ENVIRONMENTAL SUSTAINABILITY ASSESSMENT OF FACILITIES MANAGEMENT: A CASE OF APPAREL INDUSTRY IN SRI LANKA

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ABSTRACT

With the adaptation of businesses to sustainable approaches, facility manager's role has been expanded to be responsible for the sustainable performance of a building. Specially, escalating changes in the built environment has initiated the need of evaluating environmental sustainability (ES) of building facilities. Specially, apparel industry shows a significant impact to the environment, thus, it highlights the need of having a way to evaluate the environmental sustainability in facilities management (FM) in apparel sector. Therefore, this research was aimed to develop a model to evaluate the environmental sustainability of FM in apparel industry in Sri Lanka. By reviewing key literature, thirty-four (34) environmental sustainability indicators were identified under energy management, water management, waste management, asset management and maintenance management. Under the survey approach, pair-wise comparison through structured questionnaire was used to evaluate the identified indicators. Analytical Hierarchy Process (AHP) tool was used to derive the relative performance scores of each ES indicator and ranked. Energy management was identified as the most significant FM function related to environmental sustainability. Energy sub-metering and application of sub-meter reading on identification of significant energy consumers, availability of waste management policy and availability of environmental impact assessment for the assets were determined as top priority indicators that need to be considered to ensure the ES of FM in apparel industry. Accordingly, the identified performance scores can be used as a basis to evaluate the ES of FM functions in order to formulate the suitable strategies to instigate the environmentally sustainable FM practices in apparel industry in Sri Lanka.

Keywords:*Apparel Industry; Assessment; Environmental Sustainability; Facilities Management; Sri Lanka.*

1. INTRODUCTION

Achieving environmental, social and economic sustainability is a governing concern in any organisation. The increase of stakeholder requirements in sustainability acts as a motive force for organisations to achieve sustainability within their practices (Amran & Keat Ooi, 2014). With the adaptation of businesses to sustainable approaches, Facilities Management (FM) plays a major role in sustainable development. Especially, Facility Manager's role has been expanded to be responsible for assuring the instigation of sustainable building facilities (Elmualim et al., 2012). FM is a service, which is a combined approach in maintaining, improving and adjusting the built environment in order to create an environment that strongly supports the core business of an organisation (Barrett & Baldry, 2009). With the rapid changes in the environment, need of environmental sustainability is being a growing necessity. An integration of sustainability and FM is important because, FM is significant in the operations of an organisation (Hodges, 2005). Evaluating environmental sustainability of FM is useful to identify the areas which are needed to be improved in projects (Bebbington & Frame, 2003). Furthermore, it has been identified that apparel sector contributes in large quantity to environmental pollution (Junghans, 2011) and no standardised mechanism extent to evaluate ES in the apparel industry in Sri Lanka (Manjula et al., 2015). Therefore, there is an emerging need to evaluate the ES in FM in the apparel industry in Sri Lanka. Further, Elmualim et al. (2012) stated that the increasing importance of sustainability, wider variety of sustainability issues and drivers affecting and influencing stakeholders with different values, has initiated a requirement on sustainability assessment of

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industries. In line of thinking, this research was aimed to conduct an ES assessment of FM in apparel industry in Sri Lanka. Hence, this research was limited only to assess the ES of FM functions over the economic and social sustainability. Further, the study was further limited to the apparel industry in Sri Lanka; thus, the findings presented subsequently can be generalised to the aforesaid with confidence.

2. ENVIRONMENTAL SUSTAINABILITY OF FACILITIES MANAGEMENT

A major concern is on the implementation of sustainability initiatives in the apparel sector due to the increasing awareness on environmental impacts (Islam & Khan, 2014). FM profession can make an important contribution for the sustainability challenges in a business. Especially facility managers have a greater responsibility in ES (Nielsen et al., 2016). Among the FM related functions in buildings, energy management, water management, waste management, asset management and maintenance management functions were selected in this research to evaluate the ES. The highest frequency of availability in key literature was concerned as the key criteria for above selection (Nielsen et al., 2016; Sekula & Hodges, 2014). With the importance of evaluating the status of ES in facilities, several sustainability assessment criteria have emerged due the importance of sustainable development within a facility (Adams & Ghaly, 2006). Assessing FM will act as catalysts for the development of innovation in the performance of the service though no specific sustainability assessment model for FM has been developed (Pitt & Tucker, 2008). Hence, by referring to the key literature available on existing sustainability assessment models developed worldwide, ES indicators were encountered in order to assess the ES of FM. Accordingly; thirty-four (34) ES indicators were identified as stated in Table 1. The identified indicators were used to evaluate the ES of FM functions in apparel industry in Sri Lanka. The research methodology is described in Section 3.

3. RESEARCH METHODOLOGY

A comprehensive literature review was carried out to gather information on the concept of Sustainable FM and the ES indicators of FM. Under the survey method, a questionnaire survey was conducted to evaluate the identified indicators through pair-wise comparison. The sample consists of forty-eight (48) professionals (Response rate is 67%) in apparel industry including Assistant Managers (17%), Senior Executives (21%) and Executives (29%) in the fields of engineering, FM, sustainability and compliance. In the questionnaire, the comparison pairs were stated to mark the important FM function, ES indicators and their magnitude of importance.

3.1. ANALYTIC HIERARCHY PROCESS (AHP)

The use of AHP technique in this research can be justified related to the extent of key literature. Ehrhardt and Tullar (2008) stated that AHP technique as a multiple-criterion decision making technique is useful when the outcome of a decision has several different important aspects which cannot easily be summarised.

The questionnaire was developed for pair-wise comparison of sustainable FM functions and ES indicators. To make comparisons, a scale is required to indicate the magnitude of importance of one element over another element with respect to each criterion compared (Saaty, 2008). Further to author, the definitions and explanation of the ratio scale can be recognised. The ratio scale used in this research is presented in Table 2. Reciprocals of the above intensities of importance represent, if activity i has one of the above non-zero numbers assigned to it when compared with activity j. Then j has the reciprocal value when compared with i.

Pair-wise comparison

Comparison matrices and priority weights were developed by considering the Saaty's eigenvector procedure. A sample model of the pair-wise comparison matrix is illustrated in Table 3. Average of the ratings given by the respondents for each sustainable FM function is illustrated by W_1, W_2, W_3, W_4, W_5, W_6, W_7, W_8, W_9 and W_{10}. The reciprocals of them are given in the rest of the area in Table 3. Sum of each column is shown as S_1, S_2, S_3, S_4 and S_5.

Table 1: ES Indicators of FM

ES indicators	**References**																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Energy management		√		√	√		√															
Energy sub-metering and application of sub-meter reading on identification of significant energy consumers						√																
Usage of renewable energy sources	√																					
Applicability of energy audit results																				√		
Availability of referred / standards for energy efficiency	√																					
Application of energy efficiency targets																				√		
Application of advance technologies over energy management	√																					
Water management		√		√	√																	
Following efficient water fitting standards																					√	
Conducting water audit and application of audit results																					√	
Availability of as-built drawings of water distribution system and maintenance plan								√														
Availability of a baseline for water consumption																	√					
Availability of water sub-metering and data evaluations																	√					
Usage of sustainable water resources														√								
Availability of water reusing and recycling techniques																	√					
Waste management		√		√	√		√															
Availability of waste management policy			√																			
Properly identified the end disposal methods of all categories of waste generated																				√		
Life cycle analysis process availability																		√				
Availability of a green purchasing policy			√																			
Conducting waste audits											√											
Applications of reusing waste	√																					
Applications of waste recycling	√																					
Asset management		√		√	√																	
Availability of environmental impact assessment for the assets																		√				
Availability of green purchasing policy										√												
Availability of supply chain survey before purchasing										√												
Availability and application of performance monitoring system and maintenance plan of assets																√						
Application of proper GHG emissions management process																√						

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Checking the environmental legal comply of each asset														√								
Extent of green building concept applications									√													
Maintenance management	√		√			√																
Availability of facility maintenance and renovations policy											√											
Materials handling and packaging sustainable measures availability	√																					
Application of proper greenhouse gas emissions management process												√										
Availability of preventive and predictive maintenance management practices								√														
Application of chemical management concept over maintenance activities												√										
Job related training on environment sustainability aspects for maintenance staff																					√	
Following international standards in maintenance																		√				

References: 1. United States Green Building Council – USGBC (2017); 2. Nielsen *et al*. (2016); 3. Parekh et al. (2014); 4. Sekula and Hodges (2014); 5. Elmualim *et al*. (2012); 6. Wang et al. (2012); 7. Junghans (2011); 8. Mateus (2011); 9. Jasiulewicz-Kaczmarek and Drozyner (2011); 10. Meehan and Bryde (2011); 11. Smyth *et al*. (2010); 12. Ilangkumaran and Kumanan (2009); 13. Hertwich and Peters (2009); 14. Liu *et al*. (2008); 15. Morrow and Rondinelli (2002); 16. Hammond *et al*. (1995); 17. Grant (2006); 18. Seadon (2010); 19. Zutshi and Sohal (2004); 20. Bunse *et al*. (2011); 21. Randolph and Troy (2008); 22. Perron *et al*. (2006)

Normalised comparison

Normalising the entries was done by dividing the entry by the sum of each column in pair-wise comparison matrices. Performance score was generated by dividing the row sum from the total sum. Table 4 represents the normalised comparison matrix for sustainable FM functions. X_1, X_2, X_3, X_4 and X_5 indicate the sum of each row after normalising. X represents the total sum of the sum column in Table 4.

Consistency calculation

A measure of consistency is the Consistency Index (CI). The Consistency Ratio (CR), CR = CI/RI was derived using a Randomized Index (RI) and the average CI for randomly filled matrices (Goepel, 2013). Steps 1, 2 and 3 of consistency calculation which were used in this research are described accordingly.

Step 1: Entries in the pair-wise comparison matrix were multiplied by the performance score to obtain the eigenvector. Z is a new vector obtained through the addition of each row. Table 5 illustrates the model calculation model which was developed in this research for the consistency calculations.

Table 2: Ratio Scale

1	2	3	4	5	6	7	8	9
Equal Importance	Weak or Slight	Moderate Importance	Moderate plus	Strong importance	Strong plus	Very strong/ demonstrated importance	Very, very strong	Extreme importance

Table 3: The Sample Model of Pair-Wise Comparison Matrix

Sustainable FM functions	**A**	**B**	**C**	**D**	**E**
A- Energy management	1	$\mathbf{W_1}$	$\mathbf{W_2}$	$\mathbf{W_3}$	$\mathbf{W_4}$
B- Water management	$1/W_1$	1	$\mathbf{W_5}$	$\mathbf{W_6}$	$\mathbf{W_7}$
C- Waste management	$1/W_2$	$1/W_5$	1	$\mathbf{W_8}$	$\mathbf{W_9}$
D- Asset management	$1/W_3$	$1/W_6$	$1/W_8$	1	$\mathbf{W_{10}}$
E- Maintenance management	$1/W_4$	$1/W_7$	$1/W_9$	$1/W_{10}$	1
Sum	S_1	S_2	S_3	S_4	S_5

Table 4: The Sample Model of Normalised Comparison Matrix

Sustainable FM functions	**A**	**B**	**C**	**D**	**E**	**Sum**	**Performance score**
A-Energy management	$\frac{1}{S1}$	$\frac{W1}{S2}$	$\frac{W2}{S3}$	$\frac{W3}{S4}$	$\frac{W4}{S5}$	X1	X1/X = Y1
B-Water management	$\frac{1/W1}{S1}$	$\frac{1}{S2}$	$\frac{W5}{S3}$	$\frac{W6}{S4}$	$\frac{W7}{S5}$	X2	X2 /X = Y2
C-Waste management	$\frac{1/W2}{S1}$	$\frac{1/W5}{S2}$	$\frac{1}{S3}$	$\frac{W8}{S4}$	$\frac{W9}{S5}$	X3	X3 /X = Y3
D-Asset management	$\frac{1/W3}{S1}$	$\frac{1/W6}{S2}$	$\frac{1/W8}{S3}$	$\frac{1}{S4}$	$\frac{W10}{S5}$	X4	X4 /X = Y4
E-Maintenance management	$\frac{1/W4}{S1}$	$\frac{1/W7}{S2}$	$\frac{1/W9}{S3}$	$\frac{1/W10}{S4}$	$\frac{1}{S5}$	X5	X5 /X = Y5
						X	

Table 5: The Consistency Calculation Model

Sustainable FM functions	**A**	**B**	**C**	**D**	**E**	**Sum**	**Performance score**
A- Energy management	$1*Y_1$	W_1*Y_2	W_2*Y_3	W_3*Y_4	W_4*Y_5	Z_1	$Z_1/ Y_1=a_1$
B- Water management	$1/W_1*Y_1$	$1*Y_2$	W_5*Y_3	W_6*Y_4	W_7*Y_5	Z_2	$Z_2/ Y_2=a_2$

Sustainable FM functions	A	B	C	D	E	Sum	Performance score
C- Waste management	$1/W_2*Y_1$	$1/W_5*Y_2$	$1*Y_3$	W_8*Y_4	W_9*Y_5	Z_3	$Z_3/ Y_3=a_3$
D- Asset management	$1/W_3*Y_1$	$1/W_6*Y_2$	$1/W_8*Y_3$	$1*Y_4$	$W_{10}*Y_5$	Z_4	$Z_4/ Y_4=a_4$
E- Maintenance management	$1/W_4*Y_1$	$1/W_7*Y_2$	$1/W_9*Y_3$	$1/W_{10}*Y_4$	$1*Y_5$	Z_5	$Z_5/ Y_5=a_5$

Step 2: λ_{max} was calculated using the equation presented below. λ max is the average value of the column sum. The equation used is presented below.

$$\lambda_{max} = \frac{a1+ a2+ a3+ a4+ a5}{5} \quad \text{Eq. (01)}$$

Where, a= sum.

Step 3: Consistency Index (CI) and Consistency Ratio (CR) were calculated as per the Eqs. (02) and (03) respectively.

$$CI= \frac{\lambda_{max} - n}{(n-1)} \quad \text{Eq. (02)}$$

$$CR = \frac{CI}{RI} \quad \text{Eq. (03)}$$

Further, Saaty's rule of thumb can be used to accept only judgment matrices with CR< 0.1 (Deng et al., 2014). The random consistency index used in this research is presented in Table 6.

Table 6: Random Consistency Index

n	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Source: Saaty (2008)

Accordingly, the performance score of sustainable FM functions and related ES indicators were calculated and ranked as described in Section 4.

4. DATA ANALYSIS AND FINDINGS

The identified ES indicators of energy management, water management, waste management, asset management and maintenance management functions were analysed using the AHP technique. As the key findings derived through data analysis, FM functions and related ES indicators were ranked based on the relative performance scores calculated.

4.1. ENVIRONMENT SUSTAINABILITY ASSESSMENT OF FM FUNCTIONS

The FM functions of energy management, water management, waste management, asset management and maintenance management and related ES indicators were evaluated and ranked based on the relative performance score calculated. The rankings of FM functions and ES indicators are presented in Table 7. According to the analysis, the highest relative performance score of 0.4912 was achieved by energy management function where second, third and fourth places were achieved respectively by water management (performance score= 0.2139), maintenance management (performance score= 0.1198) and waste management (performance score= 0.0964) respectively. The least importance function of asset management received the relative performance score of 0.0785. It demonstrates that energy management is approximately two times relatively important than water management and four times relatively important than maintenance management. Therefore, energy management can be recognised as the most important FM function in ES.

Table 7: Ranking of ES indicators

ES indicators	Performance score	Rank
Energy management	**0.4912**	**1**
Energy sub-metering and application of sub-meter reading on identification of significant energy consumers	0.2360	1
Usage of renewable energy sources	0.2209	2
Applicability of energy audit results	0.1714	3
Application of energy efficiency targets	0.1704	4
Availability of referred codes and standards for energy efficiency	0.1216	5
Application of advanced technologies over energy management	0.0796	6
Water management	**0.2139**	**2**
Conducting water audit and application of audit results	0.2179	1
Following efficient water fitting standards	0.1627	2
Usage of sustainable water resources	0.1377	3
Availability of a baseline for water consumption	0.1305	4
Availability of water sub-metering and data evaluations	0.1296	5
Availability of as-built drawings of water distribution system and maintenance plan	0.1276	6
Availability of water reusing and recycling techniques	0.0940	**7**
Maintenance management	**0.1198**	**3**
Availability of facility maintenance and renovations policy	0.2084	1
Availability of preventive & predictive maintenance management practices	0.2044	2
Materials handling and packaging sustainable measures availability	0.1496	3
Application of proper greenhouse gas emissions management process	0.1491	4
Job related training on ES aspects for maintenance staff	0.1203	5
Application of chemical management concept over maintenance activities	0.0977	6
Following international standards in maintenance	0.0705	7
Waste management	**0.0964**	**4**
Availability of waste management policy	0.2302	1
Life cycle analysis process availability	0.1837	2
Proper identification of the end disposal methods of all categories of waste	0.1705	3
Availability of a green purchasing policy	0.1524	4
Applications of reusing waste	0.1027	5
Conducting waste audits	0.0976	6
Applications of waste recycling	0.0630	7
Asset management	**0.0785**	**5**
Availability of environmental impact assessment for the assets	0.2597	1
Availability of green purchasing policy	0.1886	2
Availability and application of performance monitoring system and maintenance plan of assets	0.1313	3
Availability of supply chain survey before purchasing	0.1120	4
Application of proper greenhouse gas emissions management process	0.1103	5
Checking the environmental legal comply of each asset	0.1023	6
Availability of green building concept applications	0.0957	7

According to the analysis, 'Energy sub-metering and application of sub-meter reading on the identification of significant energy consumers' received first ranking with the relative performance score of is 0.2360.'Usage of renewable energy sources' was identified as the second most important indicator with the performance score of 0.2209. However, it indicated that there is a slight difference between the first and second ranks. Further, the relative performance score of the third (Applicability of energy audit results) and fourth (Application of energy efficiency targets) ranks also did not show a considerable difference. It states an equal importance of the indicators. 'Availability of referred codes and standards for energy efficiency' is approximately half (1/2) of the relative weight of the rank one. The indicator of 'Application of advanced technologies over energy management' was ranked at the sixth place and approximately it was one third (1/3) of the first rank of energy management.

The relative performance scores of ES indicator in water management which were derived through AHP process are illustrated in Table 7. The highest relative performance score of 0.2179 was obtained by 'Conducting water audit and application of audit results' while, 'Following efficient water fitting standards' (performance score= 0.1627) was the second. The first ranked indicator is approximately 1.5 times greater than the thirdly ranked indicator of 'Usage of sustainable water resources' (performance score= 0.1377). According to the analysis, the fourth, fifth and sixth ranks were achieved by 'Availability of a baseline for water consumption', 'Availability of water sub-metering' and 'Data evaluations and availability of as-built drawings of water distribution system' and 'Maintenance plan' with their relative performance scores of 0.1305, 0.1296 and 0.1276 respectively. From the analysis of the relative weights, minor deviations among indicators were identified. Further, it can be identified that the professionals are more interested in applying sustainable water management practices before occurring water wastage. The ES indicators of maintenance management were ranked based on the relative performance score values calculated through AHP analysis (Table 7). 'Availability of facility maintenance and renovations policy' was ranked as the top priority indicator with the relative performance score of 0.2084. 'Availability of preventive and predictive maintenance management practices' was ranked as the second important indicator with the relative performance score of 0.2044. As recognised in analysis, a substantial difference was not found between the relative scores of first and second rankings. Thus, an equal importance of those two indicators can be observed. The third and fourth ranks which were received respectively by 'Materials handling and packaging sustainable measures availability' and 'Application of proper greenhouse gas emissions management process and monitoring the carbon footprints relevant to each maintenance activities' can also be considered as the equally important criterions because of their approximately equal relative scores. The lowest relative performance score was obtained by 'Following international standards in maintenance' with the relative performance score of 0.0705. It was approximately one third (1/3) of the first rank. From the analysis, it can be identified that the availability of maintenance related policies could affect more on the ES of maintenance management in apparel industry. The comparison of key findings with related research works in key literature is presented subsequently.

According to the analysis of ES indicators in waste management, 'Availability of waste management policy' received the top rank with its relative performance score of 0.2302. Second, third and fourth ranks were correspondingly achieved by 'Life cycle analysis process availability', 'Proper identification of the end disposal methods of all categories of waste generated' and the 'Availability of a green purchasing policy' with the respective performance score values of 0.1837, 0.1705 and 0.1524. The fifth and sixth ranks were approximately half (1/2) of the first ranked indicator. Among the ES indicators in waste management, a substantial deviation of the relative weights was not found. Moreover, it can be identified that the professionals prefer to focus on preventing waste generation rather than managing the waste generated. Based on the relative performance scores derived through the AHP process, the ES indicators of asset management were ranked as illustrated in Table 7. The highest relative performance score was obtained by 'Availability of environmental impact assessment for the assets' (performance score=0.2597). The least relative performance score was obtained by 'Availability of green building concept applications with the score value of 0.0957. The first ranked indicator was deviated by approximately three times from the least performance score. Therefore, a considerable deviation of the relative performance scores can be identified between the first and preceding ES indicators. Among the ES indicators in asset management, the assessments and policies on asset management can have a greater impact on the ES in apparel industry.

5. DISCUSSION

The findings showed the relative performance of ES indicators of selected FM functions. Accordingly, energy sub-metering and application of sub-meter reading, conducting water audit and application of audit results, availability of waste management policy, availability of environmental impact assessment for the assets and availability of facility maintenance and renovations policy were determined as top priority ES indicators among the others. According to the findings, energy management obtained a higher performance score than other functions. Junghans (2011) also stated that energy management is the heart of buildings, which states the importance of energy management. Furthermore, USGBC (2017) stated that LEED certification has an increased emphasis on energy and the associated impacts as well. When considering the performance scores of ES indicators of energy management, the highest performance score was obtained by energy sub-metering and application of sub-meter reading on identification of significant energy consumers. A similar study conducted by Wang and Xiao (2012) stated that identification of energy consumption in different zones is an important requirement for energy management. Moreover, it was found that 'conducting water audits' another top priority indicator with a high relative weight among other ES indicators of water management. It was further proven by Batchelor et al. (2003) stating that the audits could form practical recommendations in water management. By referring to the findings, availability of waste management policy which addresses ES was also recognised as a top ranking indicator. Parekh et al. (2014) mentioned that the policy could affect the total waste management procedure, which confirms the importance of such. Seadon (2010) identified the importance of ES assessment for assets. A similar outcome was derived in this research where availability of environmental impact assessment for the assets was recognised as the top priority ES indicator in asset management with the highest performance score. Ilangkumaran and Kumanan (2009) stated the importance of a maintenance policy for any facility as it plays a key role in achieving organisational goals. This research found that the availability of maintenance policy is important for assuring ES of maintenance management in apparel industry in Sri Lanka.

6. SUMMARY

With the long-term value addition for the shareholders and with the gain from sustainable development, organisations are interested in adapting with sustainable practices. Though sustainability is the integration of environmental, social and economic pillars, ES can be considered as the root of sustainable development because a healthy environment is essential. The integration of sustainability and FM is also paramount as FM is significant in the operations of an organisation. Especially, integration of ES and FM in apparel industry can also be recognised as it could contribute in large quantity to reduce the environmental impact of buildings. Since having less consideration on evaluating the ES of FM practices in apparel industry, this study stands as the best way to implement. Outcomes of this research are beneficial for the FM practitioners of the apparel industry in Sri Lanka for improving the ES. Here, a clear guidance has been provided to calculate the ES of FM in apparel industry. In addition to that, a computer-based assessment model will be developed as the next step to facilitate the industry practitioners an ease of evaluating ES of FM in apparel industry in Sri Lanka.

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