure 3. When compared to the increases in students' income levels it was seen that only green water footprint and total water footprint among all water footprint types elevated in direct proportion. It was realized that maximum green water footprint value (1808 m^3/year) and maximum total water footprint value (2306 m^3/year) belonged to the participants whose monthly income levels were above 10 thousand TL (Figure 3).

Water footprint results of the Faculty of Sports Sciences students with respect to income level are as shown in Figure 4. When compared with the increases in students' income levels it was detected that all of the water footprint components and total water footprints also rose.

Table 1. Total iron concentrations in leaves of the grapevine genotypes grown in nutrient solution

1-Monthly water consumption	2-Monthly drinking water consumption	3-How often do you wash your car in a week?
4- Weekly meat consumption	5- Weekly poultry consumption	6- Weekly egg consumption
7- Weekly milk consumption	8- Weekly cheese consumption	9- Weekly yoghurt consumption
10- Weekly vegetables consumption	11- Weekly fruit consumption	12- Daily bread consumption
13- Weekly pasta consumption	14- Weekly rice consumption	15- Weekly potato consumption
16- Weekly legumes consumption	17- How many cups of tea do you drink in a day?	18-How much sugar do you add to one cup of tea?
19- How many cups of coffee do you drink in a day?	20- How much sugar do you add to one cup of coffee?	21- Monthly dessert spending
22- Monthly electricity bill	23- Monthly vehicle fuel expenditure	24- Monthly LPG expenditure
25- Monthly expenditure on attire	26-Monthly expenditure on electronic devices	

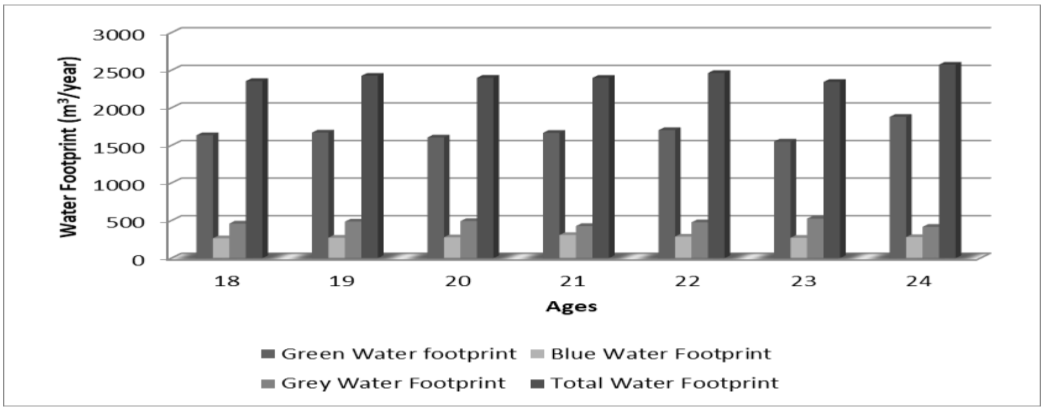

Figure 1. Mean annual water footprint results of the participants with respect to age

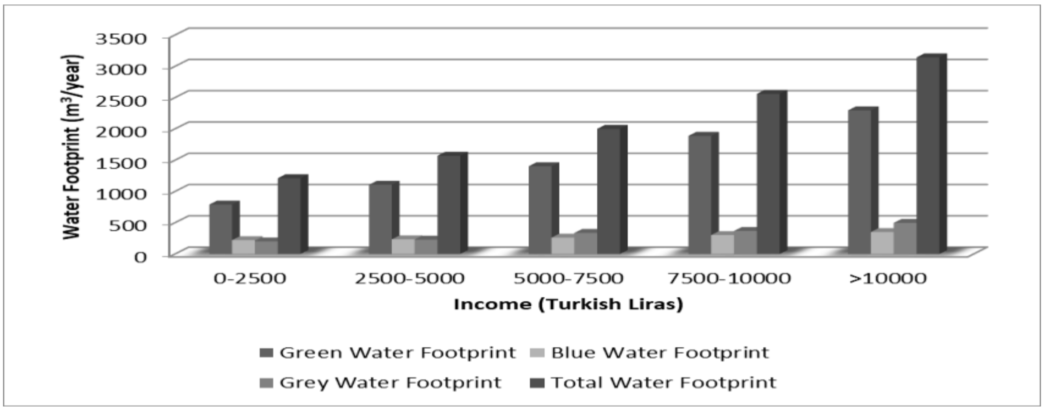

Figure 2. Water footprint results of the Faculty of Engineering students with respect to income level

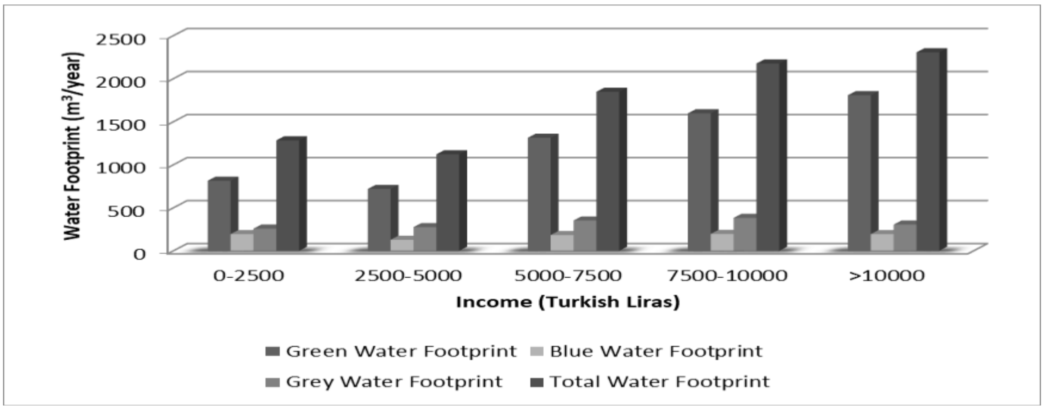

Figure 3. Water footprint results of Veterinary School students with respect to income level

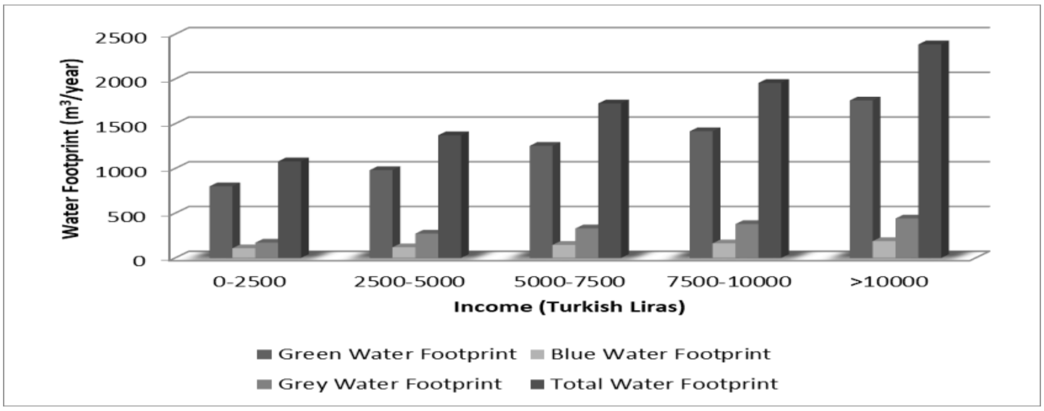

Figure 4. Water footprint results of the Faculty of Sports Sciences students with respect to income level

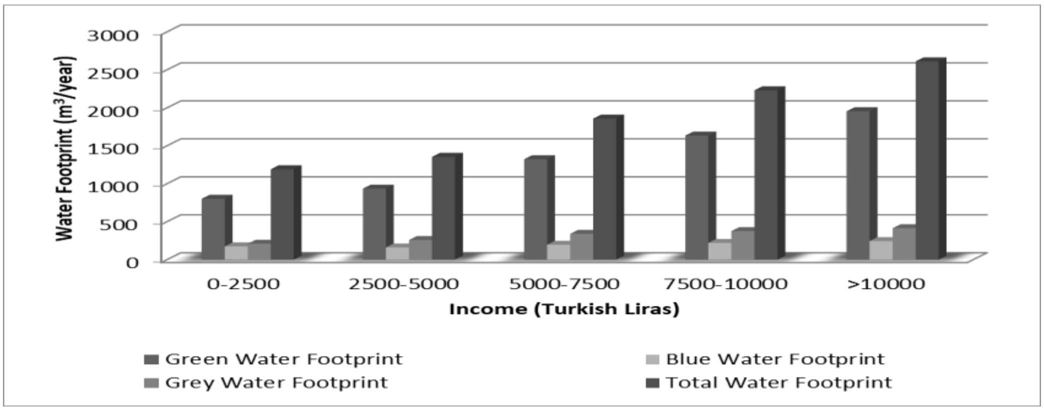

Figure 5. Mean annual water footprint and its components for Istanbul University – Cerrahpasa students with respect to income level

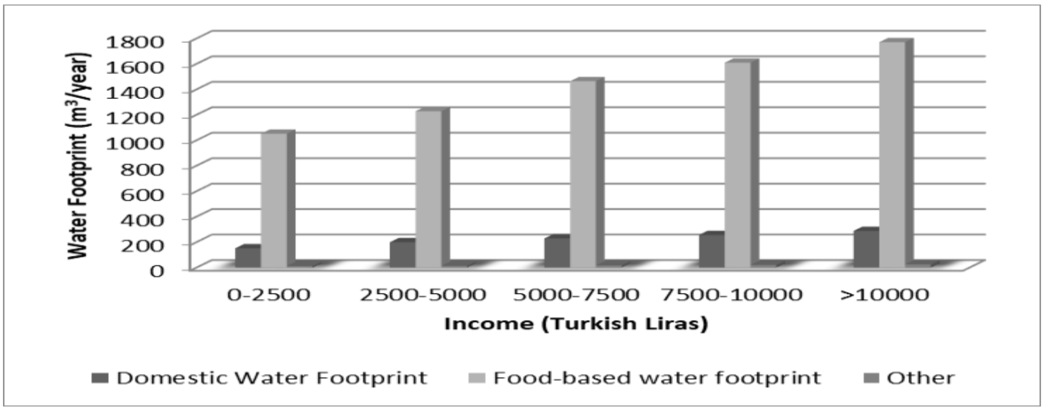

Figure 6. Water footprint distribution graphic with respect to income level

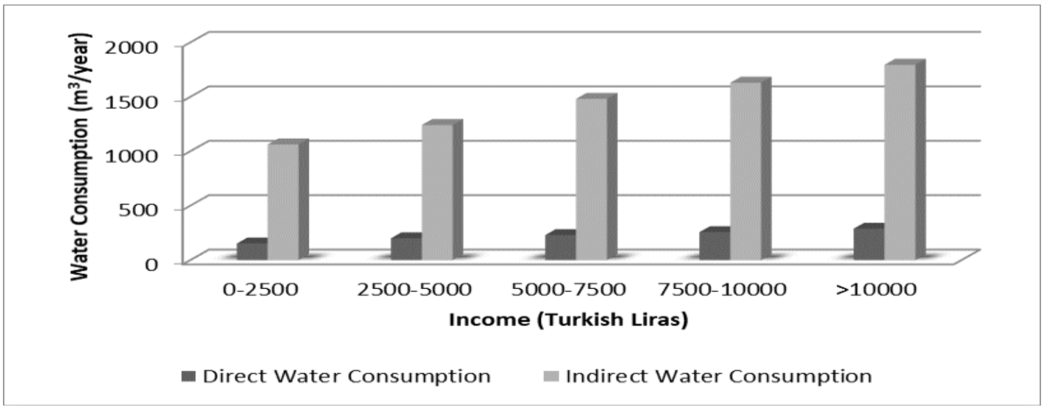

Figure 7. Distribution graphic of direct and indirect water consumption with respect to income level

Maximum green water footprint (1759 m^3/year), blue water footprint (187 m^3/year), grey water footprint (440 m^3/year) and total water footprint (2386 m^3/year) were computed (Figure 4). As water footprint values of the participants from three faculties were examined it was detected that in all faculties, maximum water footprint values belonged to Faculty of Engineering students partaking in the research (Figure 2, 3 and 4).

Figure 5 presents water footprint components with respect to income levels for all participants. As seen in Figure 5 a rise in income level heightened total water footprint. An analysis of water footprint components showed that maximum increase was evident in green water footprint while in blue water footprint the same increase was insignificant. Maximum total water footprint value (2611.63 m^3/year) belonged to the participants whose monthly income levels were above 10 thousand TL (Figure 5).

In Figure 6, income-level based distribution of water footprint inducing-factors that are related with domestic use, food and other consumptions are illustrated. Figure 6 evidenced that the largest components that constituted students' water footprint stemmed from foods. To explain this finding it was suggested that water was most heavily used in the stage of producing food products.

Figure 7 manifested that as income level climbed, direct and indirect water consumption also increased. Relative highness of indirect water consumption compared to direct water consumption was explained with food consumption.

At the end of conducted analyses, mean annual water footprint per person in students of Istanbul University – Cerrahpasa Avcilar Campus was computed as 1848.78 m^3/per person/year. As similar researches in literature were analyzed it was revealed that in a different research published in 2019 and conducted among students from a different university in Turkey, mean water footprint was computed as 1490.1 m^3/year (Dursun, 2019). The said research was conducted in a sparsely populated Eastern city of Turkey and students in this city had lower income levels. Thus obtaining a lower value than the mean water footprint value computed in our study is in support of the suggestion of our study that income level is a major contributor for water footprint.

In Turkey, mean per person water footprint is 1977 m^3/year. Per person, consumption is 216 L/day. Yet based on virtual water, per person consumption equates to 5416 L/day (URL 2). As reported currently in Turkey per person mean water footprint is 4425 L/day (1422 m^3/per person/year) (URL 3). Computed average ratio in this analysis is 1849 m^3/per person/year value, whereas in Turkey water footprint value computed for present day is above 30%. Per person consumption computed as 1.422 cubic meter in 2015 was measured as 1.386 cubic meter in 2017[(1)] Mean indirect water consumption per person is computed as 1440 m^3 in this study and direct water consumption as 224 m^3. In that computation, total sum of per person water consumption was computed as 1664 m^3. Per person water (1386 m^3) value computed for Turkey evidences that water demand in Turkey exceeds 20%. In this study, it was detected that a rise in income level corresponded to higher spending for electronic devices (mobile phones etc.) and clothes. Besides, since people with high-income levels prefer to own cars they would also pay for additional costs like car washing and vehicle fuel expenditures. Meat consumption is also relatively higher than other income groups. Consequently, it is suggested that higher income level triggered greater total water footprint values.

Data obtained at the end of this survey conducted in Istanbul University – Cerrahpasa Avcilar Campus were transferred to SPSS program to conduct an analysis. Five different variables were selected respectively as age, income, green water footprint, blue water footprint, grey water footprint. Normalcy test was administered to the variables. Results indicated that none of the 5 variables could fit with normal distribution. Hence, Spearman Correlation Analysis was performed for further comparisons. Firstly, hypothesis on the direct relationship between increased age and water footprint was tested. Although a significant relationship between variables requires that significance level should be below 0.05 value, when the age and other variables were contrasted significance level was measured to be above 0.05 value; thereby indicating that no significant relationship existed between the variables. In the second analysis, income variable was included and partial correlation analysis was then conducted. Here, age was identified as the fixed variable. Results of the analysis evidenced that a significant and positive relationship existed between income and water footprints. As the correlation coefficients between income variable and water footprints were analyzed it was detected that a strong relationship existed between 0.7 correlation coefficient and green water footprint, an average relationship existed between 0.6 and 0.4 correlation coefficients respectively and between grey and blue water footprints respectively. It can thus be observed that as income level rose, water footprint types also increased in a significant way. In the third analysis, all of the variables were co-evaluated and a generic Spearman Analysis was applied. Obtained results remained the same and identical results were observed. It was revealed that as the income level increased, the water footprint values also increased.

Conclusion

Water indeed is the very soul of life and total amount of water on Earth is 1.4 billion 350 million km^3. Yet since 97.5% of water mass is salty water, it is unviable for human consumption. A large portion of remaining fresh water resources are underground waters or glaciers. Hence, available fresh waters that living beings can directly consume is at an alarmingly low level. On the other hand, due to gradual rise in world population and increased demand for water, fresh water resources are being depleted out of control despite being already scarce. To make water resources sustainable it is essential to conduct water footprint computations.

According to Falkenmark Index Turkey is not a water rich country but rather a country stricken with water stress. The size of domestic water consumption by the sum of used water is approximately 10% and this is the sector with the least amount of water loss. Yet taking precautions is quite important in the fight against water scarcity. Domestic water consumption can be lowered only after striving to accomplish our personal duties. Our conscious choices could be of use to prevent water scarcity and it can only be achieved through promoting awareness- raising initiatives.

Consequently, in this study university students were deliberately chosen since it is assumed that acquisition and awareness gained particularly during university education could be effective in initiating a life-long change. Therefore, by measuring water footprints of students in Istanbul University-Cerrahpasa Avcilar Campus it was aimed to use obtained findings to raise environmental awareness of university students.

At the end of the analyses, mean annual per person water footprint of 559 students in Istanbul University – Cerrahpasa Avcilar Campus was measured as 1848.78 m^3. As water footprints and income levels were compared, it was detected that a rise in income level heightened total water footprint. Maximum increase was measured in green and grey water footprint whilst in blue water footprint not any significant increase could be detected. This research evidenced that the biggest component responsible for students' water footprint belonged to food products. This finding suggested that green water footprint most dramatically emerged at the stage of producing food products. As income level rose, direct and indirect water consumption also increased. Compared to direct water consumption indirect water consumption was mostly associated with food consumption. As the age increased no proportional increase or decrease could be detected in water footprint. It is suggested that conducting the research among a narrow age band of 18 – 24 played quite an important role in this result.

In addition, by transferring the data attained from surveys to SPSS environment presence and/or absence of a significant relationship between variables was analyzed. Based on the results of the analysis it was seen that a significant and positive relationship existed between income level and water footprints. It can thus be observed that as income level rose, water footprint types increased in a significant way.

At the end of this study, it was identified that daily water need of university students moved further beyond available amount of water. Findings of this study evidenced that water footprint of university students should be diminished. Suggestions offered to reduce water footprint values can be listed as below:

- It is suggested to promote lower consumption of dietary meat products hence it can be feasible to create minimal footprint.
- Packaged foods always contain higher ratio of water footprint. Water footprint tends to increase in all stages from production to packaging until the period they reach to the market. Thus, it is suggested to promote consumption of natural goods.
- In our daily activities based on water consumption we should lower our water use to half to care more about the future.
- By avoiding renewing electronic devices unless absolutely necessary and rejecting consumption of luxurious goods it is also possible to decrease water footprint.

Compliance with Ethical Standards

Conflict of interest

The authors declared that for this research article, they have no actual, potential or perceived conflict of interest.

Author contribution

The contribution of the authors to the present study is equal.

All the authors read and approved the final manuscript. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before.

Ethical approval

Ethics committee approval is not required.

Funding

No financial support was received for this study.

Data availability

Not applicable.

Consent for publication

Not applicable.

Acknowledgements

This research was acknowledged by the Jury Committee as Master's Thesis in Istanbul University – Cerrahpasa, Department of Environmental Engineering, Program of Environmental Engineering on 20th April 2020.

References

Aldaya, M.M., Chapagain, A.K., Hoekstra, A.Y., Mekonnen, M.M. (2012). In: The Water Footprint Assessment Manual: Setting the Global Standard, Earthscan, London, 53 – 55. Retrieved from https://waterfootprint.org/media/downloads/TheWaterFootprintAssessmentManual_2.pdf

Allison, D., Lohan, E., Baldwin, T. (2018). The WaterHub at Emory University: Campus Resiliency through Decentralized Reuse. Water Envıronment Research, 2, 187-192. Doi: https://doi.org/10.2175/106143017X15054988926569

Gu, Y., Wang, H., Xu, J., Wang, Y., Wang, X., Robinson, Z.P., Li, F., Wu, J., Tan, J., Zhi, X. (2019). Quantification of interlinked environmental footprints on a sustainable university campus: A nexus analysis perspective. Applied Energy, 246, 65–76. Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S030626191930635X

Hoekstra, A.Y. (2003). Virtual water trade: Proceedings of the International Expert Meeting on Virtual Water Trade. Value of Water Research Report Series, No.12. UNESCO-IHE, Delft, Netherlands, 49-75. Retrieved from https://www.waterfootprint.org/media/downloads/Report12.pdf

Hoekstra, A.Y., Chapagain, A. K. (2008). Globalization of Water: Sharing the Planet's Freshwater Resources. Blackwell Publishing, Oxford, UK, 12-19. Doi: https://doi.org/10.1002/9780470696224

Hoekstra, A.Y., Chapagain, A.K., Aldaya, M.M., Mekonnen, M.M. (2009). Water Footprint Manual: State of the Art. Water Footprint Network, Enschede, Netherlands, 20-25. Retrived from https://waterfootprint.org/media/downloads/WaterFootprintManual2009.pdf

Hoekstra, A.Y., Chapagain, A.K., Aldaya, M.M., Mekonnen, M.M. (2011). The Water Footprint Assessment Manual: Setting the Global Standard. Earthscan, London, UK, 19-68. Retrived from https://waterfootprint.org/media/downloads/TheWaterFootprintAssessmentManual_2.pdf

Kandananod, K. (2019). The Energy related water footprint accounting of a public organization: The case of a public university in Thailand. Energy Procedia, 156, 149-153. Doi: https://doi.org/10.1016/j.egypro.2018.11.120

Mekonnen, M. M., Hoekstra, A.Y. (2010). The green, blue and grey water footprint of crops and derived crop products. (UNESCO-IHE, Delft, The Netherlands) Value of Water Research Report Series, 47, UNESCO-IHE. Retrieved from https://waterfootprint.org/media/downloads/Mekonnen-Hoekstra-2011-WaterFootprintCrops.pdf

Mirzaie-Nodoushan, F., Morid, S., Dehghanisanij, H. (2020). Reducing water footprints through healthy and reasonable changes in diet and imported products. Sustainable Production and Consumption, 23, 30–41. Doi: https://doi.org/10.1016/j.spc.2020.04.002

Natyzak, J.L., Castner, E.A., D'Odorico, P., Galloway, J.N. (2017). Virtual Water as a Metric for Institutional Sustainability. Sustainability, 4, 237-245. Doi: https://doi.org/10.1089/sus.2017.0004

Pellicer-Martínez, F., Martínez-Paz, J.M. (2016). Grey water footprint assessment at the river basin level: Accounting method and case study in the Segura River Basin, Spain. Ecological Indicators, 60, 1173–1183. Doi: https://doi.org/10.1016/j.ecolind.2015.08.032

TSKB, (2019). Economical Researched Report. Retrieved from http://www.tskb.com.tr/i/content/4201_1_TSKB_2019_EFR.pdf (in Turkish).

URL 1: Water Footprint. Retrieved from https://www.abprojeyonetimi.com/su-footprint (in Turkish).

URL 2: Turkey- Water footprint report. Retrieved from https://wwftr.awsassets.panda.org/downloads/su_ayak_izi_raporweb.pdf?2720 (in Turkish).

URL 3: Tomorrows' Water. Retrieved from https://www.yarininsuyu.com (in Turkish).

Wang, Q., Ge, S. (2020). Carbon footprint and water footprint in China: Similarities and differences. Science of the Total Environment, 739, 140070. Doi: https://doi.org/10.1016/j.scitotenv.2020.140070