COMPARATIVE STUDY OF WATER EFFICIENCY IN GREEN AND NON – GREEN BUILDINGS IN APPAREL INDUSTRY IN SRI LANKA

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ABSTRACT

At present, the amount of water demanded exceeds the water quantity that remains as a resource and it becomes scarcer each year. When it comes to water consumption in buildings, apparel buildings consume a considerable amount of water for both production processes and to fulfil the requirements of a large number of occupants. However, there are different perceptions towards water efficiency. As an example, one party is aimed at adhering the green building concept in order to retrieve water efficiency while another perception focus towards achieving water efficiency through various methods without giving consideration for adaptation of green status. Therefore, this study looks at how water efficiency is addressed and what benefits have being received for green buildings compared to non-green buildings.

Initially, a comprehensive literature review was carried out with the purpose of getting familiarized with research areas. Case study method was used to compare water efficiency status in green and non-green buildings in apparel industry. Two cases are selected from each building type for the data collection purpose. Semi structured interviews were carried out with respective industrial personnel and findings of case study was analyzed using the Nvivo.

Research findings revealed that both green and non-green building are having similar purviews on the consideration towards the water efficiency and integrated with high quality water efficient practices to enhance the water efficient performances of the buildings. However, certain good practices could be observed in green buildings compared to non- green buildings. That is, individual commitment of the organisation together with third party commitment is making the building more towards water efficient. Finally, the study provides recommendations for good practices towards water efficient practices in the apparel industry.

Keywords: *Apparel Industry; Green Buildings; Non-Green Buildings; Water Efficiency.*

1. INTRODUCTION

Water is essential to life and it is a finite resource for the human and the rest of the living world (United States Environment Protection Agency, 2013). According to Vorosmarty, Green, Salisbury and Lammers (2000) there is an imbalance between the available fresh water supply and demand, which results in "water scarcity". As per the World Business Council for Sustainable Development (2006), buildings contribution towards the total water consumption is at a considerable level. Smith (2007) states that compared to non-green developments, supply of green alternatives are effective and demands for those alternatives are continuously increasing. However, Roy and Gupta (2008) describe that even though green building is an effective and efficient concept by providing benefits such as use of less energy, water and natural resources, still it is conflicted by the price constraints. According to the Singapore's National Water Agency (2008), it provides guidelines to water efficiency in building designs not only limiting to green buildings, but also for non-green buildings as well. Thus, Society has different perception to achieve water efficiency. While some parties achieve this through the green building concept others develop their systems without considering about the green concept although they too gain different benefits in terms of water efficiency. Therefore, this condition creates an argument of whether water efficiency in green buildings is more efficient and effective than non-green buildings. On the other hand,

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there are many scholars conducted researches on water efficiency in green buildings and non-green buildings separately. Yet, there is a lack of concern on a comparative study regarding the above subject area. In respect to the above proclamations, it engenders a new problem between the gap of water efficiency in green buildings and non-green buildings. The study focused on apparel manufacturing companies. This study is therefore aimed to identify whether green buildings are truly water efficient than non-green buildings achieving the following objectives.

- To identify the water consumption in apparel industry.
- To recognize the different types of water efficiency processes and technologies.
- To analyse the water efficiency in green and non-green apparel buildings.
- To recommend good practices towards water efficient practices in the apparel industry.

2. BACKGROUND TO THE RESEARCH

Following sub section explores the relevant literature in the research arena where major focus is given to few areas; water consumption in apparel industry, green buildings, different types of water efficiency processes and technologies and finally Parameters to measure the water consumption in buildings.

2.1. WATER CONSUMPTION IN APPAREL INDUSTRY

Thiry (2011) argues that apparel industry is one of the largest industries in the world and apparel industry generally consumes huge amount of water which is resulting in increased of pressure on the available natural resources (Masupha, 2007). In addition to the water consuming production processes, apparel industry is also accountable for general water consuming activities such as drinking, cooking, sanitary use, cleaning, cooling, gardening, etc. (Volmajer *et al.*, 2012). Therefore, different manufacturing processes and activities effects in water consumption on apparel buildings which makes a significant impact on total water consumption in the world. As per Thiry (2011), scarcity of resources will make the apparel industry less feasible and more expensive to continue doing business as usual. Most of the apparel industries tend to conserve resources including water, more efficiently and effectively in order to mitigate their negative impacts (Thilakarathna and Silva, 2012).

However, apparel industries are now focusing on water efficiency systems and proper treatment applications, particularly with respect to environment legislations and international competition (Masupha, 2007). Therefore, most of the industries including apparel industry have now started to evaluate the water efficiency methods and also all over the industrial world enforce legislative measures to achieve sustainable water resource management (Masupha, 2007). According to Thilakarathna and Silva (2012), many apparel industries in Sri Lanka, renewed to ethical and sustainable factories. Few of leading apparel manufacturers in Sri Lanka already obtained green building certifications and identified water as a key resource to be concerned (Sri Lanka Apparel, 2009). Thus, next section discusses about the term “Green Building” concept.

2.2. GREEN BUILDINGS

The term sustainability ensures that it meets the present needs without compromising the ability of future generations to meet their own needs (Kates *et al.*, 2005). Then, green building has become a flagship under the sustainable development (Ali and Nsairat, 2009) and the water efficiency is one of the key objectives addressed by the “Green Building” concept (Nelson, 2007).

Waidyasekara *et al.* (2013) have done a comparative study of green building rating systems of eleven countries. The study identifies 10-15 range of credits is being allocated for water section. Figure 1 illustrates, weightage allocated for the water category by each rating system. When it comes to Sri Lankan context, the Sri Lankan Green Rating System allocates 14 points for water section out of total 100 points. This proves that water efficiency is an inherited feature in green building concept which is mostly addressed in the building’s design stage. However, unlike old days, most buildings exercise the energy

efficiency and water efficiency practices without compromising as green buildings and non-green buildings (Singapore's National Water Agency, 2008).

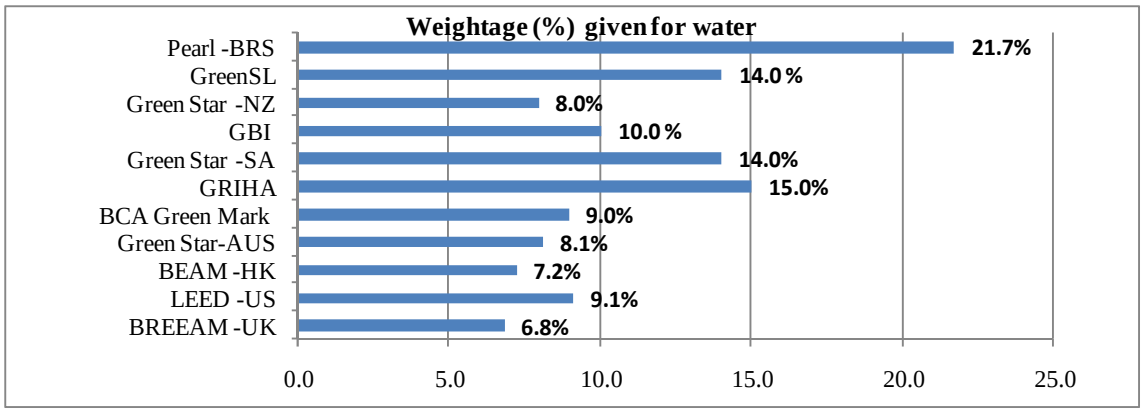

Figure 1: Weightage Given for Water Category by GBRS
Source: Adapted from Waidyasekara *et al.*, (2013)

2.3. DIFFERENT TYPES OF WATER EFFICIENCY PROCESSES AND TECHNOLOGIES

The different types of water efficiency processes and technologies describe under two sub-headings as Water efficiency processes to conserve water and different types of technologies to conserve water.

2.3.1. WATER EFFICIENCY PROCESSES TO CONSERVE WATER

Even traditionally, water efficiency received little or no attention in building design and operation, now there is a wide range of processes for improving the water efficiency in buildings (Mirata and Emtairah, 2011). Most scholars identified water hierarchy as the best process for efficient water usage in buildings, which is discussed in this section.

Mirata and Emtairah (2011) identify a ranking improvement option called "Waste Minimization Hierarchy" (see Figure 2) which is integrated with avoid, reduce, reuse, recycle and treat as major water efficiency methods in buildings. The priority order is decreasing along the triangle. Thus, according to the priority order, it is needed to implement the particular process or if not move to the next alternative along the priority order in order to address the different types of water efficiency processes in an optimum manner. Next Section describes some of the common water efficiency technologies can be used to conserve water in buildings.

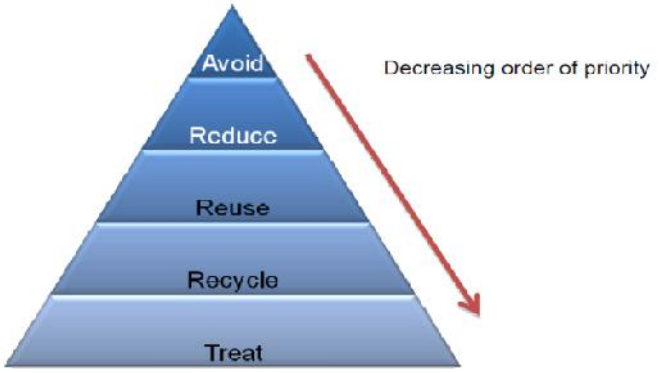

Figure 2: Hierarchy of Proffered Efficiency Process
Source: Mirata and Emtairah (2011)

2.3.2. DIFFERENT TYPES OF WATER EFFICIENCY TECHNOLOGIES TO CONSERVE WATER

According to various scholars, the term water efficiency almost always engaged with the technology. Table 1 shows available technologies that can be applied to any type of building to achieve efficient water management system.

Table 1: Water Efficiency Technologies

Water Efficiency Technology	Source
Water audits	Department of the Environment and Heritage, 2006; North Carolina Department of Environment and Natural Resources, 2004
Metering	
Rectifying leakages	
Retrofitting and replacing inefficient fixtures	North Carolina Department of Environment and Natural Resources, 2004
Water saving taps	Liu and Ping, 2012
Faucet aerators	Arab Forum for Environment and Development, 2010
Faucets with on-demand sensors	Environment Agency, 2007; Arab Forum for Environment and Development, 2010
Faucets with automatic shut-off systems	Arab Forum for Environment and Development, 2010; United State Department of Energy, 2002
Dual flush low flushing cistern	Arab Forum for Environment and Development, 2010; Singapore's National Water Agency, 2008; United State Department of Energy, 2002
Effective flushing volumes	Environment Agency, 2007
Low-flush and waterless (water-free) urinals	Singapore's National Water Agency, 2008; Environment Agency, 2007
Urinals with on-demand sensors	Arab Forum for Environment and Development, 2010
Waterless Urinal (Liquid Sealant Cartridge Type)	Singapore's National Water Agency, 2008
Urinal controls	Environment Agency, 2007
Use of grey water in flushing	Arab Forum for Environment and Development, 2010
Using pressure-reducing valves	United State Department of Energy, 2002; North Carolina Department of Environment and Natural Resources, 2004
Irrigation efficiency	North Carolina Department of Environment and Natural Resources, 2004
Reusing grey water	Environment Agency, 2007
Rain water harvesting	Environment Agency, 2007

2.4. PARAMETERS TO MEASURE THE WATER CONSUMPTION IN BUILDINGS

According to Tate (2000), water efficiency performance is affected by five basic parameters including gross water use, intake, recirculation, discharge and consumptive use (refer Table 2).

Table 2: Water Efficiency Parameters

Parameter	Description	Water Efficiency Requirement
Gross water use	the total amount of water used to carry out an activity	Low
Intake	the amount of "new" water taken into the operation	High
Recirculation	the amount of previously used water employed in the activity	High
Discharge	the amount of water exit from the activity or process	Low
Consumptive use	the amount of water used up during the process	Low

Source: Tate (2000)

Furthermore, Arab Forum for Environment and Development (2010), identifies that water efficiency technological features applied in buildings is also a common parameter that can be used to measure the water efficiency performance in buildings. Thus, above parameters are identified as the basic parameters to measure the water efficiency performance in buildings.

3. RESEARCH METHODOLOGY

Research methodology for the study followed several steps. As the first step, a background study was carried out to make clear the subject area and to develop the research problem statement by following a reference study on journal articles, online journals, e-books, web sites, electronic library data base and other publications. As the second step, case study interview guideline was developed with the purpose of investigating the research question of how green buildings are water efficient compared to non-green buildings.

Buildings which are maintained and operated in a same management were considered during the cases selection. Therefore, the research will not be affected by different organisational backgrounds and aspirations among the facilities. Thus, one case from each apparel building was selected for the study, based on access, availability and time limitations. Semi-structured interviews were used as the main data collection technique. The interviews were conducted with three key participants of each organisation. Finally, collected data were analysed using cross case analysis. The QSR.NVivo version 10.0 produced by QSR (Qualitative Solutions and Research Private Limited); computer software was used.

4. RESEARCH FINDINGS AND ANALYSIS

The findings from two case studies were discussed under several sub-headings as shown in Figure 3. Those will be the basis for following discussion. There are six headings. Contribution towards the water efficiency in general, Water efficient practices, Water consumption in green and non-green building in general and according to the process, driving factors for water efficiency on green and non-green buildings, and finally perceptions towards the green and non-green building will discuss in subsequent sections.

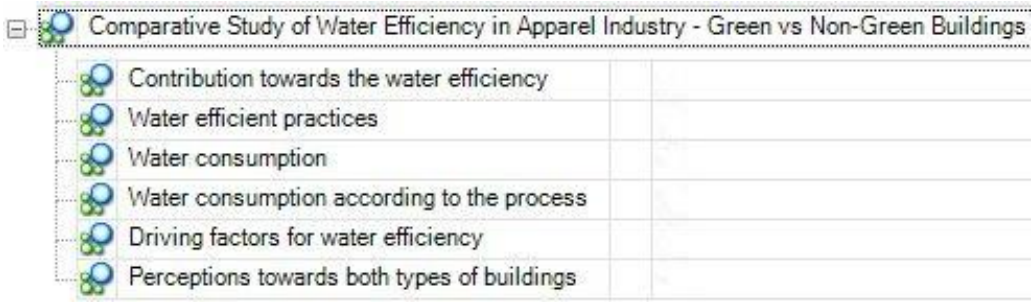

Figure 3: Coding Structure of the Research Findings and Analysis

4.1. CONTRIBUTION TOWARDS THE WATER EFFICIENCY

According to the empirical findings, Table 3 summarised the findings of general considerations towards the water efficiency in both organisations. It shows same purviews on establishing and maintaining sound water efficient systems on each building. The green building had claimed 12 points out of 14 point and was certified by the Green Gold Label in January, 2014. Thus, the green building received a sound attention on the water efficiency due to the concept of 'green' and 'the company sustainability policy'. Similarly, non-green building was also upgrading building's water efficiency performance based on the third party (sustainability division) evaluation, feedback and advises. However, at this point, it was observed that self-motivation of the internal management team of the green building was at a higher rate than the non-green building, in order to comply with the requirement of the Leadership in Energy & Environmental Design (LEED) and the company sustainability policy.

Thus, it shows both green building and non-green building had same purviews to uphold sound water efficient systems but, with the different attitudes towards water efficiency effort. The next section intends to identify existing water efficiency practices in buildings.

Table 3: Summary of the Consideration towards the Water Efficiency

	Green Building	Non-Green Building
Requirements	• LEED rating requirement • To reduce costs • To align with the company sustainability policy • To future water conservation • Uneven distribution of water throughout the year • To use as a marketing tool • To meet with the customer requirements • To meet with the local standards; EPL	• To reduce costs • To align with the company sustainability policy • To future water conservation • Uneven distribution of water throughout the year • To use as a marketing tool • To meet with the customer requirements • To meet with the local standards; EPL

4.2. WATER EFFICIENT PRACTICES

The below Table 4 summarises the findings of existing water efficient systems in both buildings.

Table 4: Summary of Existing Water Efficient Systems

	Green Building	Non-Green Building
Alternative Water Sources	tube wells, rain water harvesting, and grey water	tube wells, and grey water
Technological Applications	delay action push taps, water efficiency flush valves, dual flush cistern tanks, effective flushing volumes	delay action push taps, water efficiency flush valves, dual flush cistern tanks, effective flushing volumes, on-demand urinals
Metering And Sub-Metering	every possible point	only few points
Other	• Use only reused water for irrigation • Awareness programs	• Use only reused water for irrigation • Awareness programs

When it comes to water efficiency practices, as per empirical findings, both green building and non-green building contain similar water efficient practices such as use of alternative sources including well water and grey water, use of water efficient technologies including delay action push taps, water efficiency flush valves, dual flush cistern tanks and effective flushing volumes, use of reused water for irrigation and conduction of awareness programs as listed in Table 4. However, green building looks for more alternative water sources including well water, rainwater harvesting, and use of grey water than non-green building, where non-green building only rely upon the simply reachable and available water sources such as well water and grey water. Moreover, metering and sub-metering which is a primary criterion under the water efficiency and it is only regarded by the green building. As admitted in the LEED, the metering and sub-metering system was placed in recent years in the green building. However, for sub-metering, consideration was only given to possible water consuming points instead of all water consuming points.

When it comes to the non-green building, it was only weighted the total amount of water usage by the buildings. Therefore, both green building and non-green building contain similar water efficient practices except few differences such as; there were no on-demand urinals for green building and there were no rain water harvesting and metering and sub-metering system for non-green building. However, as per the theoretical findings, both buildings can enhance water efficiency systems by applying more technological applications which were discussed in the research background and most importantly, it is attentive to implement a sound metering and sub-metering system to uplift the efficiency of the water consuming systems. Thus, it will be enabled to have an overall view of the water consumption data in each and every water sensitive activity of the building. Because, even total amount of water usage is calculated, it is difficult to estimate water leakages, water losses and effects of the sub-water usage activities to the total water consumption of the building.

4.3. WATER CONSUMPTION IN GREEN BUILDING AND NON-GREEN BUILDING

Table 5 summarises the findings of water consumption of both buildings. As per empirical findings, both buildings were subjected to similar water consumption activities or processes including drinking, cooking, flushing, sanitary washing, cooling system, heating system and irrigation system. Well water is used as the primary fresh water source for both green and non-green buildings. Additionally, municipal water is used as fresh water source in the green building while non-green building utilizes bowser water. The activities which requires use of fresh water was same in green building and non-green building including; drinking, flushing, sanitary washing, cooling system and heating system. The average daily fresh water consumption of non-green building amounts to 95,000 L which is higher than the fresh water consumption of the green building. Since, both buildings are occupied by similar number of employees; this difference could be basically due to the rainwater harvesting system and high efficient technological applications included in the green building. The daily average total water consumption of the non-green building is 105,000 L which is again higher than the green building. Thus, it can be said that, level of water efficiency in the green building affects by efficient technological applications. Specially, compared to the non-green building, another advantage of the green building is the individual commitment on the efficient water usage.

Table 5: Water Consumption of the Green Building and Non-Green Building

	Green Building	Non-Green Building
Number of employees	2,200	2,200
Production area	6,428 m^2	6,689 m^2
Irrigation area	7,082 m^2	12,140 m^2
Building area	14,090 m^2	16,536 m^2
Fresh water consumption	90, 000 L per day	105,000 L per day
Rainwater consumption	5,000 L per day	-
Total water consumption	95,000 L per day	105,000 L per day
Reuse water consumption	40,000 L per day	30,000 L per day

4.4. WATER CONSUMPTION IN GREEN BUILDING AND NON-GREEN BUILDING ACCORDING TO THE PROCESS

Table 6 summarises the findings of water consumption in both buildings based on the process. According to the empirical findings, water consumption per person in green building is 31.82L per capita per day, while in non-green building it is 34.09 L per capita per day. Thus, compared to non-green building, green building water consumption per person is slighter by 2.27 L. Water saving due to the metering and sub-metering system, water efficient technological applications, and both individual commitment and third party commitment on the water efficiency of the green building were the reasons behind these results. When it comes to the irrigation system, water consumption in green building is 5.65L per m^2 per day while in the non-green building it amounts to 2.47 L per m^2 per day. Accordingly, when comparing to the

non-green building, water consumption per square meter is 3.18L higher in the green building. During the analysis of research findings, it was found that both buildings have not given concern on the sub-metering of the irrigation water consumption. If sub metering systems could be introduced to irrigation systems, accurate and the real values on the irrigation system water consumption can be realized. Thus, this will make the buildings to gain optimum benefit from the reused water by implementing strategies such as water recycling etc. However, compared to the overall water efficiency performance of the non-green building, green building is efficient except in irrigation system water efficiency. Nevertheless, the water efficient practices of the non-green building are also at an identical level as the green building. Lack of concern on optimum usage of reused or grey water was identified as one of the drawbacks in water usage of the green building and there may be some other factors that affected for water efficiency which describes in next section.

Table 6: Summary of Water Consumption in Green Building and Non-Green Building According to the Process

	Green Building	**Non-Green Building**
Water consuming activities	General (Drinking, Cooking, Flushing, and Sanitary washing), Cooling system, Heating system and Irrigation system	General (Drinking, Cooking, Flushing, and Sanitary washing), Cooling system, Heating system and Irrigation system
General	70, 000 L per day	75,000 L per day
Cooling system	20,000 L per day	25,000 L per day
Heating system	5,000 L per day	5,000 L per day
Total water consumption	95,000 L per day	105,000 L per day
Reused water consumption	40,000 L per day	30,000 L per day
Water consumption per person	31.818 L per capita per day	34.091 L per capita per day
Water consumption per area	5.648 L per area per day	2.471per area per day

4.5. DRIVING FACTORS FOR WATER EFFICIENCY ON GREEN AND NON-GREEN BUILDINGS

During the data analysis of the two cases, it was identified driving factors for water efficiency of the selected green building and non-green building which discuses in this section.

As per empirical findings, building engineers have to upload the monthly water usage data to the 'sustainability division'. These data is evaluated by the sustainability division and monthly reviews were submitted to building management in order to maintain the water efficiency. As per the views given by the interviewees of the green building, it is evident that green building must be self-motivated in to providing these data to the sustainable division and to take corrective actions if necessary in order to maintain the water efficiency status and to comply with the green certification requirements.

In the non-green building, an individual effort is not required since those professionals do not have to maintain water efficiency standards enforced by a green certification requirement. Only requirement is to make excuses if there were any alarmed raise of water consumption level. Although that point was evident, as per the researcher, water efficiency improvements will only be resulted, if building management gives individual commitment in to continuous evaluation of water consumption levels together with considering evaluations given by the sustainability division. Therefore, individual commitment is one of the factors that effects on the level of water efficiency of green building and non-green building.

The theoretical findings of the study also identified that to enhance the water efficiency performance of the building, it should have a big picture of the building's water consumption data. It is clear, this opinion is not limited to only non-green building but for the green building as well. Because, even though in 2013 per capita per day usage was reduced to 31 L, in 2014, it has again increased between 32-33 L per capita per day. Thus, metering and sub-metering would be one of the primary water efficiency criterion for the

buildings and at the same time, it should be received both individual and third party commitment for the continuous improvement of the water efficiency system.

Therefore, both individual commitment and third party evaluation by the sustainability division will drives green building and non-green building for effective water efficiency. Whether it is a green building or non-green building, if it will not align with any of this factor, it will be affected to the overall water efficiency performance of the building.

In the previous section, even it was identified that green building is more water efficient than non-green building in terms of water efficiency, however, both buildings were practised similar water efficiency practises, and yet water consumption performance of the green building is more efficient than non-green building. This may be due to the effect of the above mentioned driving factors for water efficiency.

4.6. PERCEPTIONS TOWARDS THE GREEN AND NON-GREEN BUILDING

The interviewees have different perception towards the green building and non-green building in terms of water efficiency. Both buildings are benefited by cost saving and resource saving resulted from water efficiency. The green building receives both international and local recognition by the Green Certification while non-green building only receives local recognition by certifications such as Environmental Protection Licence (EPL). The green building is further subjected to benefits such as use of green certification as a marketing tool and inspiration factor, updated with the new technologies, standards and receiving good reputation by the society, while same factors affected as demerits for the non-green building. On the other hand, demerits of the green building can be identified as use of a common LEED rating category to assess the building, excessive cost for acquiring the LEED Certification and lack of employee satisfaction due to the changes of the environment specially in water efficient technologies, while non-green building obtains the same level of economical benefits, resource conservation and local recognition without expending the additional high cost spent from the green building to receive the green certification. Table 7 summarise the merits and demerits of green and non-green building.

Table 7: Summary of Merits and Demerits

	Green Building	Non-Green Building
Merits	• Economical benefits by saving costs • Resource conservation • Local and international recognition • Use as a marketing tool • Use as a inspiration factor • Update with new technologies, and standards • Reputation	• Economical benefits by saving costs • Resource conservation • Only local recognition by the local standards (E.g. EPL) • No additional expenses to acquire the green certification
Demerits	• Use of a common LEED rating category • Cost of acquiring the LEED Certification • Lack of employee satisfaction	• No motivation/ inspiration factor • No international recognition • Difficult to market the building's water efficiency performance

5. CONCLUSIONS AND RECOMMENDATIONS

As the final conclusion, it can be said that, even the overall water efficiency performance of the green building is higher than the non-green building; still water efficiency performance of the non-green building is also at an identical level and there are more potentials to increase water efficiency performance in green building through use of modern technologies and good water efficient practices.

However, research findings and recommendations derived under this research is developed under a scenario where the cases managed and controlled under a same chain of management. Although, it is supported to minimize the different attitudes on the water efficiency, it resulted in similar perceptions on water efficiency. Therefore, it limits the application of research results only on apparel buildings of same management chain. The feasible recommendations on good practices towards water efficient buildings including green and non-green in the apparel industry are discussed in Table 8.

Table 8: Good Practices Toward Water Efficient Buildings

No.	Water Efficient Practice	Benefits	Description
1	Integration of Metering and Sub-metering System	• Facilitate to assess the real water requirements by the individual processes • Familiarize with the water consumption patterns by the each water consumption processes and activities	If there are any variations on the amount of water supplied and the actual amount of water requirement, then that indicates opportunities for water conservation and improvement of water efficiency.
2	Encourage for Alternative Water Sources	• Reduce the burden on the national water demand • Minimize the water utility bill • Contribution for the sustainability of the environment	Renewable alternative water can be supplied from using sources like well water and harvested rainwater.
3	Integration of Water Efficient Technologies	• Update with latest technological advancements that makes buildings more water efficient	Water efficient technologies were identified in the "Different types of Water Efficiency Processes and Technologies" Section of the Research Background
4	Encourage for Water Reusing and Recycling	• Utilize 100% grey water or reused water for irrigation systems instead of potable water • Reduce the burden on the national fresh water demand • Reduce or eliminate the discharge of waste water to the environment • Utilize the optimum water usage out of the building's total fresh water demand	As the first steps, it is need to identify the possible areas that can apply water reusing and recycling. The grey water or reused water can be utilized for the irrigation and cultivation purposes. Excess supply can be further purified for the water recycling to get the optimum usage.
5	Encourage for Individual Commitment	• Improve the employees water use habits and behaviours • Enhance the management concern for the identification of water usage patterns, areas which need further improvements, requirement of the metering and sub-metering devices, meter reading errors, water leakages, and water losses • Derive individual responsibilities for both management and employees	Encourage both management and employee level to assist the enhancement of water consumption performances of the building. Employees can be educated by awareness programs, hand bills, and visual aids.
6	Third Party Commitment	• Assess the water efficient performances in an unbiased manner • Lead to be bench marked with the other water efficient buildings	Water efficient performances further evaluate and adjudicate by a third party.

Thus, whether it is a green building or non-green building, the above mentioned water efficient practices will facilitate to earn more economical benefits and to achieve more resource efficiency. Moreover, if it is a non-green building that is hoping to obtain green certification, these practices will help out to achieve water efficiency requirements of green building without an excessive effort.

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