Sustainability Assessment in The Textile and Apparel Industry: A Review of Recent Studies

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Abstract. This study was carried out to present general concept and overview of sustainability assessment of textile industry. Textile and apparel industries generate environmental harm at all stages of production from raw material cultivation to disposal of finished goods. Large amounts of chemical loads, high amount of water usage, high energy consumption, air emission, solid waste and odour formation are the major environmental challenge in textile industries. There is a need to assess the performance of textile industry while considering the three facets of sustainability to achieve a sustainable production. Five keywords such as sustainable development, sustainable manufacturing, sustainability assessment, textile industry and triple bottom line were used to investigate and find recent and related studies. The studies were critically reviewed and evaluated at different assessment levels, source and weight of indicators and boundaries of sustainability assessment. Furthermore, the reviewed findings were critically discussed along with their strengths and weaknesses. The reviewed studies revealed that most sustainability evaluations were conducted on sector, product and process/work cell levels in the textile and apparel industry. However, it is necessary to emphasize more on company assessment level to accomplish the three pillars of sustainability objectives. Environmental dimension measurement in textile industry had been fairly developed and standardized. However, from economic and social perspectives, only cost analysis, employee’s welfare and safety were mostly considered in all the reviewed studies. Hence, more investigation and validation must be performed on social and economic indicators in textile industries.

Keywords: Sustainable development, sustainable manufacturing, sustainability assessment, textile industry and triple bottom line.

1. Introduction

Improvement in standard of living and global population growth has led to increase in textile consumption and production in the recent years. Textile and fashion industry are among the leading world’s polluting industries, such that all the phase of fashion and textile supply chain endangers our resources and planet [1], that is textile and apparel industries generate environmental harm at all stages
of the production from raw material cultivation to disposal of finished goods, such as consumption of large amount of chemical loads, high amount of water usage, high energy consumption, air emission, solid waste and odour formation were major environmental impacts of textile industries. The industry is positioned to be among the biggest polluter of fresh water which has great impact on agricultural development. The water pollution effluents are basically consisting of high Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) produced. Also, CO$_2$ and N$_2$O are associated with greenhouse gas (GHG) emission in the textile industry. Furthermore, NO$_x$, SO$_x$ and dust add to air pollution [2].

However, the textile industry plays a critical role in the economy of any nation due to its contribution to export, industrial production, foreign exchange and employment. Despite the encouraging impact on the economy, the environment received the negative impact of the sector because of resource depletion, pollution and greenhouse gas emission [2]. With all the problems associated with textile industries at every stages ranging from dye printing to production of textile product, chemical wastes are generated a lot [3], therefore various government is employing different policies to improve productivity and reduce environmental pollution [4]. It is necessary for every textile industry to adopt sustainable manufacturing in its production line owing to environmental impact identification and increase in sustainability awareness concept. [5, 6] reported the unsatisfactory nature of sustainable manufacturing implementation by companies despite its importance. [7] invented triple bottom line (TBL) approach which refers to accounting framework consisting of three pillars of sustainability that is economic, social, and environmental dimensions. Sustainability is evaluated through assessing the performance of environmental, social and economic principles being the most prominent factors also known as the three pillars model of sustainability.

Reporting the results of sustainability assessment enables organization owner to reveal sustainability objectives and advantages to investors. On the other hand, it is also a means to influence and public view and raising understanding of sustainability, hence to improve the level of any organization it is a must to integrate the three pillars of sustainability that is economic dimension, environmental dimensions and social dimensions which will help to provide full picture of sustainability assessment based on TBL approach. In the past many researchers has examined sustainability assessment in textile industry all over the world, yet to many stakeholder’s believes sustainability issues in textile industry is considered as abstract to measure because of unavailability of measurable and applicable key indicators, however many of this previous studies focus majorly on environmental issues only [8, 9, 10 & 11] or social only [12 & 13] or economic and environmental [2 & 14], neglecting triple bottom line (TBL) approach of sustainability. Though some researcher reported recently TBL concept of textile and apparel industry at products, sector, economy, company and unit process assessment levels such as [15, 16, 17 &18]. Textile industry and almost every manufacturing industry globally has become nearly automated. The automated production and energy reduction cost due to sustainable practice results in cheaper textile production. Also, it increases economic wellbeing in world population, to meet customer demand. Therefore, it is important to review the recent sustainability studies in textile and apparel industry, based on the three pillars of sustainability. This review study will help solve the gaps and broaden the knowledge of sustainable textile production for future study and all-inclusive sustainability evaluation in textile and apparel industry. The rest of this paper proceeds as follows. Section 2 briefly present some related theoretical concepts in textile industry. Section 3 the research methodology is outlined. In section 4 the review of recent sustainability assessment studies. Section 5 discussed the results. Section 6 the implication was reported, and section 7 important conclusion were made.
2. Theoretical concepts

2.1. Sustainable development

Sustainable development emanated as an idea in the early sixties when the inhumane industrialization in the developed countries began to be obvious on a natural degradation and carry pollution and ill health problem. The term sustainable development became more pronounced in 1987 after Brundtland report. The report offers two major definitions “our common future and the three pillars of sustainability. Our common future is clearly defined in the report as meeting our own (present) needs without compromising the ability of the future generation to meet their own needs [51]. Likewise, the three pillars of sustainability were tacitly acknowledged in the report as a wider objective to combine economic, social, environmental concerns [19]. Sustainable development approach does not only involve problems associated with environment and ecology. The social aspects of sustainable development are also important because the entire idea was based on economy, environment, and society. Moreover, the emphasis on sustainable development in research commenced with environmental issues, however, the triple bottom line (TBL) framework had been extensive by recognized marketing and management literature nowadays [20, 21] developed by [7]. The TBL methodology deliberates the necessity to simultaneously achieve social equity, environmental quality, and economic prosperity as the source for long term competitive gains [22 & 23].

Also, [24] described sustainable development as the maintaining system firmness by developing a balance of responsibilities, economic, environmental, social, and technological support techniques without compromising the needs of the future generation. Therefore, sustainability is perceived as having three dimensions, that is social, economic and environmental, which is labeled as the triple bottom line (TBL) and it factor in the decision of people, profit and planet by the organisation [7]. Economic dimensions are the major competitive concerns of many organizations neglecting other dimensions of the TBL, sadly which lead some organization to lose their credibility, reputation and corporate image [25]. Meanwhile, it has been established that sustainable development is based on the integration of economic, social and environmental views.

2.1.1. Environmental pillar. The environmental pillar is the most focused among the three-sustainability development. Most manufacturing industries are focusing on a way to reduce their carbon footprint, energy consumption, water consumption, packaging waste and their overall effects on the society. It is one of the major challenges the world is facing in general because most of the manufacturing industries in the developed and developing nation nowadays were not operating in a sustainable environment. To overcome these challenges, we must guarantee that our natural resources were consumed, such as materials, land, water, energy fuels etc. at a sustainable amount. Business’s impact is another issues facing environmental dimension because they are not entirely costed, that is the externalities are not being taken such as cost of land reclamation, waste water, carbon dioxide and waste were difficult to calculate because most of waste generated affects the society directly not the companies.

2.1.2. Social pillar. The social pillar is the capacity of a society, country, family and organization to function at a defined level of wellbeing and harmony for an indefinite period and must be retained in the long term. Community, employees, stakeholder approval and supports were the basis of sustainable business. In addition, it is very important to ensure that society is sustained by ensuring that the rate of resources consumed is not faster than how they are naturally renewed. The rate of discharging waste must be appropriate to what natural systems could conform without corrupting. Although, this varies with distant source for its most basic conditions.

2.1.3. Economic pillar. The ecological and social significances are importantly considered in economic movement. It provides enticements for businesses and other organizations to follow the
sustainability guidelines beyond their normal legislative requirement. Economic development is about giving people what they want without compromising quality of life, especially in the developing world and reduced the financial burden.

2.2. Sustainability and textile manufacturing industry
Population growth has risen textile production and consumption across the nation, this led to expansion of global economy. [26] reported that global textile industry valued at USD 3 trillion yearly and contributed 2% of the entire global gross domestic product (GDP). Every year over 100 million metric tonnes of textile products are being manufactured, which makes the apparel and textile product among the world’s largest industries [27]. The production stages consist of the main environmental impact from textile product. Textile and apparel industries generate environmental harm at all stages of the production from raw material cultivation to disposal of finished goods, such as released of large amount of chemical loads, high amount of water usage, high energy consumption during fabric manufacturing, air emission, solid waste and odour formation are major environmental impacts of textile industries. [28] and [29] revealed that more sustainable material should be used in textile industry. However, textile industry represents important pollution source and represent major part of the economy [30]. Similarly, [31] reported that China being the largest exporter and producer of textile products accounts for 25.1% of global CO₂ emission in 2010, this estimate reveals that the power generation accounted for 37.2% of the Chinese CO₂ total emission. As reported by [32], textile production is responsible for more than 1.2 billion of carbon emission yearly. Consequently, [33] reported that dyeing in textile industry is known not to be sustainable activities because of high chemical usage, high water and energy consumption and generating a lot of effluent emission. Hence, Textile and apparel industry have an enormous effect on the ecosystem, which plays a major entity on revolutionize the economic condition of a nation. Nowadays, most of the developed and some developing countries had adopted the sustainable manufacturing in their textile production line which in turns lead to increase in market share and competitiveness of the industry.

Consequently, China Statistic Yearbook reveals that China textile industries created 18 million jobs, increased its export rate from 10.3% to 35.2% between 2000 and 2012 and have over 33,384 functioning textile enterprise. In addition, United State textile and apparel is growing on a daily basis. [34] reported that U. S. export valued is USD 24.3 billion in 2014. On the other hand, Vietnam textile industry reported a growth and have about 6000 functioning industry and creates about 2.5 million employment which accounted for 25% of the labour force in the industrial sector as revealed by [14]. Similarly, the industrial output in china yielded 4.7612 billion Yuan with 27.46% annual increment and China textile export in 2012 were USD 212 billion with 23.76% increment according to China Bureau of Statistic. Nevertheless, China textile industry emitted a lot of pollution and consumed about 4.3% of the entire manufacturing industry energy. Today throughout the world, textile in millions of tons are entering landfill because of lack of recycling of textile. [35] stated that increase in recycling of textile will reduce negative impact on the environmental problem in textile industry attributed to landfill space, also the production of new textile. According to [36], which stated that textile industry and almost every manufacturing industry in the developed nation have become nearly automated. The automated production and energy reduction cost due to sustainable practice result in cheaper textile production. Also, it increases economic wellbeing in world population to meet customer demand. Thus, if the textile and apparel industry were assessed based on three bottom line, it would be of invaluable worth because presently most textile industry lacks sustainability practice in their operation.

3. Methodology
A systematic research literature review was performed to classify peer-reviewed studies that emphasis on the assessment of sustainability performance in textile industries. Due to the wide nature of sustainability assessment concepts in textile industries, a broad literature review was performed with a
wide search on relevant literature from journals related to sustainability assessment for data collection and evaluation principles. The literature was performed using key words like “sustainable development”, “sustainable manufacturing”, “sustainability assessment”, “textile industry”, “indicators”, “performance measures” and “three bottom line”. The data range was set for the articles published from “2009 to 2019”. The article at hand analyses related journals in key electronics databases, namely, Elsevier, Wiley, Emerald, Sage, IEEE Xplore, Tailor and Francis and Springer etc. Having utilized these criteria, a group of 216 journal papers were primarily obtained. To obtain more important literature in harmony with the study, a detailed evaluation was carried out by contemplating several research standards of the classification framework. As a screening standard for the studies, Scopus indexing is the least published journals used for the analysis while the remainder were excluded. After this procedure was completed, 76 final references were carefully chosen.

4. Recent sustainability assessment trend in textile industry

Textile and apparel industry have given sustainable development great attention worldwide due to their high polluting features, resources and labour-intensive nature of the industry. Despite the industry great potentials of economic importance to the country it operates. Today, sustainability tries to fix current needs without accepting standards that are lower than its desirable future generations and without making concessions on any of the three important pillars, such as social development, environmental protection and economic growth. The challenges we faced today is because of unsustainable manner we applied our resources, climate changes, environmental pollution and raw material exhaustion and ecosystem degradation. Similarly, several researchers that worked on product, process and plant level sustainability assessment presented several indicators and methodologies for assessing sustainability performance evaluation at environmental dimensions only such as [9,11,17,37&38]. Also, [39] worked on measurement of sustainability performance in textile industry using a multi criteria decision making method to integrate the sustainability of key performance indicator in manufacturing company. The researcher proposed that the method should be applied to more acceptable and applicable indicators. However, the researcher overlooked both social and economic dimensions. [2] focused on economics and environmental aspects while [46] focused on environmental and social aspects. Similarly, [13] reported social aspect only. However, to achieve sustainability purposes all the three dimensions of sustainability must be integrated simultaneously [40]. sustainability performance is good for reporting both internal and external policy assessment of the textile industries by the decision makers.

However, as reported Table 1 below several assessment studies were carried out at process or work cell level which is useful to report the internal decision making of the textile industries, majority of the studies was conducted at gate-to-gate assessment boundaries such as environmental [17], social [12], environmental and economics [41 & 42]. While [45] worked on supplier’s selection decision making based on TBL approach at cradle to grave boundary at process level, however purchasing and supplier’s classification were ignored in the study.

Also, sustainability assessment carried out at plant level which specifies an overall illustration of the sustainability performance of the entire structure of a company under investigation which is generally useful both internal and external reporting of the company decision making as reported by [43,2]. [2] undertaken eco-efficiency performance evaluation of three selected processing factories in Sri Lanka considering the factory five years total production period as an indicator. The research showed that eco-efficiency affects the production cost.

Similarly, the sustainability assessment performed at product level as reported by several researchers was carried out at environmental dimension only such as [8, 9, 11, 37 & 38] and social dimension [13]. The performance was done at different assessment boundaries and it is usually useful for reporting external and internal policy decision making that enhance the competitive advantage of the products. However, [38] focused on ecological benefit derived from agro-industrial residues of textile natural dyeing, since the agro-industrial waste contributes to improved textile dyeing sustainability by offering a unique natural product.
Hence, the sustainability assessment at the national or economy and sector levels are very important in reporting the external policy of the industry by the decision makers. [10] study provided a better understanding of greenhouse gas management and establishing an evaluation system for the textile enterprise to recognise their management weakness and continue improving their greenhouse gas (GHG) management level. The results revealed the actual greenhouse gas emission performance. Whereas [3, 15 & 44] reports were based on TBL approach.

However, among several studies that reports at company and process levels in the reviewed work only two studies based their discussion on TBL approach. [15] revealed a valid and reliable hierarchical framework for assessing corporate sustainability performance in Taiwanese textile industry, the study used the integration of fuzzy synthetic method and decision making trial and evaluation laboratory to assess the causal interrelationship among the criteria. However, the author failed to validate the assessment method. Also, related study which based on three facets of sustainability was reported by [16], which revealed a well-balanced analysis which focused on sustainability audit of India textile industry, additionally this study validates the assessment method developed with a case study. However, Textile industry is among the major sector for economic development of countries globally [45], labour intensive and highly polluting has always been associated with the textile industry.

| No | Reference | Manufacturing Area     | Description and Findings                                                                                                                                                                                                 |
|----|-----------|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | [15]      | Textile industry       | All the three dimensions of sustainability were undertaken at sector level. A valid and reliable hierarchical framework for assessing corporate sustainability performance was conducted in Taiwanese textile industry. The exploratory factor analysis was used to group the direct and indirect relationships among attributes and examines the validity and reliability. |
| 2  | [11]      | Cotton clothing        | The study looked at ecological footprint and sustainability awareness of Brazilian consumer impact on the environment in the clothing production stages using data mining technique. However, social and economic dimension were missed out while recycling phase was also left out. |
| 3  | [43]      | Textile industry       | Socio-economic impact analysis of 15 most vital variables that are important to competitiveness of SMEs in textile industry. The most important variables were identified and ranked in their cause-effect relationships. Also, this approach touched all the three pillars of sustainability. A hybrid model assessment method was developed. |
| 4  | [46]      | Textile industry       | The objective of this study was to propose a comprehensive model based on three facets of sustainability assessment to support the decision making related to supplier selection. However, purchasing and supplier classification were ignored. |
| 5  | [41]      | Textile Industry       | The study looked at process level sustainability assessment that reveals the economic and environmental gains relating to sustainable development goals through technological innovation. |
| 6  | [44]      | Textile Industry       | The aim of the study was to present an overview and usage of the integration of quality function deployment and pareto analysis to determine the basic requirements to increase the quality level of the industry and customer satisfaction for its application. The three facets of sustainability assessment were involved in the analysis at product level. |
| 7  | [3]       | Textile wastewater     | All the three aspects of sustainability were considered at sector level assessment. The study structural framework and proposed model were developed for wastewater management in sustainable textile to reveal the economic, environmental impacts and operational performance. critical factors consider during textile products |

Table 1. Recent sustainability assessment studies in textile and apparel industries
manufacturing were identified. Hence, the boundary of the research
is entry gate to grave boundary.

| 8 | [2] | Textile Factories | Sustainability assessment was undertaken at plant level. The impact
of ecoefficiency on sustainability measures of the selected factories
was studied. It was revealed that ecoefficiency had significant effects
on the cost reduction of the production and has strong correlation
with the factory’s revenue. |
|---|---|---|---|
| 9 | [18] | Textile Industry | The study reported the key factors of sustainable manufacturing
practices at sector level in the SMEs while considering all the three
facets of sustainability. The study links the impact of sustainable
manufacturing practice factors to the competitive capabilities. The
finding will be good for external policy reporting by the decision
makers. |
| 10 | [42] | Textile Production | A cradle to grave quantitative production process to evaluate the
improved benefit of environmental and economic sustainability
assessment of textile production. However, the environmental
impact of the distribution and use phase were missed out. |
| 11 | [12] | Clothing Industry | A process level sustainability assessment which focused on the
development of input and output-based model in SLCA methods by
determining the influence of cut-off rules, definition of hotspots
assessment and benefit and drawbacks in relation to process based
modelling. Sustainability analysis was used to test the influence of
the cut-off rule. |
| 12 | [9] | Textile Enterprises | The study aimed to provide a better understanding of greenhouse gas
management and establishing an evaluation system for the textile
enterprise to recognise their management weakness and continue
improving their greenhouse gas (GHG) management level. The
results show the actual greenhouse gas emission performance. |
| 13 | [37] | Textile apparel | Several studies were performed at the product level environmental
assessment. Protection of health workers, patients and visitor is
critical to infection control by isolating gown used in order not to
transfer micro-organisms and body fluids. However, the comparison
study between re-usable and isolation gown were conducted.
Reusable gown has a significant environmental benefit than
disposable gown. |
| 14 | [14] | Textile and Apparel Industry | The study looked at sector level sustainability assessment and
employed hybrid model for grey prediction. MPI- window analysis
was used to assess the performance of the entire textile and apparel
industries. Hence, because of realistic indicators involved, MPI was
used to measure the productivity growth. |
| 15 | [13] | Textile industry | The study aimed at social value of a manufactured product in an
industrial area. The boundary is from cradle to gate. While the
workers and local communities are the main stakeholder of the study |
| 16 | [3] | Manufacturing firms | The study was centred on TBL approach and well-balanced analysis.
The boundary is from cradle to grave and the framework was used to
assessed textile industry sustainability audit and for the validation of
the developed assessment method |
| 17 | [38] | Textile dyeing | A gate-to-gate boundary assessment focused on the environmental
aspect. The product level assessment focused on ecological benefit
derived from agro-industrial residues of textile natural dyeing.
However, the agro-industrial waste contributes to improve textile
dyeing sustainability by offering a unique natural product. |
| 18 | [17] | Textile facilities | The assessment focused on the unit level of the textile facility i.e.
dyeing, printing and finishing processes. Ecological footprint of
Portuguese textile industry was analysed, and the study revealed that
energy category contributed to over 50% of the total 4890 gha |
ecological footprint in year 2016. The study proposed energy consumption reduction of 10% overall energy consumption in the textile facility studied.

|   |   |   |
|---|---|---|
| 19 | [8] | Textile apparel |
| 20 | [47] | Textile Apparel |
| 21 | [9] | Textile product |
| 22 | [48] | Textile Production |
| 23 | [49] | Textile suppliers |
| 24 | [50] | Textile and Apparel |

The study focused on social and environmental impact reduction target based on the combination of LCA and SLCA sustainability assessment of Swedish textile sector. Renewable energy is the most effective intervention to reduce climate change in textile manufacturing industry.

Energy consumption of the usage boundary was analysed i.e. (washing and drying process). The study focused on environmental aspect of sustainability. Energy consumption is the major aspect of environmental sustainability focused while GHG and water usage and were neglected.

Audit data based on economic and environmental performance evaluation of sustainable production measures in wooden fabrics production. However, economic returns experienced during the evaluation will aid Turkish textile industry to maintain its competitive position in the global textile market.

A process level socio-economic sustainability assessment of suppliers was undertaken. However, the study made use of six critical sustainability criteria which includes discrimination, child labour, unfair competition, abuse of human right, pollution and long working hour. While economic dimensions were missed out.

The study focused on exploration of three major determinant to measures enterprises competitiveness in textile and apparel industry in China. However, the study used exploratory factor analysis to analyse the survey data. Factor condition and government supports are found to play significant role in enhancing industry competitiveness.

5. Results
Due to the abundant use of dyes, chemicals and water and the resulting release effluents in the society, the textile industry remains one of the leading pollution offenders. So many dissimilar chemicals were added to textiles in their different life cycle stages. According to [50], the textile production and manufacturing processes affect badly environmental and social impact within supply chain, this indicates the importance of sustainability issues to the textile and apparel industry. Table II presents the most recent sustainability assessment studies in textile industry, which were carried out in the developed nations such as Taiwan, Turkey, USA and Italy etc., reported by [15], [43], [37] and [13] respectively. These countries had adequate record of all the studies carried out in the sector and the data were easily retrieved. While some developing countries such as Brazil, China and India etc also carried out some sustainability assessment in the textile sector as reported by [11, 16 &42]. However, the reviewed studies showed that most of the recent work conducted reveals that most textile industries are operating in unsustainable environment. Few studies that considered all the three pillars of sustainability in textile industry were carried out in the developed nation while India is the only developing country that consider TBL approach in some reviewed studies shown in Table II.

As shown in Table II, the analysis of assessment level reveals that plant, product and process/ work cell levels of sustainability assessment was the major assessment levels region of the reviewed studies.
Hence, the plant or company assessment level provides enough details or results that will enhance the internal and external decisions of the users and decision makers in reporting of sustainability and competitiveness of the textile industry plant with well detailed assessment, such as [43 & 2]. Also, process or work cell sustainability level assessment is usually good for internal decision-making report of the textile industry as reported by [42, 44, 46 & 49]. Furthermore, it is pertinent to note that less data and time are required for sustainability assessment involved unit process levels studies due to the limited scope to analyse. However, to assess the sustainability issues involving national and sector levels it will require more resources, data and time to analyse in detail the different manufacturing sector involved in the sustainability assessment economy levels. Moreover, there are some latest studies which centred on economy and sector assessment level such as [15 & 47], these studies are more beneficial for policy making and external reporting at the national levels.

Consequently, from the boundary assessment perspective, the analysis of Table II shows that most reviewed studies on textile manufacturing industries were based on gate-to-gate boundary assessment. That is gate-to-gate boundary begins from receiving of raw materials at factory entry gate until manufacturing or production process and finally packaging of the products which ignored the usage and recycling phases. Likewise, some studies were conducted with an extension of their boundary to usage stage or grave. Among this study is entry gate-to- usage (starts from the receipt of raw materials while as well as production and packaging stage, and other phases till the usage of the manufactured product) [9], entry gate-to-grave (starts from the receipt of raw materials until production and packaging stage, usage and other phases till the recycling of the manufactured product [3], and cradle-to-grave (which includes the assessment of all life cycle phases [47].

Similarly, despite many advantages of three pillars of sustainability, most of the recent assessment studies on textile industries focused only on environmental dimension only, while only selected few addresses TBL approaches in their work. As it can be observed from Table I some of the studies reviewed addressed TBL approach (economics, social and environmental dimensions) at plant, process, economy and sector levels such as [15 & 43], but failed to validate the assessment with case study. However, most of the sustainability assessment of textile industries studies reviewed at product, process or work cell level focused majorly on environmental dimensions only such as [2, 11, 17 & 37] while both economic and social dimensions were missed out. Furthermore, [13] focused on social dimensions of sustainability assessment only while workers and local communities are the main stakeholders in the study.

Consequently, most of the reviewed studies source of data collection were based on combination of literature and expert opinions while few based their selection on literature base data only. As it can be observed, all the studies that were assessed based on TBL employed the combination of literature and expert opinion in selecting their sustainability indicators while others that were not based on three facet assessment chose between literature only or both source of indicator. Also, some study made use of weighted indicator to know their level of importance such as [15 & 43], while most of the reviewed studies chose not to weight their indicator. Finally, the utilization of result as shown in the table above revealed that the sustainability assessment analysis at economy and sector level is not useful in internal decision-making but of great help in external reporting and policy making of the industry. While, utilization at product and plant level sustainability assessment is more beneficial for both internal and external users and decision makers. Also, at process/work cell levels, the result utilization is more useful for internal decision-making only. The reviewed studies revealed that most sustainability evaluation was conducted on sector, product and process/ work cell levels in the textile and apparel industry. However, it is necessary to emphasis more on company and process level assessment to accomplish the three pillars sustainability objectives. Environmental dimensions measurement in textile industry has been fairly developed and standardized. However, from economic and social perspectives, cost analysis and employee’s welfare and safety were considered most in all the reviewed studies. Hence, more investigation needs to be performed on social and economic indicators and should be validated in textile industries.
Table II. Analysis and general highlights of recent sustainability assessment studies in the textile and apparel industry

| No. | country | Assessment levels | Sustainability Dimensions | Source of Indicators | Weight of indicator | Utility of Results | References |
|-----|---------|------------------|--------------------------|----------------------|---------------------|-------------------|------------|
| 1   | X       | X                | Gate-to-gate             | X                    | X                   | X                 | [15]       |
| 2   | X       | X                | Gate-to-grave            | X                    | X                   | X                 | [11]       |
| 3   | X       | X                | Cradle-to-grave          | X                    | X                   | X                 | [43]       |
| 4   | X       | X                | Gate-to-gate             | X                    | X                   | X                 | [46]       |
| 5   | X       | X                | Gate-to-grave            | X                    | X                   | X                 | [41]       |
| 6   | X       | X                | Cradle-to-grave          | X                    | X                   | X                 | [44]       |
| 7   | X       | X                | Entry gate-to-grave      | X                    | X                   | X                 | [3]        |
| 8   | X       | X                | Gate-to-gate             | X                    | X                   | X                 | [2]        |
| 9   | X       | X                | Gate-to-gate             | X                    | X                   | X                 | [18]       |
| 10  | X       | X                | Gate-to-grave            | X                    | X                   | X                 | [42]       |
| 11  | X       | X                | Gate-to-grave            | X                    | X                   | X                 | [12]       |
| 12  | X       | X                | Exit gate-to-grave       | X                    | X                   | X                 | [10]       |
| 13  | X       | X                | Exit gate-to-grave       | X                    | X                   | X                 | [37]       |
| 14  | X       | X                | Gate-to-exit gate        | X                    | X                   | X                 | [14]       |
| 15  | X       | X                | Cradle-to-exit gate      | X                    | X                   | X                 | [13]       |
| 16  | X       | X                | Cradle-to-grave          | X                    | X                   | X                 | [16]       |
| 17  | X       | X                | Gate-to-gate             | X                    | X                   | X                 | [38]       |
|   | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|----|----|----|----|----|----|----|
| 16 | X  |    |    |    |    |    |    |
| 17 |    | X  |    |    |    |    |    |
| 18 |    |    | X  |    |    |    |    |
| 19 |    |    |    | X  |    |    |    |
| 20 |    |    |    |    | X  |    |    |
| 21 |    |    |    |    |    | X  |    |
| 22 |    |    |    |    |    |    | X  |
| 23 |    |    |    |    |    |    |    |
| 24 |    |    |    |    |    |    |    |

Legend:
- **Gate-to-gate**
- **Cradle-to-grave**
- **Exit gate-to-usage**
- **Exit gate-to-image**
- **Gate-to-image**
- **Gate-to-gate**
6. Implications
This study has several key implications. First, the article was exceptional in its objective. The recent work on sustainability assessment studies in textile and apparel industry was reviewed based on all the three facets of sustainability because nearly all the previous reviews were mostly based on environmental only, social only, economic and environmental and environmental and social perspectives. Hence, this article will adopt and present the evaluation of textile and apparel industry based on the three dimensions of sustainability assessments. The description and findings of the reviewed study was explained briefly to furnish the practitioners clearer understanding of the strength and weakness of the reviewed article and how the study was accomplished.

Furthermore, the assessment of these studies was based on assessment levels, boundaries, source and weight of indicator and utility of results which will be presented in this article. This study will be of invaluable worth for experts in selecting suitable and robust approach for sustainability assessment in textile industry. Similarly, because of the uniqueness of textile and apparel industry it is necessary for the researcher to conduct more universal and comprehensive sustainability in this area and make use of the findings to outline their future research directions. The assessment levels, boundaries and source and weight of indicators stated in this study broadly covers all the characteristic of textile and apparel industry and can be performed as a checklist. The prioritisation of source and weight of indicator will help the investors of textile apparel and industry in creating the trade-off between several performance measures.

In addition, the analysis of the reviewed studies showed that the environmental perspective is the most investigated and improved dimensions in textile industry while both social and economic aspects still exhibit some difficulty in their measurement because of lack of applicable and measurable indicators. Therefore, researchers need to improve on data collection, indicator development and measurement method of these two dimensions namely social and economic. The study relates to overall type of textile and apparel industry evaluation and can be used to assess the sustainability performance in both developed and developing nations textile industries.

7. Conclusion
Previous review work carried out in the past on textile and apparel industry were majorly centred on environmental evaluations. It is important to review the current sustainability assessment studies in textile apparel and industry sector to present the latest level of sustainability assessment based on the three-bottom line viewpoint. This work contributed majorly by presenting a decade reviewed analysis of sustainability assessment studies of textile and apparel industry (reported from 2009 to 2019) was used to fulfil the revealed research gaps. This present work had showed the basic information about the assessment level, boundaries, source and weight of indicators and utility of results. Gathering the opinions of several researchers together and balanced the findings and methodology as well as strength and weakness, the proffered framework provides clarity and helps to improve the field further. The description and findings of the reviewed studies were revealed briefly to widen the scope of study.

As it can be observed from, the recent sustainability assessment analysis of the reviewed studies was majorly on sector, manufactured product, and processes/work cell while economy and plant level assessment were not pronounced. Equally most of the reviewed studies were based on gate-to-gate and cradle-to-grave sustainability assessment boundaries. Also, several studies were found with limited boundaries, such as exit gate-to-usage, exit gate-to grave etc. Additionally, most of the reviewed studies were reported from developed countries while all the article evaluated in the reviewed based on three facets of sustainability were reported from developed countries except the studies of [3 & 16] reported from India which happened to be among developing countries. Hence, more efforts are needed to improve the sustainability performance of textile industries in the developing nation in an inclusive way. The reviewed article revealed that to enhance the competitiveness and performance of specific companies, adequate attention should be given to the evaluation at the plant and process/work cell levels in the future based on three pillars sustainability. This would be of invaluable worth for both the
researchers and manufacturer in developing sustainability indicators to enhance the sustainability performance. The analysis of the reviewed studies revealed that most studies depend only on literature-based indicators whereas all the study assessed based on TBL approach used both literature based and expert judgement in the development of sustainability indicators. Also, there is a need to develop more social and economic indicators if we make the assessment more efficient and practical in textile industries.

Finally, future review may widen the scope of the keywords and engage different screening measures to select the research articles based on three dimensions of sustainability.

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