FEASIBILITY STUDY: ESTIMATION OF WATER USAGE IN USM ENGINEERING CAMPUS HOSTELS

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ABSTRAK

Projek penyelidikan ini bertujuan untuk mengira penggunaan air di asrama Kampus Kejuruteraan USM menggunakan dua cara iaitu pertama, menggunakan kaedah kadar yang berdasarkan bacaan meter di blok SH1, dan kedua adalah kaedah yang menggunakan data daripada soal selidik. Kemudian, perbezaan antara dua cara tersebut ditunjukkan dan dibincangkan dengan mendalam. Terdapat tiga objektif yang perlu dipatuhi iaitu pertama mencari perbezaan penggunaan air antara pelajar perempuan dan pelajar lelaki, kedua adalah kesan cuaca terhadap trend tingkah laku manusia dalam menggunakan air dan terakhir adalah pengiraan peratusan perbezaan antara dua kaedah pengiraan pengunnan air di tapak kajian iaitu Kampus Kejuruteraan USM. Bagi kaedah pertama, soal selidik telah dibuat untuk menganggarkan penggunaan air bagi setiap orang di setiap asrama. Faktor dalaman tertentu dimasukkan dalam soal selidik untuk melihat kepentingannya kepada penggunaan air. Melalui soalan-soalan tersebut, pelajar akan ditanya tentang penggunaan air untuk tiga keadaan cuaca yang berbeza. Maklumat ini kemudiannya akan digunakan untuk mengira penggunaan air untuk seorang pelajar di setiap asrama dalam tiga keadaan cuaca berbeza, tertakluk kepada suhu. Secara purata, seorang pelajar perempuan menggunakan 0.246 m^3 air setiap hari manakala seorang pelajar lelaki menggunakan 0.236 m^3 air setiap hari. Kemudian, dalam konteks keadaan cuaca, secara purata, seorang pelajar menggunakan sehingga 0.421 m^3 dalam cuaca panas, manakala dalam keadaan cuaca medium, penggunaan air bagi setiap orang ialah 0.241 m^3. Semasa cuaca sejuk, seorang pelajar menggunakan 0.209 m^3 air setiap hari. Kaedah kedua adalah pengunnan air yang dikira berdasarkan bacaan meter di SH1. Peratusan perbezaan di antara dua kaedah dikira di mana, SH4 mempunyai peratusan tertinggi dengan 32.62% dan SH5 mempunyai peratusan paling rendah iaitu 20.89%. Dalam konteks penyimpanan air, data menunjukkan pelajar yang tinggal di blok asrama menyimpan lebih banyak air daripada pelajar yang berada di rumah.

ABSTRACT

This research project aimed to calculate the water usage in USM Engineering Campus hostels using two approaches, first one using approximation based on water meter in one of the hostel building in the campus and another approach is using information from questionnaire. Then, the differences between those two methods were observed and discussed. There are three objectives needed to be followed, with first one is to find the difference is water usage between female and male students, second one is the effect of weather to human behavioural trends in using water and lastly is the determination of percentage of estimation error between the two approaches of calculating water usage at the site of the study, which is the USM Engineering Campus. In first method, to calculate the water usage, a questionnaire was made to estimate the water usage per person in each hostel. Certain internal factors, such as gender, age and ethnicity were included in the questionnaire to see the significance of them to the water usage. The questions will ask students on how much time they take a bath, for toilet, brushing teeth and even cooking, for three different weather condition. The information later will be used to calculate water usage of a student in each hostel in three different weather condition, subjected to temperature. By average, a female student used 0.246 m^3 water daily while a male student used 0.236 m^3 of water daily. Then, in context of weather condition, by average, a student used up to 0.421 m^3 in hot weather, meanwhile in average, the water usage per person is 0.241 m^3. During cold weather, a student use 0.209 m^3 of water daily. Second method is where water usage is calculated using approximation based on SH1's water usage. Then, the percentage of estimation error was calculated for each hostel where SH4 having the highest percentage with 32.62% and SH5 having the lowest percentage with 20.89%. In term of water conservation, data shown students living in hostels saved more water than students at home.

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SPAN	Suruhanjaya Perkhidmatan Air Negara
lcpd	Litre per capita per day
EPA	Environmental Protection Agency

CHAPTER 1 : INTRODUCTION

1.1 Background Study

Water is a basic necessity in human life. Human need water to stay alive, considering most of our body is made of water. Water is needed for drinking, cleaning, etc. However, overpopulation nowadays became the biggest threat to clean source of water and some of the country didn't manage to get the access to the clean water.

Water is especially being used excessively in urban area and each household has different behaviour of using the water. Lots of water is wasted daily. According to a statistic by WaterSense Label, an average person unknowingly wastes about up to 30 gallons water per day. Meanwhile, each household or family in America wastes about 180 gallons of water per week, 9400 gallons annually and this is just from leakage. (EPA, 2022) The average family can save 13,000 gallons of water and $130 in water costs per year by replacing all old, inefficient toilets in their home with proper water-saving products. Also, small acts of saving water such as close water tap when not using and such affected so much in the statistics. This led to the importance of awareness of water conservation in each person.

There are a lot of factors affecting to the different behaviour of human in using the water. The factors can be divided into two, internal and external factors. Internal factors mean the factors are influencing human behaviour by tackling the psychological state and usually are not visible to naked eyes. Meanwhile, external factors are the factors that affecting human behaviour too but from the outside as such human surroundings. These factors will determine how human in a community will use water daily and also their will to save water from wastage.

Throughout the study, the water usage per capita is highly emphasised where this is used to indicate human behaviour in using water and how they differed in different situation and influences. Therefore, in this study, the USM Engineering Campus hostels were used as an indicator of a community to figure out the behaviour of residents in the premises, which are the students in using water. For this proposed research project, the estimation of water usage was done using two methods at the hostels in USM Engineering Campus where the research will focus on to prove either the statements in the case study is relevant or not. In this project, the observation will be done on how certain characteristics will influence on the water usage among students. At the end of the project, the percentage of estimation error between the two methods of calculating water usage in USM Engineering Campus will be calculated.

1.2 Problem Statements

One of the characteristics in humanity is based on the socio-demographic which include ones educational level, income, age, ethnicity, gender and also psychological constructs such as habits, religion and belief. The thing is, the more variation of characteristics in humanity, the more type of water-using habits that can be seen. In a case study by Shan Yixing et.al, it is said that in a household with women, teenagers, and children have significant increase in water usage. From the case study made in Poland, it just concluded with the fact that women use more water than men (Shan Yixing et.al, 2015). This research was made in order to find out whether in year 2021, is women in Malaysia use more water just like in Poland or rather, did men use more water?

Weather is a state of the atmosphere at a particular place and time as regards of heat, cloudiness, dryness, sunshine, wind, rain, etc. In some case study, during hot weather, human uses more water than usual. In this research, the weather condition is

focusing on temperature, where the condition highly influenced and affected people psychology. By considering temperature, this research will provide an insight on how human behave accordingly and thus how much water used for each day.

As known, in each building, there will be a monthly bill comes in and people should pay for the water that has been used. There has been always the case where people think that he/she used less water that particular month, but eventually the bill received is high. This indicates that there is a significant amount of water loss in between water people actually used to water they were billed for. In this research study, the two methods of estimating water usage representing the situations mentioned. First method, the estimation of water usage using survey information represent water people think they used daily, while second method, calculation of water usage using water meter in SH1 represent the water usage people actually are billed for.

1.3 Objectives

1. To study the differences of water usage between men and women.
2. To study how weather can influence human behaviour.
3. To determine the water usage in USM Engineering campus hostels using two different methods.

1.4 Scope of Study

This project uses both primary and secondary data. The primary data is the questionnaire where the data will be obtained after conducting a survey to specified targets. And another one is the water meter reading for daily water usage in SH1 for year 2021. For this project, the questionnaire is done online using the Google form. Meanwhile, the target for the survey is the students in USM Engineering Campus that reside in hostels. Since the survey is done to get a trend of daily water usage, the target

is not limited to only students that reside in hostels. Students living outside the campus can also participate in this questionnaire. In the end of the survey, the difference in water usage behaviour between female and male students, how much students used water daily in each activity and also how different students used water in different weather condition should be able to obtained. Later, after the survey is done, the trend and data obtained is used to estimate the water usage in each SH buildings. The water meter readings was used to calculate definite or more accurate water usage in each hostel, considering it is from a water meter.

The second type of data is the secondary data where the data is definite and was taken from certain authorities such as the weather data, population data in USM Engineering Campus hostels and water bill of the campus. Several procedures must be followed to get these data.

In the end of the project, after the determination of the water usage using two different methods at respective facilities, which are the hostels in USM Engineering campus is done, the calculation of percentage of estimation error will be done.

1.5 Significance of study

This research study, subjected to water resources aimed to relate certain factors to human behaviour in using the water daily. Throughout this research, an updated version of information on water consumption in the USM Engineering Campus hostels will be done. This updated information will show on the variation of water consumption in each hostel while using questionnaire as the primary source of data. This research will show a different method of determining water usage in a community where the possible factors, internal and external are considered. The internal factor is the socio-demographic traits whereas the external factor is weather conditions. These factors will then

differentiate water usage of each student in each hostel. The needs to figure out the differences is that people themselves are varied. There is no way people could use the water in the same way. To the field of civil engineering, this research is needed as the in-depth investigation of the water consumption will be done.

Meanwhile, the water usage using water meter readings will also be done where it is the actual water usage being billed for. The water usage using the survey information is defined as the perspective water usage where it based on human's perspective. In fact, the two water usages can be different. Through this study, the percentage difference between the two water usage calculations was calculated and the reasons for the difference are discussed in more depth later.

Lastly, water conservation is very important since water resource is getting limited. Using the information gathered from questionnaire, the will to conserve water among engineering students is looked into.

1.6 Structure of dissertation

In this chapter, a brief introduction of the research study will be shown. The objectives and problem statements were included to express in details how the idea the research study comes from and in the end of the project, what outcomes should be anticipated of.

In chapter 2, the literature review of the study was done, where information was extracted in some cases study related to the research and put together according to their respective topics and sections. This chapter aims to explain the research topics in more details by taking cases study as references.

In chapter 3, the methodology, will explain in details on processes to undergo this project. Everything from materials, apparatus, methods, formula used will be mentioned to help ones understand more on the work flow. This chapter is highly dependent on the

objectives mentioned in chapter 1 where every process will help to achieve the objectives, and solve the problem statements.

In chapter 4, the results and discussion for every data included in the study were done. There are 2 types of data, primary and secondary. Primary data is the survey data and water meter reading in SH1, while secondary data is the raw data retrieved from third party, such as weather data, population data, and even water bill. Both of these data will be used in calculating water usage in each hostel and thus, enabling to determine percentage difference between the two calculation methods of water usage. Detail explanation and discussion on the data and outcomes was done.

In chapter 5, summary on the study was done, such as the water usage for both methods and the percentage of estimation error between the two methods. Also, the recommendation and room for improvement was mentioned.

CHAPTER 2 : LITERATURE REVIEW

2.1 Introduction

Water is one of the basic needs and is required by all life on earth. It dominates a majority of the space on our planet, covering about 71% of the total surface area of Earth (P.Senthil Kumar and P.R.Yaashikaa, 2019). Human cannot live without water since it is as important to livings just as how important air or oxygen to a human. Human will die without access to clean drinking water for more than three days. Therefore, it is very crucial to always have clean water in stock, if not for daily uses, for drinking purposes. Water conservation is very important to keep clean water resources around the world to be always in stock. People in urban countries have no problem to access clean water resources in daily life, in fact, they have more to the point that some of them waste this great source of nature. Different story for people living in rural countries that have limited, to almost none clean water resources. In other words, 1.5 million citizens do not have secure access to drinking water (INEI, 2016). In regard to those people, water conservation must always be emphasised in humanity so others won't suffer.

2.2 Importance of water

Water is a daily necessity where every living thing on earth uses them. Without water, there will be no life. The most important value to water is that it served as a medium of living to human as human body is made of water aside from bones, flesh and blood. Water covers 70% of our planet, and it is easy to think that it will always be plentiful. However, freshwater—the stuff we drink, bathe in, irrigate our farm fields with—is incredibly rare. Only 3% of the world's water is fresh water, and two-thirds of that is tucked away in frozen glaciers or otherwise unavailable for our use (WWF, 2017).

With the rising of population, the access to clean water source is getting limited. As of now, there are at least 7.95 billion of people on earth (Source : UN estimates, Population Reference Bureau). Population growth particularly will limit the amount of water available per person, because an increase in per capita water consumption driven by development will intensify water demand, straining the local water supply (Cornelius Okello et. Al, 2015). 1.1 billion people lack access to water and 2.7 billion experience water scarcity at least one month a year. By 2025, two-thirds of the world's population may be facing water shortages. When waters run dry, people can't get enough to drink, wash, or feed crops, and economic decline may occur. In addition, inadequate sanitation—a problem for 2.4 billion people—can lead to deadly diarrheal diseases, including cholera and typhoid fever, and other water-borne illnesses (WWF, 2017).

2.3 Water Uses

Water is used in many ways. From the source, water is distributed to every possible communities existed. Each community may have different usage according to the type of uses included in the community. The uses can be for agriculture, industrial and also domestic or they can be all. UNESCO (2011) reported that water used at highest percentage quantity for agriculture with 70% of the freshwater, followed by industrial uses with 22% and followed by domestic use with 8%.

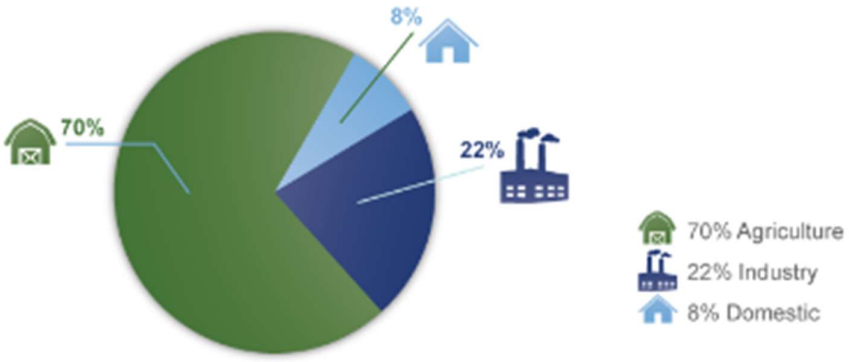

Figure 2.1 General chart of water uses in the world. (Source: Whale Coast Conservation)

2.3.1 Water in agriculture uses

As mentioned above, in general, 70% of the world's freshwater is used for agriculture. In 2008, of the total amount of extracted water, 88.7% was used for agricultural purposes, 9.2% for municipal use, and 2.1% for industrial use (including 1.1% for mining), (Daniel R. Rondinel-Oviedo and Jaime M. Sarmiento-Pastor, 2019). Based on the above statements, the majority of water used in agricultural purposes where it is mainly for irrigation. Besides irrigation, in agriculture, water is used in fertiliser and pesticide application, crop cooling, and frost control. The water from these activities is what causing water pollution since the water that mixed with pollutant such as pesticides and fertiliser flowed into the water bodies.

The crops that require lots of water uses are wheat, corn, rice, cotton, and sugarcane. Nuts are also a source of concern, especially since 74% of irrigated nuts are grown in regions facing water stress, like India, China, Pakistan, the Mediterranean area, and the US (Iulia Georgiana Ene, 2021).

There are some authorities using the water excessively. In Uzbekistan alone, cultivated lands increased from 1.3 million to 2.1 million hectares, with increasing

volumes of Amu Darya and Syr Darya river water being used for irrigation. The continued expansion of irrigated agriculture through the construction of huge irrigation systems markedly reduced river discharge to the Aral Sea (World Atlas of Desertification, 2012).

2.3.2 Water in industrial uses

Water is used in many activities and ways. One of them is in industrial uses, as such in factories, hospitals, hotels, malls, schools and more. Peru contains approximately 5% of the world's freshwater, with about 74,000 m3 per person per year (Comité Nacional del Libro Azul para el Perú, 2016, p. 36).

Among the industries mentioned, manufacturing industries used the most water. In manufacturing industry itself can be divided into several industries such as fashion, automotive, beverages, meat, machinery, papermaking and much more. Every country certainly has one or more industries that can secure their economy. That being said, each country has different industries they focused on. In general, 79 billion cubic metres of freshwater used yearly by the fashion industry making it the most water-consuming industry in the world. This is mainly because of high water demand of the cotton, the main material in clothes. It takes 7,000 litres of water to produce one pair of jeans, the same amount one individual drinks in 5-6 years. A T-shirt requires 2,700 litres of water, enough for a person to keep thirst away for almost 3 years. In 2015, the fashion industry consumed enough water fill 32 million Olympic-sized of pool (Iulia Georgiana Ene, 2021).

A study by E. S. Spang et al. (2014) estimated that the world's energy production consumes approximately 52 billion cubic meters of freshwater each year. This significant water volume comes mainly from power plants needing it for their cooling processes.

This technology is characteristic of fossil fuel and nuclear power plants. Moreover, bioenergy crops like sugarcane and rapeseed use large quantities of water for cultivating the plants. Processing the ethanol or biodiesel they generate also requires some high volumes of water.

Next, the industry of processing foods and drinks also consumed a lot of water where it takes 15,000 litres of water to produce 1 kilogram of beef and over 10,000 litres to produce 1 kilogram of sheep meat. According to the Beverage Industry Environmental Roundtable, 19 companies reported a total water use of 746 billion litres in 2017. This would be enough for over 1,081 million people to drink in one year. It takes 350 litres of water to produce one litre of soda, while one litre of beer requires 155 litres of freshwater.

In Europe, the mining and quarrying industry is responsible for about 4% of the water consumption, while the construction industry for around 3.4%. It takes around 148,000 litres of water to produce a car. Producing one tire only requires close to 2,000 litres. A ton of cement requires over 5,100 litres of water, while a ton of steel needs almost 235,000 litres. A single board of lumber takes 20 litres to grow (Iulia Georgiana Ene, 2021).

Meanwhile, in Canada, the highest usage of water also goes to manufacturing industry accounted for 7,778.9 million cubic metres. As indicated in chart below, five industries accounted for over 83% of the 2005 total intake. Different from general statistics explained above where instead of fashion industry, at 33.4% of the total, the largest quantity of water withdrawal in Canada was made by the paper industries. This was followed by the primary metal industries at 20.6% and the food industries at 17.6% of the total water intake by manufacturing industries. Significant withdrawals were also

made by the chemical industries at 6.8% of the total and the petroleum and coal industries at 4.7% (Statistic Canada, 2012).

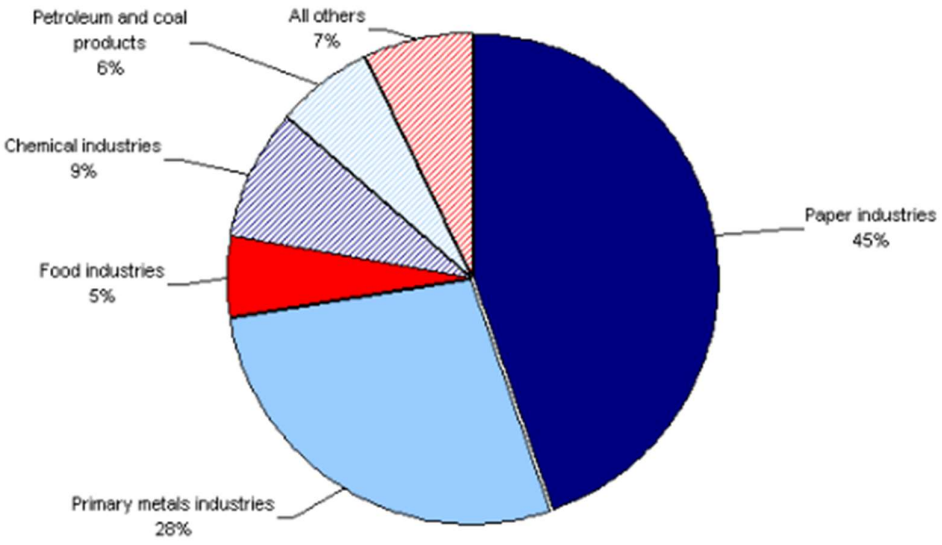

Figure 2.2 Chart of industrial water uses in Canada 2005. (Source : Statistics Canada)

2.3.3 Water in domestic uses

Water, as said before, is used in many ways and in a many activity. In domestic use only, the usage of water in each household is different. Some household use more water in irrigation, some use water more in shower, and some may use more in toilet uses. According to data analysed by the Energy Saving Trust, showering accounts for a quarter of the water consumed within UK households. In the Netherlands, a population survey indicated that the main end uses of household water were shower (40 per cent), toilet (28 per cent) and washing machine (12 per cent), while analysis of the North American Residential End Uses of Water study [7] indicated that, in single-family homes, more than half of the water consumption was taken by outdoor activities (58.7 per cent), e.g., irrigation and use of swimming pools while, for indoor end uses of water, the top three activities were toilet flushing (26.7 per cent), using the washing machine (21.7 per cent) and showering (16.8 per cent), (Yixing Shan et al., 2015). Many factors

could have influence to these differences in water usage, such as external and internal factors. More details on these factors will be explained in next section.

Figure 2.3 Domestic water uses (Source : Water Research Foundation, 2016)

2.4 Factors influencing human behaviour towards water usage

2.4.1 Internal factor (Socio-demographic characteristics)

Internal factor is the factor influencing something that can be controlled to some extent. In this research, the internal factor is the socio-demographics characteristics where socio-demographic is the characteristics of a population. Socio-demographic characteristics include household size, educational level, income, age and gender. A high income facilitates purchase of more efficient appliances; however, this saving may be negated by a reluctance to modify habits, for example, by delaying using the washing machine until a full load has accumulated (Yixing Shan et al., 2015).

For this research, the whole study is done in USM Engineering Campus where only engineering students were involved. Characteristics like household size, educational level, income are negligible since we consider all respondents are of the same level. The only things different are in term of gender and age.

2.4.1.1 Gender

As explained above, the gender characteristic was chosen to differentiate water usage behaviour among students of USM Engineering Campus. The two gender, male and female are said to use water differently, where women govern the water usage in each household. They found that the presence of females and children (and teenagers, in particular) was associated with increased shower water usage (Yixing Shan et al., 2015). In this research, we will prove either women really use more water than men, or instead men use more? The differences might have a very small margin since both male and female respondents have the same educational level, but even with the smallest bit of margin could affect the final outcomes for the water usage later in the procedure. As examples of reference values for drinking water consumption, World Health Organization (WHO) has adopted 2 L as a standard quantity of daily consumption of drinking water for adults, while European Food Safety Authority (EFSA) recently suggested using 2 L for females and 2.5 L for males for total daily water consumption from beverages and food (Melle Säve-Söderbergh et al., 2017).

2.4.1.2 Age

Based on a case study by Yixing Shan, in a typical household, teenagers and children used up much water than adults. This is probably because of the lack of awareness in conserving the water among youngsters. This one characteristic is an additional variable added to the research. Age can also be the factor to influence the water usage among students. However, this data may be neglected as the range of age among students doesn't differ much. Students may be different in like 1 to 5 years to each other. And even if there are returnee students with much older age, they are relatively in minority group and

don’t affect too much on the results. Even so, if the differences of water usage for different ages is significantly large, the data can be considered.

2.4.1.3 Educational level

Human behaviour in water usage based on educational level is pretty ambiguous since there is no precise data showing how different level of education may affected the water usage. People with high and low educational level behaves pretty much the same in front if the water source. In some studies, those most committed to conservation were those with the highest educational level [Lam S. (2006), Gilg A., Barr S. (2006)]. However, in the study by Gregory and Di Leo (2003), those with the greatest number of conservation behaviours were those with the lowest educational level. Corral-Verdugo and Pinheiro (2006) found educational level to have no effect on water conservation behaviour. Nor was a significant effect found by Fielding et al. (2012), although in their case, they informed of a possible overlapping between education and income level.

2.4.1.4 Ethnicity

Ethnicity is highly related to certain culture. Different ethnics counter for different culture. Some cultures may have significant perspectives towards water usage and conservation. People’s decision-making vis-à-vis water consumption, such as purchasing particular home appliances e.g., using a water-efficient washing machine, tend to be economic; but, their decisions are either directly or indirectly attached to preferences and habits which stem from norms and beliefs developed in certain cultural context (Elizondo & Lofthouse, 2010a; Gibson et al., 2011; Medd & Shove, 2005). In other words, the values behind decision-making are ‘fundamentally cultural’ (Gibson et al., 2011, p. 5). Allon and Sofoulis (2006) suggest that culture, as a combination of values, practices and

interactions, is also helpful in understanding the importance of daily water-usage related activities, such as daily showers, dishwashing or watering a garden.

Given that water use attitudes and practices are closely related to culture, and that diverse cultural beliefs and practices give rise to diverse cultures of nature, the question is, in terms of water management: how should demand-management strategies deal with cultural diversity and sensitivity (Medd et al., 2007). Ethnicity has been considered one potential way of approaching cultural diversity and sensitivity (Medd et al., 2007). However, the influence that ethnicity has on domestic water use, as well as the diverse cultural knowledge brought by ethnic minority groups pertinent to domestic water use, remains under-explored.

2.4.1.5 Religion

Muslim take in average five times of ablution per day to perform prayer. The average use of water for a Muslim for an ablution is 5 litres (T.S. Mr. Rahman, 2008). This means a Muslim used around 25 litres of water daily for ablution. Chinese and Indian just use water only for shower and toilet use. From information provided, it can be concluded that, physically, religion more or less affect water usage where this only applied to Muslims. In this research, this trait is not included in the calculation of water usage since there is no way of knowing the exact times a Muslim take ablution daily. Some may take five times, four times, and even three times daily. Some even took ablution right after a shower. The inconsistency of the times ablution taken by each Muslim each day also being one of the reasons for this trait to not be included in calculation.

In scope of water conservation, in the other hand, religions may not affect much on human psychology. Being committed to religion does not mean an individual is kind

enough to conserve water in his/her daily life. No scientific study could be found researching how faith can influence members of a religion so to adopt more environment-friendly behaviours. Konisky (2017) concluded in a later study, investigating whether there was a greening of Christianity in the past decades in the United States, that:

> "Like most survey research in this area, important questions are left unanswered. For example, establishing correlations (positive or negative) between religious identity and environmental attitudes do not provide an explanation as to why affiliation with different faiths is associated with environmental concern."
>
> (Konisky, 2017)

2.4.1.6 Habits

Water conservation may depend on an individual's habits. Good habits lead to water-saving while bad habits will lead to water wastage. Ones habits can lead to good intentions to conserve water. Jorgesen et al. (2012, p. 133) further indicated that habits have a positive effect on intention to conserve water – especially where people perceive conservation as being part of their daily lives and consistently looked for opportunities to participate in water conservation activities. Some studies have indicated that habits are difficult to change and consequently the instilling of repetitive behaviours amongst people is said to yield better results, meaning that habits thus exercise an influence on the intention to conserve water (Mallett & Melchiori, 2016, p. 223). Intention, as defined by Untaru et al. (2016, p.51), indicates an individual's readiness to engage in a certain behaviour. The stronger the intention, the more likely the behaviour is to be carried out (Kim & Han, 2010, p. 998).

H1: Attitude will have a significant influence on the intention to conserve water.

H2: Subjective norms regarding water conservation will have a significant influence on an individual's intention to conserve water.

H3: Intention to conserve water has a significant and positive influence on water conservation behaviour.

H4: Living habits will exercise a significant and positive influence on intention to conserve water.

H5: Living habits will exercise a significant and positive influence on water conservation behaviour.

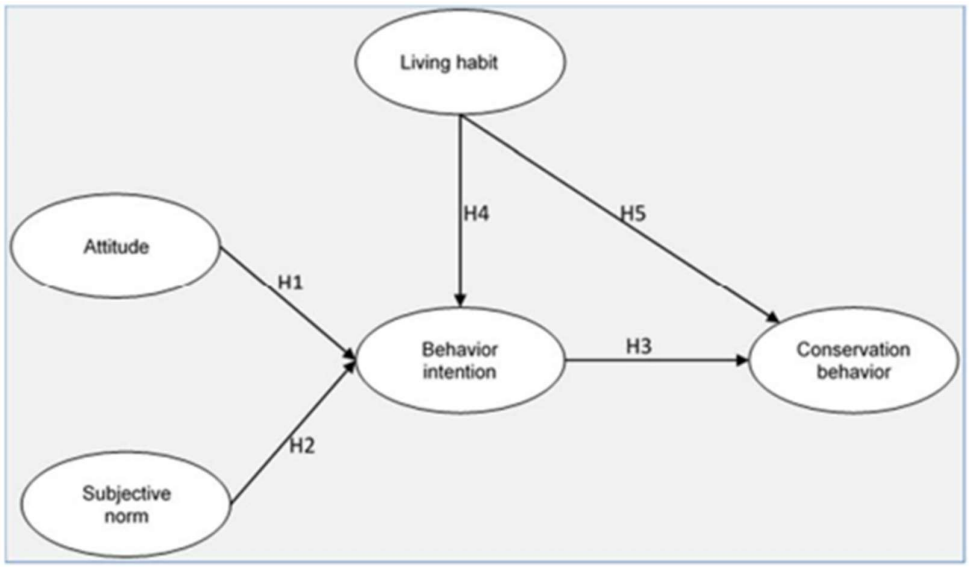

Figure 2.4 Conceptual model of elements leading to water-conserving behaviour.

(Source: Palesa T. Gule et al., 2014)

2.4.1.7 Health status

Health level of a human affected on amount of his/her drinking water. The daily four-to-six cup rule is for generally healthy people. More than that amount is possible if an individual have certain health conditions, such as thyroid disease or kidney, liver, or heart problems; or if he/she is taking medications that retain water, such as non-steroidal anti-inflammatory drugs (NSAIDs), opiate pain medications, and some antidepressants (President and Fellows of Harvard College, 2022).

According to article in Healthline, written by Kris Gunnars (2020) which later was medically reviewed by Natalie Butler, R.D., L.D, human in certain health conditions may need more water than someone's healthy :

- If an individual has an infection or a fever, or has been vomiting or having diarrhoea, he/she will need to drink more water. Person with health condition like diabetes also need to drink more water. Some medications like diuretics can also make a person loses water.
- If a woman is pregnant or nursing her baby, as such breastfeeding, she'll need to drink extra water to stay hydrated, since her body is doing the work for two (or more), after all.
- A person is also likely need to drink more water if his/her diet is high in salty, spicy, or sugary foods. Or, more water is necessary if he/she don't eat a lot of hydrating foods that are high in water like fresh or cooked fruits and vegetables.

2.4.1.8 Job / Workload

Workload is the length of time for someone to carry out activities according to his work capacity without showing signs of fatigue. If the workload is too heavy, it will affect someone's performance (Hariono W, et al, 2009). Person that having heavy

workload daily consumed much more water than person that just having deskwork. Heavy workload is associated with excessive sweating, also means a person can loss a lot of water from his/her body from working. To replace the water losses, people having heavy workload drink more water daily and also uses more water to clean themselves. If he/she is active during the day or walk or stand a lot, he/she'll need more water than someone who's sitting at a desk. If he/she exercise or do any intense activity, he/she will need to drink more to cover water loss (Kris Gunnars, 2020).

The rate of perspiration varies considerably, depending upon the climatic conditions, exercise intensity and clothing worn [1]. Sweat rates between 0.3 and 1.5 L per hr can be expected of workers in hot climates [2], resulting in large volumes of fluid loss over the course of a day. Drinking at mealtimes is important because eating encourages fluid intake, and electrolytes in food promote water absorption as well as replacing sweat losses [3] (Graham P Bates et. al., 2008).

2.4.2 External factor (Weather condition)

In contrast to internal factors, external factor is the one that we cannot control nor change its incoming. For this case, weather condition is used for the external factor that will affect the students' behaviour in using water daily. Weather is the state of the atmosphere at a particular place and time as regards heat, cloudiness, dryness, sunshine, wind, rain, etc. Geographic locations with cold winters and warm summers are especially sensitive. In such locations, two water consumption segments occur in the year: the warm part (spring-summer) and winter [2]. Cold temperatures, freezing precipitation and snow-covered ground surfaces, for example, tend to restrict water use to indoor activities in the winter. On the other hand, spring-summer warm temperatures and snow-free ground surfaces may induce significant increases in water consumption, both indoors and

outdoors (Dejan Dimkić, 2020). Among weather conditions available, only some conditions that are very influential to water usage behaviour. They are the temperature, rainfall intensity and rate of evaporation. In this research we didn't include the rate of evaporation as it is considered to be of the similar variable to the temperature.

2.4.2.1 Temperature

Temperature means the degree or intensity of heat present in a substance or object, especially as expressed according to a comparative scale and shown by a thermometer or perceived by touch. The temperature on weather condition can be hot or cool and each day will have different degree of temperature. This temperature will lead to rate of evaporation of water in surface or in reservoir. Also, human reacts actively towards temperature changes. Temperature impacts on drinking water consumption for the spring-summer months (average daily temperatures between 14 °C and 30 °C) in the analysed examples vary; T increases of 1 °C cause an average increase in the TWC from 1% (Serbia, South Korea and Bahrain) through 3% to 5% for cities in the USA and Canada (Dejan Dimkić, 2020).

2.4.2.2 Rainfall intensity

This one weather condition was used for two reasons, one of them of such this rainfall intensity is highly related to the temperature as to high rainfall intensity means the temperature for that day or month is low. And, low rainfall intensity indicates that the significant day or month have high average temperature. The second reason is that this rainfall intensity may affected on clean water sources. High rainfall intensity may result in increasing volume of clean water source in the reservoirs, ponds, lakes, etc. The reliance of the families upon multiple water sources is illustrated in Table 4. When calculated (only for families coded 1-5) rainfall was a key source (not harvested or stored

rainwater, but the estimated amount of rainfall used by rainfed crops), even for families with access to irrigation (Rocio Bustamante et al., 2004). If the rainfall was properly managed, it can be one of the main sources of clean water, instead of just relying upon rivers, lakes, ponds and even reservoirs.

The influence of maximum temperature is stronger than that of precipitation on water consumption at the monthly scale (Heejun Chang et al., 2014). In a case study in Dutch by Maria Xenochristou et al. (2018), it is said that no strong correlations were identified between water consumption and precipitation amount or duration. In other words, precipitation or rainfall is less likely to affect on human psychology in using the water daily.

2.4.2.3 Humidity

According to an article by Airthings (2022), humidity is a measure of the amount of water vapor in the air. Relative humidity measures the amount of water in the air in relation to the maximum amount of water vapor (moisture). The higher the temperature, the more water vapor the air can hold. While the effect of the relative humidity is particularly prominent during the summer, the effect of temperature and radiation are equally strong during the spring and summer months [1]. Out of the three weather variables that were found to have the highest correlation to consumption, humidity was the least influential one [2] (Maria Xenochristou et al., 2018).

For this research, humidity is not applied though Malaysia is a tropical country, having hot and humid weather condition throughout year, as accordance to the site location of the project, which is Nibong Tebal. Considering relative humidity will open up on more variables that later will lead to error in calculation. Therefore, it is assumed

that the location not having variation of relative humidity and instead, temperature data is used to indicate the different climate condition at the said location of the research.

2.5 Water demand

Water demand can be defined as the volume of water requested by users to satisfy their needs (EEA Glossary, 2022). There are a few types of water demand, domestic, industrial and commercial. Domestic demand includes water for drinking, cooking, washing, laundering, and other household functions. Public demand includes water for fire protection, street cleaning, and use in schools and other public buildings. Commercial and industrial demands include water for stores, offices, hotels, laundries, restaurants, and most manufacturing plants (Encyclopaedia Britannica, 2010).

2.5.1 Estimation of water usage

Estimation of water usage nowadays is by using metering devices. This water meter is available in every infrastructure includes houses, buildings, stores, schools, campus and more. This water meter will record how much each facility used water daily and accumulated them for monthly billing. However, without the water meter, there is another way to estimate water usage in desired facility. It is by approximation method where water usage for each activity that could possibly done in significant facility is estimated. Estimates vary, but, on average, each person uses about 80-100 gallons of water per day, for indoor home uses (Water Science School, 2019).

In a household, activities that use water are probably for toilet, shower, clean dishes, washing machine or hand washing clothes, cooking, irrigation or gardening and lastly, for drinking. The estimation of water usage during shower can be done by recording the time taken for a person to be done with a shower and how many times does he/she take a bath for a day. The average American shower uses 17.2 gallons (65.1 liters)

and lasts for 8.2 minutes at average flow rate of 2.1 gallons per minute (gpm) (7.9 lpm) (WaterSense label, 2019). A non-water- saving showerhead uses 5 gallons per minute. Water conserving showerheads use 2 gallons per minute. A full tub uses 36 gallons (NYC Environmental Protection, 2020). Meanwhile, the estimation of water usage for toilet uses can be done by recording how many times a person uses toilet daily and the water usage is estimated based on the flushing system. Most toilets use 5 gallons a flush. Water-saving, high efficiency, toilets use 1.28 gallons per flush (NYC Environmental Protection, 2020). Next, as for washing dishes, the duration for the dishes to be done is used to estimate water usage. Washing dishes with the water running uses about 15 gallons in 5 minutes. Filling the sink/ washing dishes without water running uses only 5 gallons (NYC Environmental Protection, 2020). And lastly, for teeth-brushing and hand and face washing, the estimation of water usage is done by approximation. Brushing your teeth with the water running uses about 4 gallons. Turning the water off when you're not rinsing uses less than a quarter or .25 gallons. Washing your hands or face with the water running uses about 4 gallons. Turning the water off saves 3 gallons, using only 1 gallon each time you wash up (NYC Environmental Protection, 2020). And lastly, a washing machine utilizes 15 gallons a load (EPA, 2020). For hand-washing clothes, the water usage is assumed to be the same as the water usage of a washing machine since we use the loading system.

For this research project, the whole set of study was in a USM Engineering Campus hostels where the residents are engineering students. Activity like washing dishes is included in cooking activities while, activities like teeth-brushing and hand and face washing are included with shower time. The water usage of toilet uses which is per flush and water usage for washing machine which is per load are the constant variables for the study. The 1.28 gallon per flush and 15 gallons per load are kept unchanged