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Indoor environment quality in green buildings: A case of apparel firm in Sri Lanka

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Abstract

Though the use of green buildings is a world trend, it is less popular among Sri Lankan industries due to a lack of awareness. Particularly, the Sri Lankan apparel industry can improve its efficiency through numerous benefits of green buildings such as lower operating cost and higher labor productivity. Therefore, this study attempts to increase awareness about the benefits of green buildings among apparel manufacturers providing evidence for the social benefits based on the indoor environment quality. The indoor environment quality was assessed by five dimensions (dust, noise, illumination, relative humidity, and temperature) selecting green and non-green apparel factory buildings in Sri Lanka. The data covering 24 days were used and analyzed by mean analysis. Though both green and non-green buildings confirm the standard limits of dust, noise, illumination, and relative humidity, the non-green buildings lay out of the standard limits of temperature. Interestingly, the green buildings record relatively favorable indoor environment quality in terms of all factors while generating numerous other benefits. Thus, the adoption of green buildings in the apparel industry is desirable, and the findings help enhance the awareness of its benefits and inclination towards the green buildings.

Keywords: *Apparel industry, green building, indoor environment quality, Sri Lanka.*

1. Introduction

Though the concept of green building has become a fad in the world construction industry yet, it is not popular in some regions such as Sri Lanka (Waidyasekara & Fernando, 2012; Green Building Council of Sri Lanka, 2015), and in some contexts such as tropical countries. However, there are a few companies that initiated to use and set up green building factories in Sri Lanka especially in the apparel sector. The green buildings positively impact on the sustainability of companies by lowering operating cost, reducing resource consumption and wastes, creating a healthier and comfortable working and living environment for the employees (Wedding & Brown,2007), strengthening marketability, increasing energy efficiency and employee productivity, creating a non-toxic environment to the occupants (Ali & Nsairat, 2009; Sauve, 2012). Also, it reduces employees' stress, depression (Kroll, 2010), absenteeism and litigation thereby, the costs (Heerwagen, 2000). Building designers identify lower operation costs, lower lifetime cost, higher return on investment, and enhanced marketability as the business reasons to use green buildings (Chan, Qian, & Lam, 2009). Thus, adoption of green buildings helps the Sri Lankan apparel industry to be competitive and enter into the best ten global exporters as per the expectation of the country (Gaille, 2018).

Presenting a set of approaches towards sustainable building architecture, Cam and Ong (2005) propose three roles of building environment domain to ensure a positive impact. Those roles include: (1) set an institutional setting to raise awareness of building environmental issues among stakeholders and economic benefits of the environment friendly architecture; (2) set benchmarks for building an environmental practice to safeguard and evaluate against those benchmarks; (3) set a platform for inspiring new designs, ideas and technical solutions. Lack of awareness about the benefits of green building among individuals, organizations, and environment is the main cause for not adopting it in the Sri Lankan apparel sector (Thilakarathne & Silva, 2012). Chan et al. (2009) also recognize the lack of awareness as an obstacle to the use of green buildings. Thus, taking this fact with the suggestions of Cam and Ong (2005), the study attempts to provide evidence for the benefits of green buildings thereby, enhance the awareness. Ali and Nsairat (2009) suggest that the green building assessment system in a developing country should focus on three dimensions: social, environmental, and economic benefits. The focus of this study is to inquire about the existence of social benefits of green buildings in the apparel sector in Sri Lanka. Therefore, the study selected Indoor Environment Quality (IEQ) considering its direct influence on occupants' productivity, health, and well-being (Kamaruzzaman, Egbu, Zawawi, Ali & Che-Ani, 2011). Also, improved IEQ minimizes the adverse impact on the occupants and environment, and enhance economic benefits. Also, this study strives to clear the contrasting findings in present literature about the level of IEQ of green buildings (i.e. Lee, Wargocki, Chan, Chen, & Tham, 2018 vs. Lee & Kim, 2018). Therefore, this study particularly attempts to substantiate that IEQ is better in green factory buildings than non-green in the apparel sector in Sri Lanka.

The outcome of this study will be useful to convince the benefits of green buildings to the decision-makers. Further, perceived benefits may widen the popularity of green buildings in the apparel sector, and across the industries in Sri Lanka. Also, it will lead to the establishment of a legislative framework and an appropriate evaluation mechanism for the building architecture in Sri Lanka. Also, this study presumes that improved productivity by green building helps the Sri Lankan apparel industry enhance its presence in the global apparel market. The rest of the paper is organized as follows. The next section discusses relevant literature followed by the methodology employed in this study. The next sections are devoted to data analysis, results & discussion, and conclusion.

2. Literature review

Sri Lankan apparel industry is recognized for providing high-quality ethical fashion apparel for iconic global fashion brands such as Victoria's Secret, Pierre Cardin, GAP, Nike, Land's End, Marks & Spencer, Liz Claiborne. During the last four decades, the industry has marked an epic growth transforming from sawing solution provider (as a contracted manufacturer) depend on textile quota from developed countries to total apparel solution provider. Today, as the leader in Sri Lankan manufacturing sector, the apparel industry contributes 42.2 percent of total principal commodity export in 2017 (Department of Census and Statistics, 2018). Also, the apparel industry is an important employment sector generating over 650,000 employments, and having over 2,078 establishments which employee 25 or more employees (Department of Census and Statistics, 2019). Irrespective of its importance to the country, Sri Lanka presently is not among the best global apparel manufacturers though it aims to become one of the best ten (Gaille, 2018).

In today's competitive business landscape, every business faces the challenge of business sustainability. The apparel industry has been adapting various techniques such as lean manufacturing and total productive maintenance to face this challenge. Adaption of green buildings helps firms to be sustainable (Yoon & Lee, 2003). Being a labor-intensive industry, apparel industry consumes space, energy, water, and generates greenhouse gasses, thus it becomes a cause of environment pollution. Concern on green building is becoming essential since both apparel manufacturers and buyers recognize the importance of being environmentally sensitive by mitigating adverse effects to the environment. Apart from being environment-friendly, green buildings provide various other benefits such as social and economic. However, by nature, social and economic benefits are prominent in developing countries (Gibberd, 2005; Libovich, 2005).

The Office of the Federal Environmental Executives defines the green building as "the practice of (1) increasing the efficiency with which buildings and their sites use energy, water, and materials, and (2) reducing building impacts on human health and the environment, through better siting, design, construction, operation, maintenance, and removal – the complete building life cycle" (Fischer, 2010, p. 6). Accordingly, the green building concept focuses on designing and constructing the buildings that use resources more effective manner (American Chemistry Council, 2015), and on reducing and eliminating the harmful effect and create a healthier and comfortable environment for people (Chatterjee, 2009; Green Building Council SA, 2007). Accordingly, the green buildings differ from non-green buildings by particularly aiming at protecting human health, environment, and resource throughout the building lifecycle.

The adaption of green buildings can be evaluated by the extent of efficient use of resources based on ecological principles that provide healthy facilities for occupants (Kibert, 2007). Further, the green buildings are certified against various assessment tools such as Leadership in Energy and Environmental Design (LEED), Comprehensive Assessment System for Built Environment Efficiency (CASBEE), and Green Building Assessment Tool (GBTool). The LEED assesses the green buildings under six categories: sustainable sites, water efficiency, energy, materials, indoor environmental quality, and innovation and design. CASBEE uses six subcategories under two broad categories: build environment quality and reduction of built environment load. GBTool assesses green performance against seven categories: resource consumption, loadings, indoor environmental quality, quality of service, economics, pre-operations management, and commuting transportation. Also, the green building assessment method proposed for developing countries by Ali and Nsairat (2009) considers IEQ as a category to assess social benefits. Accordingly, every assessment tool presented here considers IEQ as an essential criterion in green building.

LEED uses air quality, lighting quality, acoustic design, and control over one's surroundings to evaluate IEQ, whereas CASBEE uses noise and acoustics, thermal comfort, lighting and illumination, and air quality. GBTool assesses IEQ by air quality and ventilation, thermal comfort, daylighting and illumination, noise and acoustics, and electromagnetic pollution. Also, Ncube and Riffat (2012) develop an IEQ index considering thermal comfort, indoor air quality, acoustic comfort, and lighting. The proposed green building assessment method for developing countries by Ali and Nsairat (2009) uses occupant health and safety, indoor air quality performance, quality of life, increase ventilation efficiencies, thermal comfort, daylight, acoustic and noise control, and visual quality to assess IEQ. Based on those facts, five factors namely, dust (indoor air quality), noise (noise and acoustics), illumination (lighting), humidity (indoor air quality), and temperature (thermal comfort) are chosen to assess the IEQ.

3. Methodology

The study selected a case including green and non-green factory buildings of a leading apparel manufacturer in Sri Lanka located in the same geographical location. The study considered two green and non-green buildings and made a comparison of IEQ factors of both categories. The study selected dust, noise, illumination, relative humidity, and temperature to assess the IEQ. The standard measurements were used to assess the variables. The secondary data from the Environmental Monitoring Report of the firm gathered for 24 days were used for the analysis. The descriptive statistics were used in data analysis.

4. Results and discussion

This study attempted to provide evidence for the benefit of green buildings focusing on the social dimensions of IEQ with the aim of raising awareness about green-buildings among apparel manufacturers. The IEQ in green and non-green buildings were assessed and compared in terms of five variables namely dust, noise, illumination, relative humidity, and temperature.

The mean value analysis with standard deviation was used to assess the level of IEQ variables and their dispersion in green and non-green factories, and the results are presented in Table 1. The analysis of data shows a low standard deviation indicating relatively stable values for each IEQ factor.

Table 1
Mean analysis

Type of the factory	IEQ factors				
	Dust (mg/m^3)	Noise (dBA)	Illumination (lux)	Relative Humidity (%)	Temperature (Celsius)
Green	0.15 (0.03)	77.09 (2.76)	1877.83 (351.07)	63.15 (4.41)	23.57 (1.44)
Non-green	0.20 (0.03)	79.11 (1.96)	1378.65 (367.38)	58.37 (11.21)	27.46 (2.21)

Note: Mean value and standard deviation in the parenthesis are reported

The dust level in non-green buildings is 33 percent higher compared to green buildings whereas, the noise is higher by 2.62 percent in non-green buildings. The illumination level is 36.21 percent higher in green buildings than in non-green buildings, whereas the level of humidity is also higher in green buildings by 8.19 percent. The temperature in non-green buildings is higher by 16.5 percent than green buildings.

The radar chart comparing the mean values of IEQ variables in green and non-green buildings is presented in Figure 1.

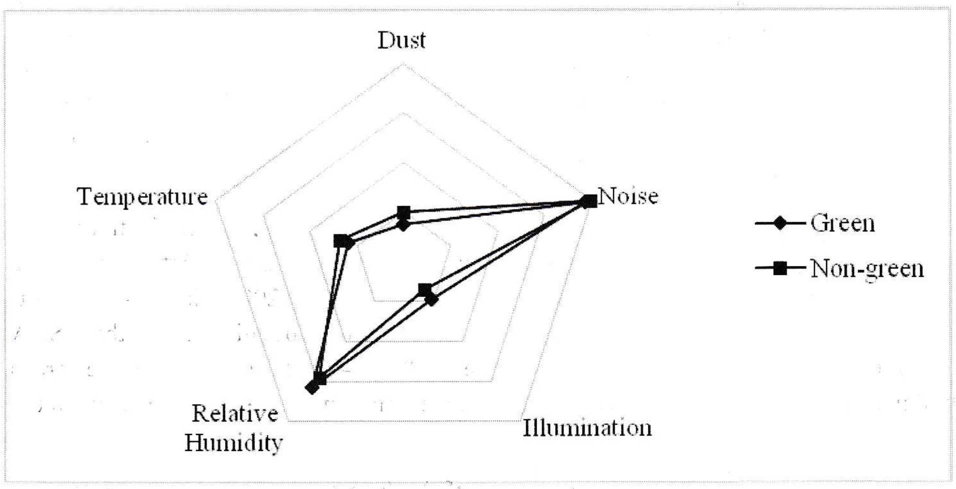

Figure 1 Radar chart

Accordingly, both the level of dust and temperature in green buildings are lower compared to the non-green buildings. The level of Illumination and relative humidity is higher in green buildings. Also, the level of noise is slightly lower in green buildings.

Lower dust level in green buildings makes it attractive to the occupants as absorbing dust adversely affects human health and comfort. Though the green buildings are within the threshold limit of dust level, 0.2 mg/m3, according to the American Conference of Government Industrial Hygienist (ACGIH), the non-green buildings marginally reach the threshold.

The National Institute for Occupational Safety and Health (NIOSH) recommends the 85 dBA exposure limit for occupational noise, and both types of buildings are within the limit. However, the green buildings record a lower noise level than the non-green buildings, and lower noise level is desirable for the occupants.

The different tasks require different levels of illumination. As per the European Lighting Standard EN12464-1, some activities such as cleaning, napping, sewing, netting, and quality control require higher illumination levels as 1000 lux while other activities require lower illumination levels. However, the tasks that involve special visual requirements such as quality inspections need higher illumination levels as 1000-2000 lux. Both types of buildings reach the standard of 1000 lux. Interestingly, the green buildings become attractive recording higher illumination level that positively affects the task performance and productivity, and reduce the number of rejects and the accident (Bommel, Beld, & Ooyen, 2002; Hiba, 1998).

ACGIH recommended relative humidity level for a comfortable working environment is between 40-70 percent. Also, the U.S. Occupational Safety and Health Administration (OSHA) recommends a 20-60 percent humidity level. Maintaining appropriate humidity is especially important in the apparel sector as all textiles are hygroscopic. To facilitate the humidity requirement of different textiles (as an example, silk: a 65-70 percent RH), the environment humidity should be maintained at higher levels as textiles absorb or release moisture based on environment humidity. Also, the weight of the textile is determined at 65 percent humidity level. Thus, the higher relative humidity level is desirable in the apparel industry. Though both types of buildings are within the recommended limits, the green buildings are attractive as they record comparatively higher humidity.

The temperature in labor-intensive settings adversely affects productivity and absenteeism (Somanathan, Somanathan, Sudarshan, & Tewari, 2015). After considering the findings of several studies, Seppänen, Fisk, and Faulkner (2003) find 21-25 Celsius as the optimal range of temperature for the occupants of a building. Also, the OSHA recommends temperature control in between 20-24.4 Celsius. Though the green buildings are within these standards, the non-green buildings have a higher temperature over the upper limit.

Discussing the occupants' satisfaction on IEQ, Abbaszadeh, Zagreus, Leher, and Huizenga (2006) conclude that occupants are highly satisfied with thermal comfort and air quality of green buildings over non-green buildings. Investigating the IEQ with respect to the level of dust (air contaminant), temperature, humidity, noise and light during winter and summer seasons, Kanika, Rana, and Dahiya (2016) found similar results as of the present study and concluded that all factors are favorable in green buildings. The study on thermal, air quality and acoustic environment of office buildings in two climate zones in China is also in line with the findings of the present study and confirms that green buildings confirm the design standards of buildings (Pei, Lin, Liu, & Zhu, 2015). A similar study was done in green and non-green office buildings in Singapore also concludes that the satisfaction of occupants about temperature, humidity, lighting level, and air quality is higher in green buildings (Lee et al., 2018). Although those studies are done in different environmental contexts, they have come up with similar findings as of the present study. However, arriving at a contrasting finding, Lee and Kim (2018) conclude that the occupants' satisfaction in terms of both lighting and acoustic quality is better in non-green building in the US. Thus, the present study helps clear this disagreement and delivers clear evidence for the benefits of green buildings in terms of IEQ in the apparel sector in Sri Lanka.

5. Conclusion

IEQ of both types of buildings are within the recommended limits in terms of dust, noise, illumination and relative humidity however, only the green buildings confirm the standard requirement of temperature. Moreover, the five indicators show relatively favorable conditions in green buildings creating an appropriate indoor environment for the occupants. Thus, the green buildings in the apparel industry set a favorable indoor environment to the occupants.

The use of green buildings is justified because of not only its favorable indoor environment quality but also various other benefits. Among other benefits of green buildings, lower operating cost, increased labor productivity and health, environmental friendliness are prominent in the apparel industry. The demanding concept of sustainability can also be addressed by green buildings. Thus, the green buildings in the apparel industry help firms remain competitive. Hence, the findings of this study enhance the awareness of apparel manufacturers about the benefits of green buildings, and encourage them to move into green buildings. Though the non-green buildings also marginally reach the standards in terms of the selected IEQ variables, the study encourages the firms to use green buildings as they generate comparatively better IEQ while generating various other benefits, including the demanding requirement of being environment-friendly. In light of the benefits, the regulators can come up with appropriate regulations to promote the green buildings in the apparel sector, thereby ensure the apparel industry's sustainability.

This study focuses on the social dimension of green buildings through IEQ. It opens the new research opportunity to inquire about several other aspects of the social dimension of green buildings, and the environment and economic dimensions referring to the Sri Lankan apparel industry. Also, the studies to investigate the benefits across industries are encouraged. The generalizability of findings can be improved by a study that focuses on a number of apparel manufacturers. Further, this study can be extended to investigate the behavior of the selected variables in specific functional areas in apparel factory buildings.

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