The Utilization of Water Footprint Education to Build-up the Level of Environmental Awareness

Karin Kandananond, Valaya Alongkorn Rajabhat University, Thailand

The European Conference on Education 2016
Official Conference Proceedings

Abstract
Due to the water scarcity situation worldwide, there are many campaigns introduced to raise the awareness of people for the purpose of saving water. According to the manufacturing businesses, one of the initiatives is the water footprint focusing on the calculation of the amount of freshwater used to manufacture a product. For Thailand, the income from the exported ceramic products is accounted for approximately 15,000 million baht per year. Likewise, the large amount of water usage related to the manufacturing is also high. Therefore, if the industry itself is able to assess how its manufacturing process contributes to the water consumption and polluted water, the study will lead to the increasing level of awareness of the business operators. In this study, the amount of water used for the whole life cycle of a ceramic product, i.e., resource extraction, manufacture, daily use and disposal, is assessed by following ISO 14046: 2014 guidelines. The water footprint is calculated by categorizing into blue water, green water and gray water footprint. Moreover, the water footprint of ceramic package is also included in the calculation. Afterwards, the water footprint is used as the scaffolding technique to enhance the level of environmental awareness among ceramic business operators. The results indicate that the awareness is significantly built up after the application of water footprint education. This will lead to the sustainable use of water in the ceramic business.

Keywords: Awareness, ceramic, environment, water footprint

Introduction

The environment issues have come into the attention of people since the last decade and they are ranged from global warming to water drought. Although the society starts to be aware of the importance of the environment, the pathway which leads the conservation of environment in reality is still unclear and not practical. As a result, initiatives, such as carbon footprint, are introduced in order to be used as a tool to assess the carbon emission due to human activities with the objective of having the medium for carbon trade. Similarly, water footprint is the concept introduced by A.Y. Hoekstra from UNESCO-IHE in 2002 and it is the amount of freshwater used to make goods or provide services. The water footprint of every product or service will reflect the tangible amount of used water which is easy to understand for people who are related to any part of the life cycle of product or service. The objective of this research is to study the potential of water footprint as a tool to increase the level of awareness among the people.

Literature Review

According to Badruzzaman, Oppenheimer, Hess, Smith, Upson, Postle, and Jacangelo (2014), the purposes of water footprint are differentiated into four categories, the measurement of water consumption, the identification of environmental influence in term of numerical results due to the consumption, the risk assessment regarding the consumption, the introduction of strategies leading to the reduced consumption. Noga and Wolbring (2013) conducted a study on the perceptions of water ownership and water management among one hundred and sixty four individuals. The questionnaires were used as a research instrument and the questions regarding the water footprint were included. The results reveal that the questionnaire respondents are concerned with the water scarcity. Another finding is that education regarding the water conservation and recycling are needed and it is key leading to the raise of awareness. Moreover, most respondents agree that the water footprint might be a potential tool leading to alleviate the awareness. A study by Attari (2013) also points out that the accuracy of water use perception (water footprint) is more precise than other means of perception measurement in the similar category, e.g., carbon footprint.

Hoekstra and Chapagain (2007) signify that the amount of water consumed for the production of services and commodities is the clear definition of water footprint and this number directly reflects the water use of the population in a nation. Their study is also extended to the identification of four factors affecting the amount of water footprint, namely, volume of consumption, consumption pattern, climate (growth conditions) and agricultural practice.

Gerbens-Leenes and Hoekstra (2008) identify that there are two parts of water footprint, i.e., operational water footprint and supply chain water footprint. Another way to categorize the water footprint is based on the types of freshwater sources, blue, green and gray water footprint. The blue water footprint is the amount of water retrieved from the surface and ground water while the green water footprint is the water evaporated from the rainwater in the soil. On the other hand, the gray water footprint is the polluted water due to the manufacturing activities.

According to Čuček, Klemeša and Kravanj (2012), footprint is a powerful indicator used to measure the level of sustainability in term of environment, society and economy

Method

In this study, there are two folds of processes used to carry on the research, the total water footprint calculation and the increasing level of awareness after the workshop regarding water footprint was introduced. The main concept of water footprint calculation is based on the identification of the framework of life cycle analysis. In term of framework, there are five steps incorporating with the framework creation.
-identify the studied impact
-identify the studied product
-identify the functional unit of product
-identify the period for data collection
The initialization of the framework is shown in the following Figure 1.

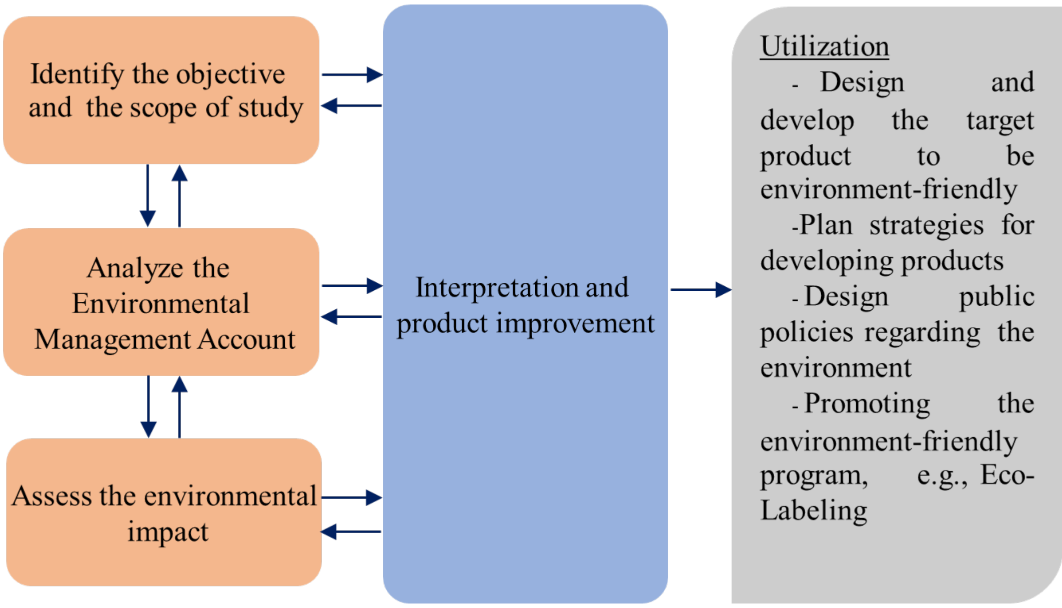

Figure 1: Study framework.

The life cycle analysis is depicted in Figure 2 as material flow analysis (MFA) which shows the scope of product life assessment (in this case, cradle to gate). For cradle to gate, the analysis focuses the life cycle only from resource extraction (cradle) to factory gate. However, if it is cradle to grave, the scenario will cover the whole life cycle of product (resource extraction, manufacturing, distribution, use and dispose). Moreover, another critical function of MFA is to identify the flow of materials in the manufacturing process of a certain product. Elaborately, MFA breaks the whole process into sub-processes and each sub-process has inputs (resources), waste (emission) and output (Hoekstra, 2011).

Another important method used to assess the potential of water footprint as a tool to raise the level of awareness is the questionnaires. They will be distributed before and after the workshop regarding the water footprint was carried on. The paired t-test was utilized to signify the different level of awareness after the workshop.

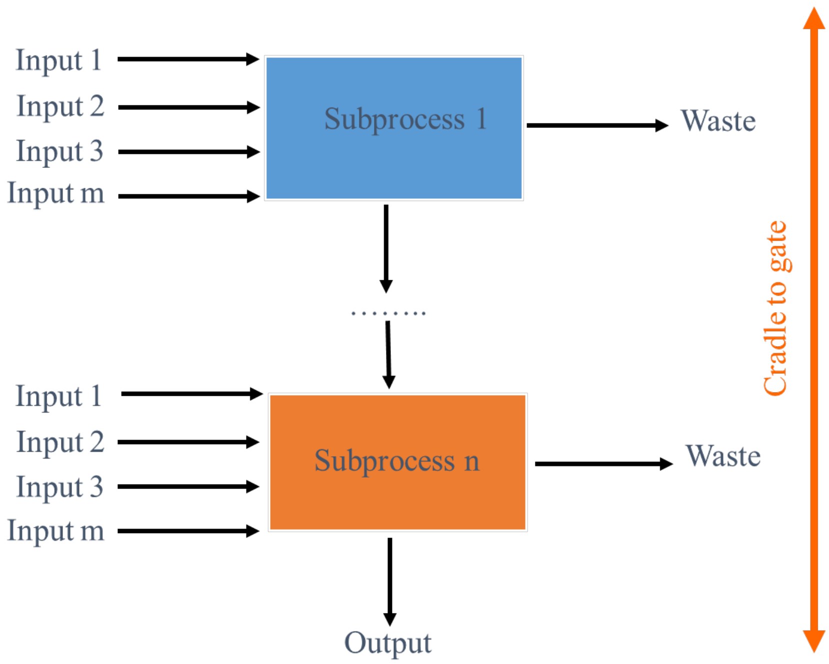

Figure 2: Material flow analysis.

Research Procedure

Since the target group of this study is the ceramic business owners and executives, the life cycle analysis of the ceramic product is limited to only cradle to gate which covers the impact from a partial product life cycle, i.e., resource extraction and manufacturing. A ceramic product which is used as the case study is a ceramic yellow jug for serving water. The weight of this jug is 500 gram and it is shown in Figure 3. Therefore, the function unit of product is a jug.


Figure 3: Ceramic jug.

To illustrate the life cycle analysis, the manufacturing flow chart is depicted in Figure 4 and it composes of six steps as follows: forming and finishing, biscuit firing, glazing, glost firing, polishing and packaging.

Input	Item	Unit	Quantity	Process
Raw material	Prepared ceramic body	g	450	Forming + Finishing
Resources	Electricity (Jolly machine)	kWh	0.004	
Resources	LPG	kg	0.3	Biscuit Firing
Raw material	Glaze	g	50	Glazing
Resources	LPG	kg	0.5	Glost Firing
Resources	Electricity (Polishing machine)	kWh	0.07	Polishing
Resource	Corrugated paper	g	60	Packaging

Figure 4: Manufacturing flow chart.

Water Footprint Calculation

According to the material flow diagram, there are three raw materials required to manufacture a ceramic jug, prepared ceramic body, glaze and corrugated paper (for packaging). Due to Table 1 and 2, the water footprint of prepared ceramic body (l/kg) is equal to 14.4 while the one of glaze is 65 l/kg (the data was forwarded from the suppliers who conducted the in-house experiment to determine the water footprint data). On the other hand, the water footprint of corrugated paper (l/kg) in Table 3 is equal to 38.9 (Corrugated Packaging Alliance, 2010).

Table 1: Water footprint of raw material extraction (prepared ceramic body).

Resource	Weight(kg)	Water Footprint (l/kg)	Total(l)
Prepared ceramic body	0.45	14.4	6.5

Table 2: Water footprint of raw material extraction (ceramic glaze).

Resource	Weight (kg)	Water Footprint (l/kg)	Total (l)
Glaze	0.05	65	3.25

Table 3: Water footprint of raw material extraction (corrugated paper).

Resource	Weight (kg)	Water Footprint (l/kg)	Total (l)
Corrugated paper	0.06	38.9	2.334

Therefore, the total water footprint due to the resource extraction equals 6.5+3.25+2.334 = 12.084 liter. The forming, finishing and polishing tools are run by electricity which is generated by natural gas. However, the fuel of kiln is LPG (liquefied propane gas). The water footprint calculation for electricity and LPG is shown in Table 4 and 5.

Table 4: Water footprint of generated electricity.

Resource	Process	Quantity (kWh)	Blue Water Footprint (5.6 l/kWh)	Gray Water Footprint (5.7 l/kWh)	Total(l)
Electricity	Forming and Finishing	0.004	0.0224	0.0228	0.0452
Electricity	Polishing	0.07	0.392	0.399	0.791
					0.8362

The water footprint shown in Table 4 obviously shows that the generated electricity is contributed to both blue and gray water footprint. Since the blue water footprint equals 5.6 l/kWh while the gray water footprint is 5.7 l/kWh, the generation of electricity causes more polluted water than the used water (the amount of gray one is higher than the blue one.). In conclusion, the electricity used to manufacture a jug leads to the water footprint of 0.8362 liter.

Table 5: Water footprint of LPG.

Resource	Process	Quantity (kg)	Blue Water Footprint (2.51 l/kg)	Gray Water Footprint (2.51l/kg)	Total (l)
LPG	Biscuit Firing	0.3	0.75	0.75	1.5
LPG	Glost Firing	0.5	1.25	1.25	2.5
					4

According to Table 5, the blue and gray water footprint are equal to 2.5 l/kg and this implies that the extraction of LPG spends the same amount of surface water as the water it polluted (EPE Empresa de Pesquisa Energética, 2012). Totally, the water footprint of LPG for a jug is equal to 4 liter. In conclusion, the total water footprint of the resource extraction and fuel used is shown in Table 6. Therefore, the water footprint of a ceramic jug (cradle to gate) is equal to 16.9202 liter.

Table 6: Total water footprint.

Product	Water footprint (Resource extraction)			Water footprint (fuel)		Total (l)
	Ceramic prepared body	Glaze	Paper	Electricity	LPG	
Ceramic jug	6.5	3.25	2.334	0.8362	4	16.9202

Level of Awareness

Two groups of samples are selected to be studied. The first group is the business owners and top executives (N=9) while the second group is the mid-level management (N=15). The last group is the operators in the workshop (N=20). All of them is working in the ceramic business. The level of awareness is started from distributing questionnaires by mails to all groups of respondents. Afterwards, all respondents was invited to participate in a one-day workshop. The content covers the life cycle analysis, the water footprint calculation as well as the above case study. After the class, the same set of questionnaires is re-utilized to assess the awareness. The questions are adapted from Carbon awareness questionnaires (available on https://www.dorsetforyou.gov.uk/media/191602/Carbon-Awareness-Questionnaire/s) which are designed to assess the following aspects: attitude, environmental impact, water cost and waste, water saving, water usage reduction and motivation.

Table 7: Descriptive statistics of the questionnaire.

Question	Pre-training		Post-trainig		Mean Differnce
	Mean	S.D.	Mean	S.D.	
Q1: To what extent is your general attitude towards reducing your water footprint?	1.21	0.98	3.95	0.81	2.74
Q2: How aware are you of the environmental impact of water usage?	1.58	1.04	3.51	0.78	1.93
Q3: What is your level of awareness of water costs and where water is wasted?	1.96	1.21	4.05	0.89	2.09
Q4: How aware are you of the ways in which you can save water?	1.41	1.44	4.29	0.82	2.88
Q5: Other than reducing your water use, how aware are you of the other ways to reduce your water footprint at work?	1.77	1.13	3.69	0.96	1.92
Q6: How motivated are you to reduce your water footprint?	1.28	1.22	4.41	0.85	3.13
Q7: The life cycle analysis for water footprint is useful for	1.15	0.98	4.69	0.91	3.54

create environmental awareness.					

The paired t-test was conducted to assess the knowledge and awareness of experimental group regarding the water footprint by comparing the pre-workshop and post-workshop means. The results signify that there both means differ significantly ($p<0.01$). Therefore, the conclusion is that the awareness of the top-executive and workforces towards the environment increases dramatically after water footprint has been used a tool.

Conclusions

Theoretically, environmental awareness is the issue that comes to the interest of many people. Although a lot of information regarding the environment keeps flowing to the society through different mediums, a number of people still finds that the environmental issue is not tangible. As a result, this study focuses on the utilization of the water footprint concept an instructional media to raise the environmental awareness of a specific group of people (who works in the ceramic industry). Based on the life cycle analysis, the water footprint of a case study (a ceramic product) is calculated to show a certain amount of water contributed to manufacturing a ceramic jug. Afterwards, the lesson learned from the computation of water footprint was used to train the target group with the objective to raise the environmental awareness. The pre-test and post-test were used to assess the awareness of the corresponding group while the paired t-test shows that the level of awareness before and after the test is significantly different after the water footprint training was introduced to the target group. Therefore, the practical water footprint method is proved to be effective in alleviating the awareness of people towards the environment.

Discussions and Further Studies

The accuracy of water footprint calculation heavily relies on the inventory data. However, the preparation of inventory data in Thailand is not standardized. Therefore, most of the data is adopted from the foreign sources. This practice has the influence on the final result of the calculation. Since the target group of this study is the people who works in the manufacturing, the life cycle analysis only convers the manufacturing stage. However, the research study might be interesting to a large group of people if it is extended to the whole life cycle of the product (including distribution, use and dispose).

References

Attari, S.Z. (2014). Perceptions of Water Use. Proceedings of the National Academy of Sciences, 111(14), 5129-5134.

Badruzzaman, M., Oppenheimer, J., Hess, T., Smith, H., Upson, S., Postle, M. & Jacangelo, G. J. (2014). Water Footprint: A New Concept for Sustainable Water Utilities, Denver: Water Research Foundation.

Corrugated Packaging Alliance (2010). Corrugated Packaging Life-cycle Assessment Summary Report. Grove Village.

Čuček, L., Klemeša, J. J. & Kravanja, Z. (2012). A Review of Footprint Analysis Tools for Monitoring Impacts on Sustainability. Journal of Cleaner Production, 34, 9-20.

EPE Empresa de Pesquisa Energética (2012). National Energy Balance 2011: Base year 2010. Rio de Janeiro: Ministério de Minas E Energia.

Gerbens-Leenes, P. W. & Hoekstra, A. Y. (2008). Business Water Footprint Accounting, Delft: UNESCO-IHE Institute for Water Education.

Hoekstra, A. Y. & Chapagain, A. K. (2007). Water Footprints of Nations: Water Use by People as A Function of Their Consumption Pattern. Water Resource Management, 21(1), 35-48.

Hoekstra, A. Y. (2011). The Water Footprint Assessment Manual: Setting the Global Standard. London: Earthscan.

Noga, J. & Wolbring, J. (2013). Perceptions of Water Ownership, Water Management, and the Responsibility of Providing Clean Water. Water, 5, 1865-1889.

Contact email: kandananond@hotmail.com