# Thesis on Water Footprints: Relating Consumers' Perceived utility of Water Footprints to Reducing Water Consumption


## Abstract

Water scarcity is presumed to be a growing problem in our world and questions arise whether it is possible to enjoy a secured food supply for much longer in the future. Tools to measure to what extent water is consumed are useful to calculate whether food supply and the environment are at risk.

Water footprints calculate the entirety of water consumed for producing a single product, for production in a country, for the entire production cycle of a single crop among more. This study poses the question '*To what extent does knowledge of water footprints increase the willingness of reducing consumption of water by consumers?'* to explore the utility of water footprints in having individuals make an effort of reducing their water consumption. By collecting quantitative data from individual consumers via a questionnaire, this research has been able to conduct a multiple linear regression. This analysis shows a significance of 0,000 on a positive relation between consumer's willingness to reduce water consumption on one hand and consumer's knowledge about water footprints and consumer's awareness of water scarcity as a problem on the other hand with a correlation value of 0,522. Herewith, the research shows there is a sizeable contribution from using water footprints to countering water consumption. Nonetheless, water footprints may be very misinterpretable and might mislead consumers into thinking they are protecting environmental principles with their choices when in fact they aren't. To elaborate on the main research question, this study attempts to answer the questions 'How do consumers interpret a water footprint?' and 'To what extent do consumers think water scarcity is a problem?'. The utility consumers mostly relate to water footprints is that of measuring an individual's water footprint.



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# Introduction

## Background

As the world's population is growing ever larger, the pressure on food security and water supply may increase unless proper actions are taken. In addition, a changing climate may negatively affect global freshwater supply as well. Water quality degradation is a growing concern worldwide and management for sustaining water sources is lacking coordination and cooperation between different and often conflicting water users (Tzanakakis et al., 2020). In order to tackle a problem of global magnitude, instruments of measuring which allow comparison of water use, need to be adopted. Therefore, the concept of a water footprint has been developed by researchers to allow measurement of water consumption more precisely (Mekonnen & Hoekstra, 2011). An ongoing debate splits the field of water management as the relevance, usefulness and ambiguity of the concept and the methods it requires are questioned by many scientists (Chapagain & Tickner, 2012; Ridoutt & Pfister, 2010; Wichelns, 2011).

One of the main reasons there is mostly insufficient assessment of global water resources is the lack of a model that captures all aspects of water consumption. It is necessary to solve this issue in order to allow better water management (Wada et al., 2017).

According to Ridoutt & Pfister (2010), water stress factors should be included in water footprints to assess the severity of impact of a certain volume of water in different basins, regions or countries. To determine whether adaptations of this kind should be made to calculating water footprints, it is important to examine the impact of the concept in the current state.

Since environmental concerns are of growing impact on consumer's purchasing behaviour (Laureti & Benedetti, 2018) and Companies are increasingly confronting consumers with water footprints of their products (Aivazidou et al, 2018), the impact of the water footprints concept along with the way they are calculated will grow more dominant and may determine the future of water management.

## Research Problem

Developed as a single number volumetric unit, a water footprint is easily misinterpreted. Water scarcity is a large problem in some places and not at all in others. In calculating a water footprint as proposed by Mekonnen & Hoekstra (2011), no attention is paid to where

the water is consumed and therefore the actual impact on the surrounding environment might differ a lot per basin, region or country.
When presenting a number as the total volume of water consumed for a product, it has an impact on the consumer and might even influence whether or not they will end up buying the product. This study will assess how understanding of a water footprint affects the behaviour of consumers and tries to capture underlying assumptions made by these consumers when confronted with a water footprint. Therefore, this study will try to answer the question '*To what extent does knowledge of water footprints increase the willingness of reducing consumption of water by consumers?*'.

To allow the formulation of an answer to the main research question, this study will elaborate by answering two sub-questions. Firstly, the question 'How do consumers interpret a water footprint?' is posed to assess what meaning people actually assign to the term 'water footprint'. Since there are many different applications for water footprints, it is important to know if consumers can tell what a water footprint may represent. A water footprint may be that of a product supply chain (Aivazidu et al., 2018), of a country's agriculture (Hossain et al., 2020), of a region or population (Vanham, 2018; Zotou & Tsihrintzis, 2017), of a river basin (Zhuo et al., 2018), of an aquifer (Gleeson et al., 2012), of specific energy consumption (Schyns & Vanham, 2019), or that of an individual (Lee et al., 2016). Many more applications are possible for water footprints, because water is consumed in so many different processes and measurement is possible at various scalar levels. For these reasons, gaining understanding of consumers' associations with the broad concept of water footprints is requisite in order to assess the impact the use of this concept has on consumers' willingness to reduce water consumption.
Next, the question 'To what extent do consumers think water scarcity is a problem?' will be answered. Water scarcity is a global phenomenon and therefore, according to Mekonnen & Hoekstra (2011) and Hoekstra (2017), should be measured as such and managed as such. However, there is no discussion about the fact that water scarcity is not as prevailing in some parts of the world as it is in others (Chapagain & Tickner, 2012). In particular, areas undergoing huge demographic change and areas with extreme climatic fluctuations are vulnerable to human activities and environmental change resulting in a water deficit (Tzanakakis et al., 2020). The population studied in this paper is not necessarily living in one such area prone to water scarcity, however it might very well be consuming products which are from water scarce areas. To understand to what extent consumers are willing to reduce their own water consumption, it is required to assess their stance on the extent to which water scarcity is a problem or even a threat worldwide.

**Structure of Paper**

This article starts with summarizing the entire paper within the abstract, giving an indication of what to expect from this article.
The introduction contains some background information on why the topic is relevant as well as the research problem derived from this background information. Here the main research question is stated and justified.
The theoretical framework goes into depth on various other researchers and creates a framework of concepts and theories within which this study was conducted. The conceptual model visualises the hypotheses which this research aims to test.

In the Methodology section, the data collection instrument and the way in which the data was collected are explained. Next, the data analysis scheme shows how the data collected by the instrument is then translated into analysable data, making it suitable for a multiple linear regression.
The analysis then shows multiple tables on the outcome of the regression, explaining what values to look at and what is important about these findings.
The results part then interprets the outcomes of the analysis and assigns meanings to the values, relating back to the theoretical framework and placing this analysis back into perspective of other research.
The conclusions then summarize the most important findings of this study, evaluate strengths and weaknesses, and advise about future research and implementations for policy.

## Theoretical Framework

This study makes use of the concept water footprint as is proposed by Mekonnen & Hoekstra (2011). This water footprint distinguishes between green, blue and grey water footprints. The green water footprint represents the rainwater consumed. The blue water footprint represents the ground and surface water. The grey water footprint represents the volume of water necessary to assimilate pollutants so that the water becomes 'regular' fresh water, according to quality standards. These three combined make up the total of a water footprint, expressed either in liters or in metric tonnes.

Different researchers use water footprints in various ways. In the study by Mekonnen & Hoekstra (2011), the water footprints of several crops are measured as metric tonnes of water per ton of crop. This gives a perspective of the different crop water footprints and even allows for a ranking from large to small water footprints. However, this pays no attention to where the crops are grown. It seems evident that a ton of crop cultivated in a very moist region requires a different amount of water than a ton of the same crop cultivated in an arid region since there will be differences in evapotranspiration (Chapagain & Tickner, 2012).

Another perspective is given by Zhuo et al. (2018) in their study on the role of reservoirs. This research evaluates different water basins and the total available water they have over a period of several years. In this study, they propose a blue water footprint cap for individual basins. This caps the volume of water that may be used for storage, from a basin by establishing the minimum volume of water that the basin needs to maintain environmental flow.

Furthermore, a study by Ridoutt et al. (2009) discusses similarities between carbon footprints and water footprints. The study concludes that these both footprints are very dissimilar in the fact that lack of characterisation factors in the water footprint concept results in incomparable values. Since both concepts use the term 'footprint', individuals might easily compare water footprints like they would with carbon footprints. Ridoutt et al. (2009) argue that this is deceiving and leads to confusion. On the other hand, Hoekstra (2009) compares water footprints to ecological footprints as well as draws a parallel with carbon footprints in his article. He argues that these footprints are all rather similar, because they all assess the sustainability of human and other activities on basic resources (in contrast to other approaches). Hoekstra (2009) does argue that these different approaches of assessing sustainability on basic resources should be harmonised into one framework, which allows for analysis of different footprints combined.

All the different applications of water footprints mentioned above vary on many aspects. Water footprints can be measured both top-down (dividing total water flow into footprints) and bottom-up (adding up footprints into total water flow). Some researchers focus solely on either blue, green or grey water footprints. For example the blue water footprint of global aquifers are believed to be highly unsustainable (Gleeson et al., 2012).

Consumer pro environmental behaviour is, among others, influenced by internal, social, situational and demographic factors (Nguyen & Johnson, 2020). While this is the case for most kinds of behaviour, it shows that there is a wide variety of possibilities for changing one's attitude towards environmental sustainability. Furthermore, in their study on Italian consumers, Laureti & Benedetti (2018) demonstrate that environmental concerns are becoming more prominent in purchasing decisions. They also argue that people living in highly polluted areas are less inclined towards environmentally sustainable behaviour. Khan

et al. (2020) support this in their research. They found a positive relationship between knowledge and attitude and consumer green behaviour. Therefore they conclude that consumer attitude towards pro environmental behaviour is crucial for combating environmental problems.

The link between the academic field of water management and the consumer's personal behaviour on water consumption has not been established strongly as of today. However, the business sector is confronting consumers more and more with water footprints as the growing awareness of the impact of water consumption on the climate and environment of consumers creates a social responsibility of large businesses to be transparent on their supply chains' water consumption (Aivazidou et al., 2018). Corporations adopt water-friendly policies as a marketing strategy as well as integrate water related risks into their business plans (Vlachos & Aivazidou, 2018).
Companies such as Coca Cola and Puma are investigating their own water footprint to assess business risks in water consumption (Chapagain & Tickner, 2012). This allows these multinational businesses to evaluate whether their processes of production are sustainable over a longer period of time.
As companies will use their own water footprint analyses for advertising products, consumers will be confronted with the values these companies calculated themselves. Therefore, it is necessary to gather information on the knowledge consumers have of water footprints and assess the impact this knowledge has on their awareness of water scarcity and on the consumer's willingness to reduce water consumption.

**Conceptual Model**

The conceptual model shown in figure 1 represents the expected behaviour of an average consumer. When a consumer has knowledge of the concept of water footprints, the consumer will have greater awareness of water scarcity and the problems derived from it. Alternatively, the awareness of water scarcity might also increase knowledge of water footprints. Consequently, this will result in a greater willingness of the consumer to reduce water consumption. This conceptual model is based on the hypotheses which are stated in the next section.

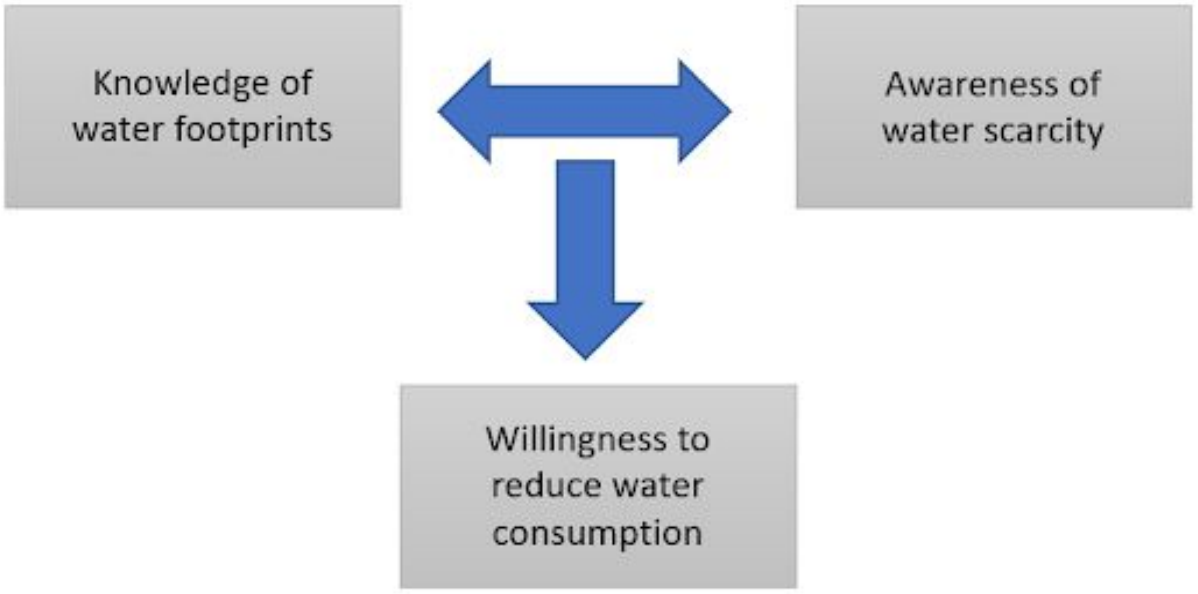


**Figure 1**: Conceptual model of consumer behaviour

**Hypotheses**

Prior to conducting the research, the following hypotheses have been posed:

1. There is a positive relation between the consumer's knowledge of water footprints and the consumer's awareness of water scarcity as a problem
2. There is a positive relation between the consumer's awareness of water scarcity as a problem and the consumer's willingness to reduce water consumption.
3. There is a positive relation between the consumer's knowledge of water footprints and the consumer's willingness to reduce water consumption.

# Methodology

To properly answer the question posed in the *research problem* section, this research has performed a quantitative data analysis to measure the relations between consumer's knowledge about water footprints, the consumer's awareness of water scarcity as a problem, and the consumer's willingness to reduce water consumption. By conducting a linear regression, with consumer's willingness to reduce water consumption as the dependent variable, this paper tries to prove a positive relation both between consumer's knowledge about water footprints and the dependent variable and between consumer's awareness of water scarcity and the dependent variable. With this analysis we test the hypothesis "H0: In the population, there is no linear relationship between consumer's knowledge of water footprints and consumer's awareness of water scarcity on the one hand, and consumer's willingness to reduce water consumption on the other hand".

**Data collection instrument**

The data collection instrument (see appendix A) has twelve total questions. The first four questions aim to gather general knowledge about the participant on gender, age, country of residence and income.

General question 4 assess to what extent the participant thinks his/her monthly income suffices for his/her needs. This gives an insight in the extent to which the participant's income allows for more expenses.

The purpose of the remaining eight questions has been to gather the data for conducting the analysis. These eight questions together comprise the three variables which will be the main input for a multiple linear regression model.

Questions 1, 2 and 3 represent the respondent's knowledge of water footprints. The first question is to assess how many respondents started the survey with prior knowledge about water footprints. The second question assesses how much the respondent perceives to be familiarized with the concept. A respondent is able to understand this concept to some extent without ever having heard of it and therefore this question is applicable to all respondents. The third question is a multiple answer question where the respondent can cross as many answers as he/she wants. Deliberately, all answers are correct, so the perfect response would be to cross them all. This way, the more a respondent crosses, the more knowledge about water footprints can be attributed to him/her. This also means that the answers to this question can be treated as an interval variable, since the values can range from 0 to 5.

Furthermore, it gives an insight in which application is perceived to fit the most with the concept by participants.

Questions 4, 5 and 6 target the respondent's awareness of water scarcity as a problem. Question 4 is about the severity of a problem in the present, whereas question 5 measures the perceived pressure on global food supply as a consequence of water scarcity. Question 6 assesses whether the respondent thinks of water scarcity as a growing global problem towards the future.

Questions 7 and 8 then represent the dependent variable, which is the willingness to reduce water consumption. Question 7 asks the respondent how much effort he/she spends on a daily basis for reducing his/her consumption of water via products. Question 8 directly asks the respondent to assess his/her own behavioural change to linking supermarket products to their complementary water footprint.

**Collecting data**

The questionnaire has been spread digitally for the sake of targeting as many respondents as possible. Using social media and other sources for easy communication, this questionnaire aimed to reach as many possible respondents as was feasible. There has not been any use of paid advertising for targeting respondents.

The collecting process went smooth, as there were enough possible participants to approach using the different sources of communication. A month after initial distribution of the questionnaire, another round of distribution was set up. The first distribution round accounts for about 60% of the total responses. The second distribution round accounts for about 40%.

The questionnaire has recorded a total of 173 responses, of which 133 were useful for analysis. These 'false' responses were due to the survey saving responses in case they were not completed twelve days after being started. All the recorded responses which had a status of less than 100% completion have been left out of the research entirely.

**Ethical considerations**

While composing the questionnaire which was used for collecting the data, certain ethical standards were taken into account. The participants were fully anonymous, so their responses could not be traced back to them. These responses were used confidentially. Furthermore, the beginning of the questionnaire stated exactly what the participant could expect and that they could stop the questionnaire at any time.

**Data analysis Scheme**

In figure 2, a schematic shows the steps which were taken for conducting the analysis. Questions 1, 2 and 3 will together make up independent variable Y, which represents the knowledge of water footprints. Questions 4, 5 and 6 make up independent variable Z, which represents the awareness of water scarcity as a problem. Questions 7 and 8 together make up the dependent variable, which represents the willingness to reduce water consumption. The independent variables and the dependent variable were analysed in SPSS and the method has taken the form of a multiple linear regression. The outcome of this analysis is a significance value which could either substantiate or contradict the assumption that there is a relation between knowledge of water footprints and awareness of water scarcity as a problem on the one hand, and willingness to reduce water consumption on the other hand.

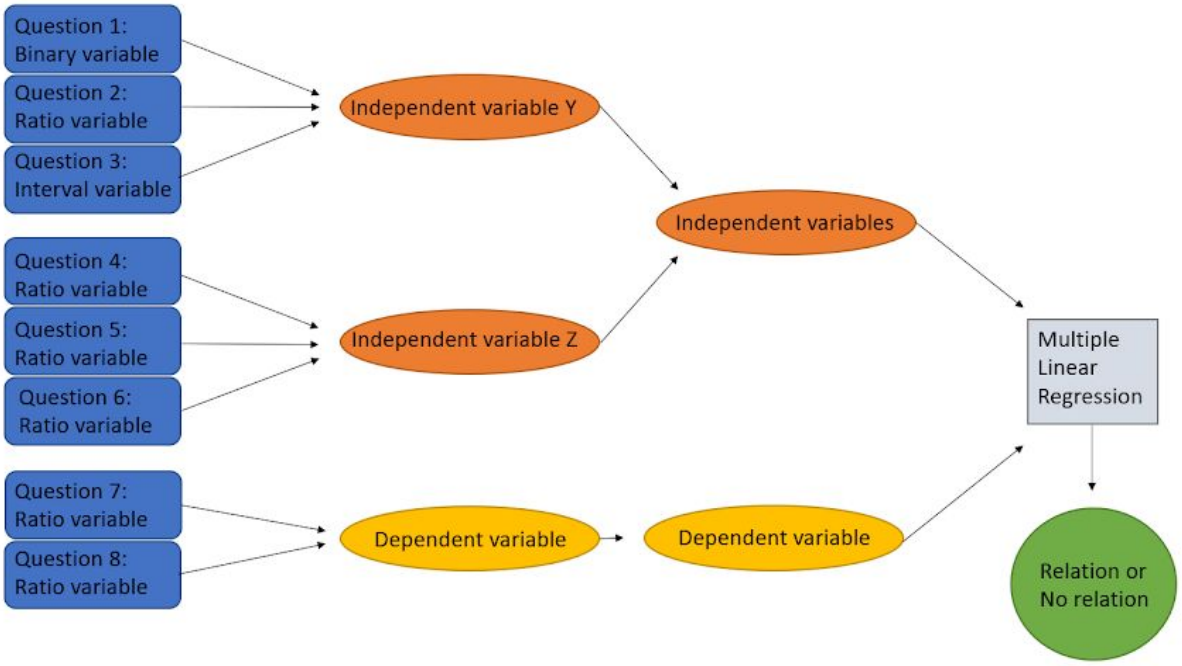


**Figure 2**: Data analysis Scheme

## Results

A linear regression has been conducted with willingness to reduce water consumption as the dependent variable, and knowledge of water footprints and awareness of water scarcity as two of the independent variables.
As a third independent variable, the consumer's income (as judged by him-/herself) has been added to the regression model. Although this is not in line with the hypotheses to which this research is dedicated, it shows a meaningful comparison between the variables perceived to influence the dependent variable according to the hypotheses and a variable excluded from the hypotheses. This allows for an interpretation of the data that supports the stated hypotheses rather than other possible hypotheses that have not been stated by this research.

**Table 1**: Descriptives

| | Mean | Comparable Means | Std. Deviation | N |
|---|---|---|---|---|
| Willingness | 6,14 | 6,14 | 2,498 | 133 |
| Knowledge | 5,89 | 5,89 | 2,388 | 133 |
| Awareness | 13,94 | 9,29 | 2,817 | 133 |
| Income | 5,42 | 8,84 | 1,509 | 133 |

The calculated independent variables; consumer's knowledge about water footprints, consumer's awareness of water scarcity as a problem as well as the consumer's income, and the calculated dependent variable; consumer's willingness to reduce water consumption are shown in table 1. Putting these means into perspective, Both willingness and knowledge are rated averagely, while awareness and income are both a bit on the high end (See appendix B for more information).
These four variables have been entered in the regression model.

**Table 2**: Model Summary a. Predictors: (Constant), Income, Knowledge, Awareness

| R | R Square | Adjusted R Square | Std. Error of the Estimate | R Square Change | F Change | df1 | df2 | Sig. F Change |
|---|---|---|---|---|---|---|---|---|
| 0,522 | 0,272 | 0,255 | 2,156 | 0,272 | 16,069 | 3 | 129 | 0,000 |

Looking at table 2, the significance value shows 0,000, meaning this regression model was significant as a whole. R has a value of 0,522. This number represents the correlation between the observed and expected variables. From this table, it derives that the null

hypothesis for the F-test (In the population, the explained variance equals zero) can be rejected.

**Table 3**: Analysis of Variance

a. Dependent variable: Willingness
b. Predictors: (Constant), Income, Knowledge, Awareness

| | Sum of Squares | Mean Square | F | Sig. |
|---|---|---|---|---|
| Regression | 224,036 | 74,679 | 16,069 | 0,000 |
| Residual | 599,528 | 4,648 | | |
| Total | 823,564 | | | |

The significance value as shown in table 3 is 0,000. This means we reject “H0: In the population, there is no linear relationship between consumer’s knowledge of water footprints and consumer’s awareness of water scarcity on the one hand, and consumer’s willingness to reduce water consumption on the other hand”.

**Table 4**: Regression coefficients

a. Dependent variable: Willingness

| | B | Std. Error | Beta | t | Sig. | Tolerance | VIF |
|---|---|---|---|---|---|---|---|
| (Constant) | -1,187 | 1,106 | | -1,073 | 0,285 | | |
| Knowledge | 0,175 | 0,080 | 0,167 | 2,184 | 0,031 | 0,962 | 1,039 |
| Awareness | 0,381 | 0,069 | 0,430 | 5,548 | 0,000 | 0,939 | 1,065 |
| Income | 0,180 | 0,127 | 0,109 | 1,415 | 0,159 | 0,957 | 1,045 |

The regression coefficients are shown in table 4. The constant represents the outcome of the dependent variable in the case of all independent variables having a value of zero. Furthermore, the three independent variables are measured to what extent they correspond with the dependent variable, given the other two independent variables. Striking is the regression coefficient for consumer’s awareness of water scarcity as a problem, which has a rather large regression coefficient and a significance of 0,000. The third independent variable of the consumer’s income has generated an insignificant result. This means the variable of income on its own cannot be interpreted to have a linear relationship with the independent variable consumer’s willingness to reduce water consumption. Furthermore, the high values for tolerance; or the low values for VIF both signal that there is a lot of variance in the independent variables which is explained by the other independent variables.

**Table 5**: Correlation matrix

| | | Willingness | Knowledge | Awareness | Income |
|---|---|---|---|---|---|
| Pearson Correlation | Willingness | 1,000 | 0,255 | 0,480 | 0,210 |
| | Knowledge | 0,255 | 1,000 | 0,176 | 0,113 |
| | Awareness | 0,480 | 0,176 | 1,000 | 0,191 |
| | Income | 0,210 | 0,113 | 0,191 | 1,000 |
| Sig. (1-tailed) | Willingness | - | 0,002 | 0,000 | 0,008 |
| | Knowledge | 0,002 | - | 0,021 | 0,097 |
| | Awareness | 0,000 | 0,021 | - | 0,014 |
| | Income | 0,008 | 0,097 | 0,014 | - |

As we can see in the correlation matrix in table 5, the correlation coefficients between our independent variables range between 0,1 and 0,2. Thus we can state that there are weak positive correlations at best. Furthermore, the correlation between consumer's knowledge about water footprints and the consumer's income is insignificant and can therefore be disregarded altogether.
However, the very weak correlations between consumer's awareness of water scarcity as a problem and consumer's knowledge about water footprints, and between consumer's awareness of water scarcity as a problem and income are both found to be significant.

# Discussion

The output of the regression model in the analysis section has shown that there is evidence in the data for a positive linear relationship between consumer's knowledge about water footprints and consumer's awareness of water scarcity as a problem on one hand, and consumer's willingness to reduce water consumption on the other. This answers the main research question: '*To what extent does knowledge of water footprints increase the willingness of reducing consumption of water by consumers?*'.

It indeed seems that a consumer with more knowledge about water footprints and their meanings has an increased willingness of reducing his/her water consumption in comparison to a consumer with less knowledge about water footprints.

However, an even stronger relation was found between consumer's awareness of water scarcity as a problem and consumer's willingness to reduce water consumption. This signals that consumer's knowledge about water footprints is to be subject to the consumer's awareness of water scarcity as a problem, which does not come as a shock. Important is here, how a consumer's knowledge of water footprints influences his/her awareness of water scarcity as a problem. This is where this research fits into the greater debate about the added value of water footprints as a concept for raising awareness of water scarcity and increasing willingness to reduce water consumption in general.

The outcomes of the analysis in this research strengthen the argument by Chapagain & Tickner (2012), as they state that water footprints have so far enlarged comprehension of water scarcity at regional, national and global scale. Furthermore, they suggest that using water footprints may stimulate developing a more sustainable framework for global trade.

Penru et al (2016) state that water footprints are well suited for companies to be used for demonstrating the environmental improvement of their technologies, since the single unit is easily interpreted by consumers. Use of water footprints by large companies as a way to convince the public of their environmentally friendly behaviour is obviously a good thing, whenever the calculations for these footprints are done in the same comparable way everywhere. The link established in this research between water footprints and willingness to reduce water consumption is valuable as long as this comparability between water footprints is harnessed. Willingness to reduce water consumption has no use if numbers of water consumption are deceiving. Hoekstra (2017) argues that by introducing water footprints as a concept, which allow for easy communication to the public, businesses are directing their focus more on water management, whereas before this was mainly a matter for governments.

To elaborate on the main research question, the sub-question 'How do consumers interpret a water footprint?' was formulated. This research has collected data to answer this question while measuring the participant's knowledge of water footprints. Question 3 of the questionnaire (see appendix A) is a multiple answer question on the utility of water footprints. Participants were able to pick as many answers as they wished. In table 6, the distribution of frequencies is displayed. The most staggering result of this question has been the overwhelming frequency of the last answer to the question. Out of a total 133 participants, 128 agreed that a water footprint represents the amount of water a person uses by consuming various products.

**Table 6**: Data on question 3: What does a water footprint represent?

| | Frequency |
|---|---|
| The total water consumption of a country's agriculture | 37 |
| The total water consumption of agriculture in a river basin | 14 |
| The amount of litres used to manufacture a product | 54 |
| The amount of water a manufacturing company consumes for production in a country | 37 |
| The amount of water a person uses by consuming various products | 128 |

While it is very well possible to calculate an individual's water footprint, it is not very common in the scientific field of water management to focus hereupon. Rather, scientists focus on large scale quantities of agricultural crops (Liu et al., 2009; Mekonnen & Hoekstra, 2011), on the net water influx or outflow of river basins (Bakken et al., 2015; Zhuo et al., 2018) or on the supply chain of a product (Ercin et al., 2011; Noya et al., 2016).
Since the average participant of the questionnaire used for the data collection of this research is probably not very engaged in the current scientific debate on the utility of water footprints, their knowledge on the topic might very well be transferred from other concepts.
One such concept would be the carbon footprint. These two terms seem similar for both making use of 'footprint'. Ridoutt et al. (2009) compare these two footprints with one another to evaluate whether it is justified to regard these concepts as similar. They conclude that we should not think lightly about assigning characteristics of the carbon footprint to the water footprint. The main critique on which this advice rests its foundations is the fact that water footprints are not standardised like carbon footprints are (Ridoutt et al., 2009). This is due to the fact that water is not scarce to the same extent in different places. Therefore, a water footprint of 200 litres in the Netherlands might not contribute as much to water scarcity as would a water footprint of 200 litres in Australia. This poses a problem for individuals who want to assess their water footprint in order to specify their impact on the water aspect of environmental issues. Whenever a person measures his or her own water footprint, the issue it poses for the global environment might be more dependent on the location or region where the water was used, than on the actual size of the water footprint.
Other researchers (Chapagain & Tickner, 2012; Wichelns, 2011) agree that it would be very misleading to compare water footprints without adding weight on water stress or other important factors to a single number water footprint.
The data collected for this research shows that researchers mentioned above among others have a very valid point. Consumers seem to give a meaning to a concept like a water footprint that is easy to understand and many do seem to transfer properties of the carbon footprint to a water footprint, even without having ever heard of water footprints at all.
As Ridoutt et al. (2009) mention, it is possible for a product with a smaller water footprint to have a greater negative impact on the environment than a product with a larger water footprint. The same logic of reasoning is applicable to individuals. As people buy and consume products which they know have small water footprints, these people themselves have small water footprints. Again, due to the origins of products and to supply chains being

of a global scale, the location or region where the water has been consumed, might be more important to assessing environmental impact than the size of the water footprint.
Large companies are able to make a large contribution to raising awareness about water scarcity as a global problem (Hoekstra, 2017). Nevertheless, doing so is a benefit on its own for global businesses as it raises its own environmental friendly status as perceived by consumers (Aivazidou et al., 2018).

# Conclusions

This research contributes to the scientific debate on water footprints, their utility and their weaknesses.

Consumers who have more knowledge of the water footprint as a concept will have more awareness of water scarcity as a problem and will therefore be more willing to spend effort in reducing their water consumption. Hereby, we can state that an answer to the central research question '*To what extent does knowledge of water footprints increase the willingness of reducing consumption of water by consumers?'*, can be: The consumer's knowledge of water footprints, combined with his/her awareness of water scarcity as a problem, contribute largely to his/her willingness to reduce water consumption.

This research supports the claim that water footprinting is useful in counteracting global water scarcity and will help secure global food supply in the future.

Nevertheless, it is evident that the meanings assigned to water footprints must be placed in perspective if to be comparable. Therefore, this study advises to use standardised versions of water footprints, which may take into account the region, country or basin where the water has been used and respective water scarcity of that region, country or basin.

This study finds consumers to relate water footprints mostly with individual consumption water footprints. Whereas this is not an incorrect application of the concept, it is rarely used in this sense in academic context. Measuring a personal water footprint is already made possible by certain websites. It is of importance that location of water consumption is added to calculations of water footprints in this context as well, in order for the concept to be relevant to water scarcity and water stress.

Since this study has found consumers overwhelmingly relate the water footprint to an individual person's water use, and companies can be expected to gain a larger share in water management and presenting facts about water footprints to the general public, it is inevitable that a segment of the population will partly rely on these companies for their information about their own water consumption and consequences theroff.

This research has been conducted without targeting a specific group other than general 'consumers'. Therefore, anyone was eligible to contribute data for the analysis. Were this study to be repeated by other people in another region of the world, outcomes may be very different. Furthermore, the analysis has been greatly dependent on the way in which the three main variables in this study have been calculated. If these three variables were measured more precisely or in depth, the analysis would have definitely changed and with that perhaps its conclusions.

Lastly, this study recommends further exploring the utility of water footprints in the field of science as well as for the common consumer. The latter of which needs to be always traceable back to the former, as a number without scientific evidential background has no meaning.

In order for governing actors as well as companies to make use of water footprints in addressing environmental issues, it is of utmost importance that water stress factors will be included.

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# Appendix A: Questionnaire

**General question 1**: What is your gender?

Male / Female / Other

**General question 2**: What is your age?

**General question 3**: What is your country of residence?

**General question 4**: Pick the answer that best suits your opinion about the statement.
*'My average monthly income is sufficient for my needs.'*

1 / 2 / 3 / 4 / 5 / 6 / 7

1 = Strongly disagree
7 = Strongly agree

**Question 1**: Have you ever heard of water footprints?

Yes / No

**Question 2**: Pick the answer that best suits your opinion about the statement.
*'I understand what is meant by a water footprint.'*

1 / 2 / 3 / 4 / 5 / 6 / 7

1 = Strongly disagree
7 = Strongly agree

**Question 3**: What does a water footprint represent? (Multiple answer)

The total water consumption of a country's agriculture

The total water consumption of agriculture in a river basin

The amount of litres used to manufacture a product

The amount of water a manufacturing company consumes for production in a country

The amount of water a person by consuming various products

**Question 4**: Pick the answer that best suits your opinion about the statement.
*'I think water scarcity is currently a global problem.'*

1 / 2 / 3 / 4 / 5 / 6 / 7

1 = Strongly disagree
7 = Strongly agree

**Question 5**: Pick the answer that best suits your opinion about the statement.
*'I think a consequence of water scarcity is pressure on global food supply.'*

1 / 2 / 3 / 4 / 5 / 6 / 7

1 = Strongly disagree
7 = Strongly agree

**Question 6**: Pick the answer that best suits your opinion about the statement.
*'I think water scarcity is a growing problem globally.'*

1 / 2 / 3 / 4 / 5 / 6 / 7

1 = Strongly disagree
7 = Strongly agree

**Question 7**: Pick the answer that best suits your opinion about the statement.
*'I make effort on a daily basis to buy products which consume less water during production.'*

1 / 2 / 3 / 4 / 5 / 6 / 7

1 = Strongly disagree
7 = Strongly agree

**Question 8**: Pick the answer that best suits your opinion about the statement.
*'I would make more effort to reduce water consumption if I were able to compare in the supermarket the amount of water products use during production.'*

1 / 2 / 3 / 4 / 5 / 6 / 7

1 = Strongly disagree
7 = Strongly agree

# Appendix B: Computing Variables

The variables consumer's knowledge about water footprints, consumer's awareness of water scarcity as a problem, and consumer's willingness to reduce water consumption have been computed according to the following schematics:

Q1: Yes = 1 point / No = 0 points
Q2: 0-6 points
Q3: 1 point per answer, max 5
Q4: 0-6 points
Q5: 0-6 points
Q6: 0-6 points
Q7: 0-6 points
Q8: 0-6 points

Independent Variable Y (knowledge):
Q1 + Q2 + Q3 = points scored on knowledge of WF
Min: 0, Max: 12

Independent Variable Z (Awareness):
Q4 + Q5 + Q6 = points scored on awareness of water scarcity
Min: 0, Max: 18

Dependent Variable (Willingness):
Q7 + Q8 = points scored on willingness to reduce consumption
Min: 0, Max: 12

Furthermore, the variable for income has been calculated by general question 4.
Independent Variable A (Income):
GQ4 = points rated on income satisfaction
Min: 1, Max: 7

# Appendix C: Full SPSS Output

| R | R Square | Adjusted R Square | Std. Error of the Estimate | R Square Change | F Change | df1 | df2 | Sig. F Change |
|---|---|---|---|---|---|---|---|---|
| 0,522 | 0,272 | 0,255 | 2,156 | 0,272 | 16,069 | 3 | 129 | 0,000 |

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Regression | 224,036 | 3 | 74,679 | 16,069 | 0,000 |
| Residual | 599,528 | 129 | 4,648 | | |
| Total | 823,564 | 132 | | | |

| | B | Std. Error | Beta | t | Sig. | Tolerance | VIF |
|---|---|---|---|---|---|---|---|
| (Constant) | -1,187 | 1,106 | | -1,073 | 0,285 | | |
| Knowledge | 0,175 | 0,080 | 0,167 | 2,184 | 0,031 | 0,962 | 1,039 |
| Awareness | 0,381 | 0,069 | 0,430 | 5,548 | 0,000 | 0,939 | 1,065 |
| Income | 0,180 | 0,127 | 0,109 | 1,415 | 0,159 | 0,957 | 1,045 |

| | | Willingness | Knowledge | Awareness | Income |
|---|---|---|---|---|---|
| Pearson Correlation | Willingness | 1,000 | 0,255 | 0,480 | 0,210 |
| | Knowledge | 0,255 | 1,000 | 0,176 | 0,113 |
| | Awareness | 0,480 | 0,176 | 1,000 | 0,191 |
| | Income | 0,210 | 0,113 | 0,191 | 1,000 |
| Sig. (1-tailed) | Willingness | - | 0,002 | 0,000 | 0,008 |
| | Knowledge | 0,002 | - | 0,021 | 0,097 |
| | Awareness | 0,000 | 0,021 | - | 0,014 |
| | Income | 0,008 | 0,097 | 0,014 | - |