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Applicability of Ecological Footprint for Environmental Sustainability Evaluation in Sri Lankan Apparel Sector Built Environments

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Abstract

Ecological Footprint (EF), Carbon Footprint (CF) and Water Footprint (WF) are prominent amongst the environmental footprints, which are used to evaluate environmental sustainability. Although, the evaluation of CF and WF is evident, the application of EF for environmental sustainability evaluation remains unclear in Sri Lankan apparel sector. Therefore, this research investigates the applicability of EF to evaluate environmental sustainability in Sri Lankan apparel sector built environments. A critical review of literature were conducted to establish the relationship of EF with CF and WF in environmental sustainability evaluation. Subsequently, a qualitative research approach was followed under which, three apparel sector factories were investigated and in-depth interviews with experts were conducted to identify the nature of EF application in Sri Lanka. The gathered data were analysed using code based content analysis technique. Research findings revealed that although EF is not fully calculated, it is partially evaluated through quantification of CF and Grey WF. Difficulty of understanding the underlying assumptions of EF of water utilisation and EF of waste generation was identified as the main barrier. Providing training and awareness on the application of EF, raising awareness on calculating EF of water utilisation and EF of waste generation could be identified as key strategies to overcome the barriers.

Keywords - Ecological Footprint, Carbon Footprint, Water Footprint, Environmental Sustainability, Apparel Sector Built Environments

INTRODUCTION

Environmental sustainability is conceptualised based on the notion of eco system services of resource consumption and waste absorption capacity [1]. With the escalating world population growth, resource consumption has surpassed the regeneration capacity of earth [2]. Hence, environmental footprints are used as indicators to evaluate environmental sustainability [3]. It was identified that Ecological Footprint (EF), Carbon Footprint (CF) and Water Footprint (WF) are the most commonly used environmental footprints among other footprints such as Energy Footprint, Nitrogen Footprint, Phosphorous Footprint, Land Footprint, Bio diversity Footprint, to name few [4].

As argued by Wood and Lenzen [5], due to the diverse scope of EF, it can be considered as the main indicator, which addresses the broad spectrum of sustainability. The Global Footprint Network [6], which is a leading body in improving national footprint accounting and footprint standardisation defined EF as "a measure of how much area of biologically productive land and water an individual, population or activity requires to produce all the resources it consumes and to absorb the waste it generates, using prevailing technology and resource management practices". EF is considered as a successful indicator for measuring environmental impacts, since it can be used with WF and CF [7].

a,lthough EF was initially developed to assess the environmental impacts of individuals and nations in the global context, it is being widely used as an environmental sustainability indicator at industrial, organisational and products levels [8]. EF can be applied to textile sector in order to evaluate the environmental impacts of manufacturing factories and production processes [9]. Similarly, Munasinghe *et al.* [10] emphasised about the growing interest for applying CF to evaluate environmental sustainability in Sri Lankan apparel sector. Moreover, applying WF concept for Sri Lankan apparel sector helps in reducing water consumption, which in turn minimises environmental impacts [11]. Although the application of CF and WF to evaluate environmental sustainability is trending, lack of an investigation in to the applicability of EF in apparel sector built environments in Sri Lanka is evident. Hence, this paper presents the study on an investigation into the applicability of EF to evaluate environmental sustainability in apparel sector built environments in Sri Lanka.

LITERATURE REVIEW

The Concept of Ecological Footprint

During last few decades, many solutions have been put forward to address the escalating environmental issues as a result of the numerous attempts undertaken by environmental scientists and ecologists [12]. Since indicators provide simplified information on a certain phenomenon [13], environmental and ecological indicators have been gaining wide attention in the recent history [14]. Hence, several indicators have been recently introduced to evaluate environmental sustainability [15]. Moreover, researchers have made several attempts to bring footprint approaches together for the assessment of the environmental impact of productions [16]. In one such attempt, Galli and co-researchers [16] have integrated EF, CF and WF into a common set called footprint family, since they complement, overlap and interact each other. They further defined this footprint family as "a set of indicators, which able to track human pressure on the surrounding environment, where pressure is defined as appropriation of biological natural resources and CO_2 uptake, emission of greenhouse gases (GHGs), and consumption and pollution of global freshwater resources" and monitored these three key ecosystem compartments through the Ecological, Carbon and Water Footprints, respectively.

CF quantifies the total GHG emissions caused directly and indirectly by a person, organisation, event or product, which is measured in tonnes of CO_2 equivalent [17], whereas WF assesses the consumption of fresh water and discharge of waste water [18]. The sub components of WF are Blue WF, Green WF and Grey WF [19].

Amongst the indicators in footprint family, EF is used to measure overall environmental impacts [20] and to quantify resource consumption and waste generation [21]. Rees [22] introduced the term, "Ecological Footprint" and Rees and Wackernagel [23] defined EF as the total productive land and water area needed to generate resources consumed and absorb waste generated of a specific population or economy. Since then, EF is a tool, which is evolving with many improvements and advancement [24]. It is generally measured in terms of global hectares of biologically productive land types [7]. Biologically productive land areas, which also refer to as economically useful land types with regenerative capacity, are employed for EF accounting [25]. The six categories of biologically productive lands are [26, 27]:

- Crop Land - Provides plant based food and fibre products
- Built-up Land - Provides built-up surface for shelter and infrastructure
- Fishing Ground - Provides marine and inland area for fish products
- Pasture Land - Provides animal products and grass
- Forest Land - Provides timber and other forest based products
- Carbon uptake Land - Sequestration of CO_2 by forests

Since carbon uptake land sequesters CO_2, which is generated mainly by combustion of fossil fuel and carbon absorption is mostly occurred in forests [27], EF methodology assumes forest land as carbon uptake land [26, 6]. In EF accounting, equivalence factors and yield factors are the two important coefficients to be informed of, with respect to the aforementioned biologically productive land categories [26]. The equivalence factor converts a land type in to a universal unit of a biologically productive area and the yield factor measures the productivity of a land type in different countries [6].

EF quantifies the required biologically productive areas to absorb carbon dioxide, which is a GHG and hence, it is evident that there are many overlapping between EF and CF [28, 29]. Moreover, EF and WF are partially overlapping as the biological capacity of earth is influenced by water [16]. The comparison of EF with CF and WF is presented in Table 1.

Table 1: Comparison of EF with CF and WF

EF and CF	EF and WF
Indicators are overlapping	Indicators are partially overlapping
Carbon uptake land accommodates CF by accounting for sequestration of carbon dioxide emissions	A biologically productive land category is not assigned to quantify fresh water consumption
CF originated as a sub set of EF	WF originated as an analogue of EF
CF is a sub category under EF	WF is not a sub category under EF

As indicated in the table, EF has a strong relationship with CF and it is a sub set of EF. The relationship between the EF and WF is manifested by the partial overlapping between the two indicators.

Ecological Footprint of Energy Consumption, Water Utilisation and Waste Generation

According to Butnariu and Avasilcai [30], fossil land is allocated to absorb CO_2 emissions created from combustion of fossil fuels to generate energy. The authors further asserted that EF of fuel usage should be assigned to fossil land since carbon dioxide is generate through direct combustion of fossil fuels. Although electricity is not an energy source, which is directly obtained from nature, indirect carbon dioxide emitted due to fossil fuel combustion in generating electricity is accounted under EF of electricity [9]. The authors further explained that the area for absorbing carbon dioxide emissions is also known as fossil energy land. Moreover, Martinez-Rocamora *et al.* [31] suggested that EF of electricity is determined by carbon absorption land. Therefore carbon uptake land is also known by the terms, fossil land, fossil energy land and carbon absorption land, when energy consumption related environmental impacts are expressed in terms of carbon dioxide emissions, which occur due to fossil fuel combustion.

EF of water consumption is assigned to forest lands assuming forest as a water producer [32, 33]. However, Kitzes *et al*. [34] stated that the National Footprint Accounts does not recognise assigning a land category for fresh water consumption. Borucke *et al.* [26] confirmed this opinion by pointing out that forest land category is only dedicated to provide timber and other forest based products. Since Martinez- Rocamora *et al.* [31] proved the possibility of quantifying the EF of water consumption, in terms of energy utilised in treating waste water generated, EF of water utilisation is assigned to carbon uptake land.

As stated by Tian *et al.* [35], biologically productive land category of waste generation is determined based on waste type and waste disposal process, due to treating and disposing waste consumes resources, occupies land and pollutes water and air. Hence, waste disposal and emission methods have to be accounted and the share of energy recovered through waste treatment must be deducted [31]. Herva *et al.* [36] also pointed out that the impact of hazardous and non-hazardous waste must be considered separately for the EF calculations depending on their treatment method. Moreover, reusing of materials reduces the EF of waste generation [37]. Hence, EF of waste generation is accounted based on the waste product and waste processing method.

Ecological Footprint in Apparel Sector

Potential applications of the EF concept can assist in informing scenarios and formulating policies and strategies in accomplishing sustainable consumption [38]. Therefore, EF has been used worldwide in a variety of organisations as an approach for integrating sustainability in to the industrial context.

According to Niinimaki and Hassi [39], textile industry provides basic materials and apparel industry converts these materials to meet the demand of consumers. Hence, apparel industry plays the major role in terms of economic development, in which the textile industry is a sub segment in apparel sector. According to Jaganathan *et al.* [40], apparel industry consumes a large amount of energy, water and uses chemicals, which generates waste products. Therefore, it is responsible for creating environmental impacts mainly through energy consumption, water utilisation and waste generation. Since energy consumption, water utilisation and waste generation in apparel sector create adverse environmental impacts, determining the EF of these three impact categories is of paramount importance. Further to Butnariu and Avasilcai [30], energy consumed in apparel manufacturing processes comprises of electricity and fuels, and hence, EF of fuel usage and EF of electricity consumption are assigned to carbon uptake land. Hence, EF of apparel sector built environments is mainly quantified by EF of energy consumption, EF of water utilisation and EF of waste generation and assigned to relevant land categories. Therefore, Herva *et al.* [9] proposed EF as a tool to assess the environmental performance of apparel manufacturing factories and their manufacturing processes in order to optimise resource utilisation and minimise waste generation.

RESEARCH METHODOLOGY

The research methodology presents the overall guidance to answer the research problem by providing the approach for obtaining information required for the study [41]. This research was initiated with a literature review on the concept of EF and to identify the relationship between EF with other environmental footprints such as CF and WF. The literature review was followed by a background study, which revealed that EF is a new concept to Sri Lankan context and only few apparel sector factories are evaluating environmental footprints. Based on the comprehensive literature review and the background study, following research problems were developed.

- How EF is currently evaluated in apparel sector built environments in Sri Lanka?
- What are the barriers in evaluating EF in apparel sector built environments in Sri Lanka?
- How to overcome the identified barriers in evaluating EF in apparel sector built environments in Sri Lanka?

As explained by Yin [42], qualitative approach contributes to explore emerging concepts and is most suitable for researches, which have small sample of respondents. Since EF is relatively new to Sri Lanka and only few apparel sector factories are currently evaluating environmental footprints, case studies were undertaken under the qualitative approach in order to conduct an in depth investigation. Accordingly, three apparel manufacturing factories, which evaluate environmental footprints were selected as cases.

Employing un-structured interview method is preferred in qualitative approach since the respondents are given the opportunity to answer independently with a limited control imposed by the researcher [43]. Three respondents from each case, who involve in the current footprint evaluation process were interviewed. Moreover, observations of apparel factory premises and reviewing relevant documents were undertaken to capture data. Data analysing was carried out using content analysis. Research findings were presented to an industry expert and an academic expert for validation and the final outcome of the research was refined accordingly. The profile of the case study factories and respondents is summarised in Table 2.

Table 2: The Profile of the Case Study Factories and Respondents

Case Name	Description of Case	Respondents	Description of Respondent
Factory A	Board of Investment approved apparel manufacturer and exporter, located outside Industrial Zone of Ekala. The factory manufactures loungewear and operates a fabric washing and colouring plant. The factory is a single storey building of 11,400m^3 and has 683 employees.	A1	Group Facility Manager with 17 years of work experience and responsible for evaluating footprints and formulating action plans.
		A2	Senior Maintenance Executive with 10 years of work experience and responsible for calculating footprints and monitoring data collection procedure.
		A3	Senior Maintenance Technician with 11 years of work experience and responsible for collecting and recording data for footprint calculations.
Factory B	Board of Investment approved apparel manufacturer and exporter, located in Export Processing Zone of Katunayake. The factory manufactures sportswear. The factory is a single storey building of 9,800 m^3 and has 550 employees.	B1	Director Compliance with 27 years of work experience and responsible for analysing footprints for decision making.
		B2	Engineering Executive with 08 years of work experience and responsible for calculating and interpreting footprints.
		B3	Maintenance Officer with 10 years of work experience and responsible for collecting data for footprint calculations.
Factory C	Board of Investment approved apparel manufacturer and exporter, located in Ratnapura. The factory manufactures lingerie. The factory is a single storey building of 9,500 m^3 and has 472 employees.	C1	Maintenance Manager with 21 years of work experience and responsible for assessing footprints and formulating strategies.
		C2	Factory Engineer with 15 years of work experience and responsible for calculating and interpreting footprints.
		C3	Maintenance Supervisor with 14 years of work experience and responsible for collecting and recording data for footprint calculations.

For data collection through unstructured interviews, one managerial level respondent, one executive level respondent and one non-executive level respondent were chosen based on their role in the data collection for footprint calculations, calculation of footprints and evaluation of results for decision making through footprint calculations.

RESEARCH FINDINGS AND DISCUSSION

The case study findings are presented and discussed under following sections:

- Situational analysis of EF evaluation in apparel sector built environments in Sri Lanka
- Barriers in evaluating EF in apparel sector built environments in Sri Lanka
- Strategies to minimise barriers in evaluating EF in apparel sector built environments in Sri Lanka

SITUATIONAL ANALYSIS OF EF EVALUATION IN APPAREL SECTOR BUIL TECOLOGICAL FOOTPRINT ENVIRONMENTS IN SRI LANKA

In order to determine the current level of applicability of EF, it was investigated whether EF is calculated by the selected factories. Furthermore, the type of data, which is currently collecting for footprint calculations to evaluate environmental impacts created by energy consumption, water utilisation and waste generation in these factories was investigated. Currently practicing footprint calculation methods and strategies to minimise footprints were further explored in terms of energy consumption, water utilisation and waste generation. Respondent's opinions on possibility to calculate EF at respondent factories were captured.

All the respondents of factories A, B and C stated that they use footprint indicators to evaluate the environmental impacts of energy consumption, water utilisation and waste generation. They further mentioned that CF is calculated to quantify the environmental impacts of energy consumption in respondent factories through fuel usage and electricity consumption. According to B1, *"We already account for carbon emissions under CF. So, the EF of energy consumption is accounted using* *carbon emissions, but without converting to carbon uptake land".* Accordingly, data on CF of fuel usage and CF of electricity consumption are used to calculate EF of energy consumption in respondent factories. Furthermore, C3 emphasised that *"all necessary data is already available through CF calculation process to commence EF of energy consumption calculation".* Hence, it is observed that EF is partly evaluated using CF, which is a sub category of EF. However, it was further revealed that EF of energy consumption is currently not expressed in terms of carbon uptake land.

All the respondents claimed that current calculation of Grey WF, which is a sub category of WF, facilitates the quantification of waste water generation. Therefore, calculating Grey WF is an indication that waste water is treated at factory level and energy consumed in treating waste water can be quantified. However, B2 highlighted that *"EF methodology does not directly assign land categories to water consumption".* A1 further confirmed this view stating that *"there is no land category assigned for water consumption related impacts, but there should be a way to compute those impacts under EF".* Nevertheless, literature findings revealed that quantifying EF of water utilisation can be partly achieved through the energy utilised for waste water treatment. Since all the respondent factories treat waste water using effluent treatment plants, which are operated from electricity, EF of energy consumption for treating waste water in a factory should be deducted from total EF of electricity in that factory. Therefore, quantification of impacts of waste water generation through Grey WF calculations immensely facilitates the valuation of EF of water utilisation.

The case studies further revealed that environmental impacts due to waste generation are not quantified under currently practicing footprints. Since, majority of waste products are processed by third parties, their impacts could not be quantified at the factory level. B2 opined about assessing EF of waste generation in factory as, *"When it comes to waste types, impact of each and every waste should be considered to account under EF, for which the waste management strategy of each of them has to be known. But in our factory, waste is handled by a third party".* When waste products are processed by third parties, energy recovered from recycling and other processing methods cannot be quantified by the respondent factories in quantifying EF of waste generation.

As expressed by A1, A3, B2, B3, C2, C3, availability of necessary data on energy consumption, water utilisation and waste generation enables calculating EF. B3 emphasised, *"we already have energy, water and waste related data and so that EF can be calculated".* C3 also confirmed this view stating *"all necessary data is already available through CF and WF calculation processes to commence EF calculation".* Summary of the responses given by all the respondents is tabulated in Table 3.

Table 3: Footprints Evaluated in Case Study Factories

Impact categories	Sub Categories	Footprint Indicator		
		Factory A	Factory B	Factory C
Energy Consumption	Direct emissions due to fuel usage in the factory	CF	CF	CF
	Indirect emissions due to electricity consumption in the factory	CF	CF	CF
Water Utilisation	Impacts due to waste water generation in the factory	Grey WF	Grey WF	Grey WF
Waste Generation	Impacts due to waste products generation in the factory	Not quantify, but data is available for quantification	Not quantify, but data is available for quantification	Not quantify, but data is available for quantification

The strategies to minimise CF and WF in the case study factories, which contribute to reduce EF of energy consumption, EF of water utilisation and EF of waste generation were further determined through document review and observations made at case study factories. The research findings revealed that EF is not currently fully evaluated in all three factories. But, all the respondents acknowledged that they have partly evaluate and also have the potential to calculate EF for evaluating environmental sustainability in their factories. Case study and literature review findings can be further used to determine the related biologically productive land categories for energy consumption, water utilisation and waste generation as illustrated in Figure 1.

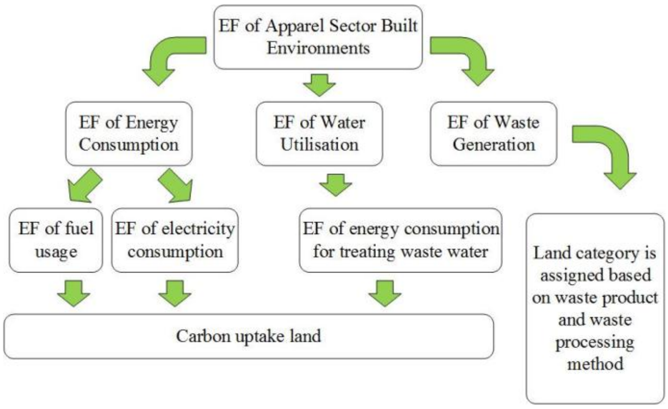

Figure 1: Assigning Land Categories to Energy Consumption, Water Utilisation and Waste Generation

As illustrated above, EF of energy consumption and EF of water utilisation can be assigned to carbon uptake land and EF of waste generation can be determined as per the waste product and waste processing method.

BARRIERS IN EVALUATING ECOLOGICAL FOOTPRINT IN APPAREL SECTOR BUILT ENVIRONMENTS IN SRI LANKA

Barriers, which constrain the successful application of EF were determined through the opinions of respondents. Accordingly, difficulty of understanding underlying assumptions of EF of water utilisation and EF of waste generation was identified as the major barrier by A1, A2, B1, C1 and C3. A1 emphasised that "*Although the calculation of EF of energy consumption is straightforward, since it quantifies a part of EF through CF calculations, EF of water utilisation and EF of waste generation have controversial assumptions because of not allocating direct land categories by standard EF methodology, to measure their impacts"*. A1, B2 and C2 highlighted difficulty to obtain conversion factors for EF calculations as another barrier. Expressing his views, B2 added, "*Yield factors and equivalence factors are not readily available in the local context and we have to download international reports like National Footprint Accounts to obtain this data. Without having conversion factors, EF calculations cannot be done in terms of global hectare units*". Unavailability of waste water treatment in some factories is another barrier highlighted by A2, B3, and C2. C2 emphasised "*Not all the factories treat waste water at their premises. So they cannot account for EF of water utilisation by quantifying energy consumed in waste water treatment''*. Therefore unavailability of waste water treatment in some factories is a barrier to calculate EF of water utilisation. Lack of data to calculate EF of waste generation in some factories is highlighted as a barrier by A3 and B2. A3 asserted, *"At our factory waste generation related data is available and we can calculate EF of waste generation. But I don't know how the factories which do not maintain records of waste generation calculate EF of waste generation"*. B3 and C1 pointed out that insufficient commitment of top management to calculate EF as another barrier. C1 explained *"Since the management is not convinced about the importance of applying EF, they stick with CF and WF calculations"*. A1 pointed out lack of promotion of the EF concept by responsible authorities as a barrier. A1 shared his views as, *"Government level and other responsible environmental related authorities are not determined to go beyond from environmental sustainability indicators such as CF and WF.* Reluctance of footprint calculating personnel to calculate many footprints is a barrier as per A3. A3, who collects and records data required for footprint calculations stated, *"I have to collect necessary data for CF and WF calculations, while attending to maintenance activities of the factory. Sometimes I find very difficult to attend to data collection, due to the workload and responsibilities of my job position"*.

The summary of barriers identified in this study are listed below:

- Difficulty to understand underlying assumptions of EF of water utilisation and EF of waste generation
- Difficulty to obtain conversion factors for EF calculations
- Unavailability of waste water treatment mechanism in some apparel manufacturing factories
- Insufficient commitment of top management to calculate EF
- Lack of data to calculate EF of waste generation in some apparel manufacturing factories
- Lack of promotion of EF concept by responsible authorities
- Reluctance of footprint calculating personnel to calculate many footprints simultaneously

Overcoming these barriers is of utmost importance to employ EF to evaluate environmental sustainability in apparel sector built environments in Sri Lanka.

STRATEGIES TO MINIMISE BARRIERS IN EVALUATING ECOLOGICAL FOOTPRINT IN APPAREL SECTOR BUILT ENVIRONMENTS IN SRI LANKA

Strategies were proposed based on the opinions of respondents to minimise aforementioned barriers. Providing training and awareness on EF calculation at factory level, and raising awareness on calculating EF of water utilisation and EF of waste generation are two of such strategies proposed by all the nine respondents. Since calculation of EF of water utilisation and EF of waste generation is based on certain assumptions, according to B3, *"Providing awareness about the EF concept throughout the apparel sector is the best way to address controversial assumptions".* A3 commented on the importance of conducting training programmes about EF as, *"These should specially focus non-executive employees who involve in current footprint calculation process, because they find it difficult to understand these concepts, without proper guidance".* A2, B3 and C3 pointed out that aforementioned two strategies can contribute to communicate the importance of EF calculations and encourage factories on treating waste water and managing waste. A2 and B2 suggested that implementing waste water treatment and waste management in factories should be mandated. Appointing a designated employee for footprint calculations at factory level is another strategy, which was highlighted by A3 and C2. C2 proposed, *"A job title for a Sustainability Officer should be created at factory level to calculate all these footprints and oversee the footprint calculation process".* Implementing programmes to increase recognition for factories which calculate EF is a strategy to promote applicability of EF concept in factories as per the opinions of B1 and C2. B1 suggested "*Government and responsible authorities can take measures to encourage factories to calculate EF. If they can provide incentives like tax reduction schemes and increase recognition of such factories by presenting awards, factories will be motivated to calculate EF".* Convincing top management about the importance of EF calculation should be undertaken. B2 emphasised *"Awareness programs have to be conducted in Sri Lankan apparel sector by responsible authorities which can in turn convince the top management and provide guidance on the applicability of concept".* In order to overcome the barrier of difficulty to obtain conversion factors, C1 suggested to secure the support of responsible authorities by stating *"These responsible authorities must make available the conversion factors for calculation process by providing access to international reports on conversion factors* conversion *factors in a centralised database for apparel sector*"

The summary of strategies proposed by the respondents are listed below:

- Providing training and awareness on applicability of EF to apparel manufacturing factories
- Raising awareness in the apparel manufacturing sector on calculating EF of water utilisation and EF of waste generation
- Appointing a designated employee for footprint calculations at factory level
- Implementing waste water treatment and waste management in apparel manufacturing factories
- Convincing top management about the importance of EF calculation
- Maintaining records of conversion factors in a centralised database for apparel sector
- Implementing programmes to increase recognition for apparel manufacturing factories, which calculate EF

Ecological footprint calculations to evaluate environmental sustainability can be initiated by implementing aforementioned strategies in apparel sector built environments in Sri Lanka.

CONCLUSIONS AND RECOMMENDATIONS

With the escalating adverse impacts on environment, numerous indicators have been developed to evaluate environmental sustainability. Due to its wide scope, EF plays a major role in the context of environmental sustainability. EF can be used as an indicator to quantify resource consumption and waste generation. Findings from the case studies proved that EF is partially calculated in apparel manufacturing factories through CF and WF, although it is not quantified in terms of biologically productive land categories. It was deduced that EF is applicable to evaluate environmental sustainability in apparel sector in Sri Lanka. Barriers which constrain the successful applicability of EF were determined by the opinions of respondents. Accordingly, difficulty of understanding underlying assumptions of EF of water utilisation and EF of waste generation was identified as the major barrier to apply EF to evaluate environmental sustainability in apparel sector built environments in Sri Lanka. Strategies were proposed by the respondents to overcome these barriers. Providing training and awareness on EF calculation at factory level, raising awareness on calculating EF of water utilisation and EF of waste generation, appointing a designated employee for footprint calculations at factory level are some of the strategies. Outcomes of this research will be beneficial for the industry practitioners of apparel industry, for improving the environmental performance of Sri Lankan apparel sector built environments.

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