Towards a Blockchain-enabled Social-Life Cycle Assessment Service for Increased Value Chain Sustainability

Maria Flavia Mogos[1[0000-0002-7147-5287]], Gabriela Maestri[2[0000-0001-7430-5171]], Thomas Victor Fischer[2], Gessica Ciaccio[3]

[1]SINTEF Manufacturing, Raufoss 2830, Norway
[2]German Institutes of Textile and Fiber Research (DITF), Denkendorf 73770, Germany
[3]Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), Rome 00196, Italy
maria.flavia.mogos@sintef.no

Abstract. As sustainability requirements are growing, more and more companies are falsely claiming to supply sustainable products, thus creating an unfair playing field for companies that do comply. The Textile and Clothing (TC) industry is one of the least sustainable and transparent industries, often manufacturing products in low-cost countries with inadequate working conditions and environmental standards. The purpose of this study is to investigate how social sustainability assessments can be conducted, to increase the reliability of sustainability claims. The paper proposes a concept of a Social-Life Cycle Assessment (S-LCA) service that is based on site-specific primary data and is grounded in the international Social Accountability (SA) 8000 certification system, to increase the reliability of sustainability claims. United Nations recommends the SA8000 in their S-LCA guidelines. The S-LCA service is also enabled by Blockchain to secure that critical data remains unaltered. The concept and service are being developed through the Design Science methodology, combining: i) case studies in an EU project, to understand the practical problem, ii) a S-LCA literature study, and iii) action research, to iteratively apply the service to the cases and refine it with project contributors representing the entire TC value chain. The concept consists of a workflow diagram, preliminary user interface, data collection template, and an overview of critical data to be secured by Blockchain. To the best of our knowledge, this is the first research paper about a concept of a site-specific S-LCA service that is integrated with an international certification system and a Blockchain-enabled platform.

Keywords: Social-Life Cycle Assessment·Value Chain Transparency· Sustainability·Textile and Clothing Industry·Social Impact

1 Introduction

As sustainability requirements are growing, more and more companies are inaccurately claiming to supply sustainable products, thus creating an unfair playing-field for companies that do comply. However, the anti-counterfeiting methods are ineffective [1]. In the TC industry, a common practice is to use sustainable materials to manufacture the product lots that might be controlled or audited, and non-sustainable, cheaper materials for the other product lots [2]. Moreover, it is reported that nearly 10% of the chemicals used in the TC sector are of potential concern to human health and that almost 6% of the TC workers get injured every year [3]. The TC sector is the 4th highest 'pressure category' in EU, in terms of use of primary raw materials and water, while Food is the highest [4]. Unlike the food sector, most of the pressure and impact linked to TC occurs outside the EU, making the value chain transparency and sustainability goals even more challenging. The TC production typically takes place in developing countries with lower production costs, but also poorer working conditions and environmental standards [4]. Other social impacts include long working hours, child labor, poor salary rates, and limitations to freedom of association [4-7]. Increasing the value chain transparency would imply disclosing data such as the origin of the products, suppliers, health and safety reports, testing results, and sustainability reports [8]. While assessments such as the Life-cycle assessment (LCA), S-LCA and Life-cycle Costing are seen as a good starting point when evaluating environmental, social, and economic sustainability [5], verifying the results through internationally accredited audits and securing critical data by help of technology like Blockchain would facilitate transparent processes, unaltered data, and reliable results [9].

In recent years, the S-LCA research and development has been increasing, particularly after the UN Environment Programme (UNEP) and Society of Environmental Toxicology and Chemistry (SETAC) had published the 'Guidelines for Social Life Cycle Assessment of Products' in 2009 [10]. S-LCA databases and services that have been developed include the Social Hotspots Database (SHDB) and Product Social Impact Life Cycle Assessment (PSILCA). These are also recommended by UNEP [11], and SimaPro, a software commonly used for LCA is providing the possibility to import the SHDB database [12]. Nonetheless, existing solutions are primarily based on secondary data, like country-specific indicators [e.g., 13-14]. Site-specific assessments are more accurate and can lead to significantly different results [14]. However, a site-specific S-LCA would further increase the criticality of ensuring the reliability of primary data. Even though several S-LCA relevant policies were developed in the last decades (e.g., Fairtrade and SA8000 certification) [11], the effectiveness of Blockchain for securing critical data was mainly investigated for LCA [e.g. 15]. Finally, only a few peer-reviewed case studies have been published on S-LCA’s for the entire life cycle of TC products [e.g., 13,14]. The purpose of this study has been to investigate and better understand how social sustainability assessments can be conducted in order to increase the reliability of sustainability claims. The paper proposes a concept of a Blockchain-enabled and site-specific S-LCA service, for increased reliability of product sustainability claims.

2 Methodology

The research methodology that we applied was the Design Science, as described by Holmström et al. [16]. This methodology is recommended both for the development of artifacts with enhanced practical relevance – such as a digital service – and for the development of new knowledge (e.g., [9, 10]). As Design Science is a multi-method strategy, this study combined TC case studies within a Horizon 2020 EU project, a systematic literature review and action research. First, to understand the practical problem of the case companies, we studied their needs, as well as the inhibitors and enablers of these user needs. Second, a literature review was conducted, on the topic of S-LCA. Third, a preliminary concept was developed based on the literature. Thereafter, over a 5-month period, the concept was iteratively refined together with the project partners- through the action research method. To this end, workshops and semi-structured interviews were organized with the project partners representing the TC value chain. The research contributors comprised traditional and technical TC manufacturers, yarn and fiber producers, an online retailer of second-hand clothing, a platform provider for the sourcing of TC production capacity, a recycling company, a customs agency, service and platform developers, and research partners. When the service prototype will be completed, the project partners will use it to conduct specific S-LCA studies and the service will be further refined.

3 Literature review

This section outlines the literature background for the proposed S-LCA concept.

The S-LCA was developed by the United Nations and SETAC [5] and it is a method that is applied for the assessment of the actual and potential social impacts (positive or negative) of a product through its life cycle. The goal is to safeguard and enhance workers' well-being while improving business performance [6]. It addresses the extraction and processing of raw materials, manufacturing, distribution, use, reuse, maintenance, recycling, and final disposal. It can use generic and site-specific data and can be quantitative, semi-quantitative or qualitative [11].

The S-LCA users may have roles, such as the producer of a final product, component or raw material, the supplier or subcontractor that provides goods or services to the producer, the sub-supplier, the S-LCA expert within or outside the organization initiating the study, and the independent reviewer [11]. The S-LCA main activities comprise the definition of the S-LCA goal and scope (e.g. system boundaries), the data collection ('life cycle inventory'), the calculation of the results for the (sub)category-indicators that were selected ('life cycle impact'), and the interpretation of results and reporting. To increase the transparency, apart from a summary of the main activities, the report should include details about the data quality and about the findings prior to any data aggregation [11].

Currently, there are more than 450 environmental and sustainability labels [17]. Relevant policies for the S-LCA that the UN recommends include: UN's Guiding Principles on Business and Human Rights from 2011, Good Weave label, Fairtrade, Rainforest Alliance label, SA8000 standard, ISO 45001, Global Reporting Initiative, and the Accountability 1000 Assurance standard [11].

The social performance of an organization depends on the relation that it has with its various stakeholders. For each stakeholder categories there are defined impact subcategories. The main stakeholder categories in the S-LCA are the workers (e.g. with 'fair salary' as an impact subcategory), local communities (e.g. 'local employment'), value chain actors (e.g. 'fair competition'), consumers (e.g. 'health and safety'), children (e.g. 'community education'), and the society at large (e.g. 'contribution to economic development') [11]. PSILCA, one of the databases recommended by UN aims to provide transparent and up-to-date information for almost 15,000 industry sectors and commodities, and for 69 qualitative and quantitative S-LCA indicators [18].

4 The S-LCA service concept

This section presents the concept of the site-specific, Blockchain-enabled S-LCA service, which was developed based on results from the literature study, case studies and action research (see Section 2). It consists of the workflow and preliminary user interface (Figure 1), and the data collection needs (Table 1).

The upper part of the Fig. 1 depicts the main user activities (pink) and their connection to the Blockchain enabled platform (blue). The lower part of Fig. 1 illustrates the preliminary service interface, which consists of the main S-LCA study page and is based on the data categories in Table 1. The figure also indicates the certification status of the relevant value chain actors. The data categories in Table 1 are based on the SA8000 standard, while the data indicators are based on the PSILCA database. Section 5 includes further details about the concept.

5 Discussion and Conclusion

This section discusses the proposed S-LCA concept - the workflow diagram and user interface in Fig. 1 and data needs in Table 1 - in light of earlier literature.

The service workflow consists of the user roles and activities that the research participants selected among the literature findings. Compared to UNEP and SETAC's recommendations [11], these roles were synthesized into the producer, its internal or external S-LCA expert, the supplier/subcontractor of goods or services and the reviewer, which is the accredited certification auditor. The *producer* starts by selecting the product that fits the *goal and scope* [11] of the assessment and by appointing an expert, for ex. its Health and Safety coordinator. The *expert* is registered on the data management platform, and (s)he initiates the life cycle inventory [11] process by retrieving the list of materials, suppliers, and subcontractors, which had been previously uploaded on the platform. The participants regarded the cost-benefit of uploading this document on the Blockchain layer of the platform as high, as this would mitigate the risk that a producer would later replace the product materials with less sustainable ones. Thereafter, the producer or the expert uploads its own primary data on the user interface of the S-LCA service (lower part of Fig. 1), and the data is stored on the platform.

Next, the expert evaluates the compliance of each of the S-LCA categories and supports her/his assertions with appropriate documentation. The participants strongly recommended the integration of an internationally acknowledged certification process in the concept, to maximize the reliability of the suppliers/ subcontractors' self-assessments. They selected the SA8000 standard [19], as this certification is aligned with the S-LCA guidelines [11] and enables a site-specific S-LCA. Table 1 summarizes all the categories in this standard. In line with [14], the user interface enables the evaluation and visualization of the compliance of all value chain actors. Inspired by the popular

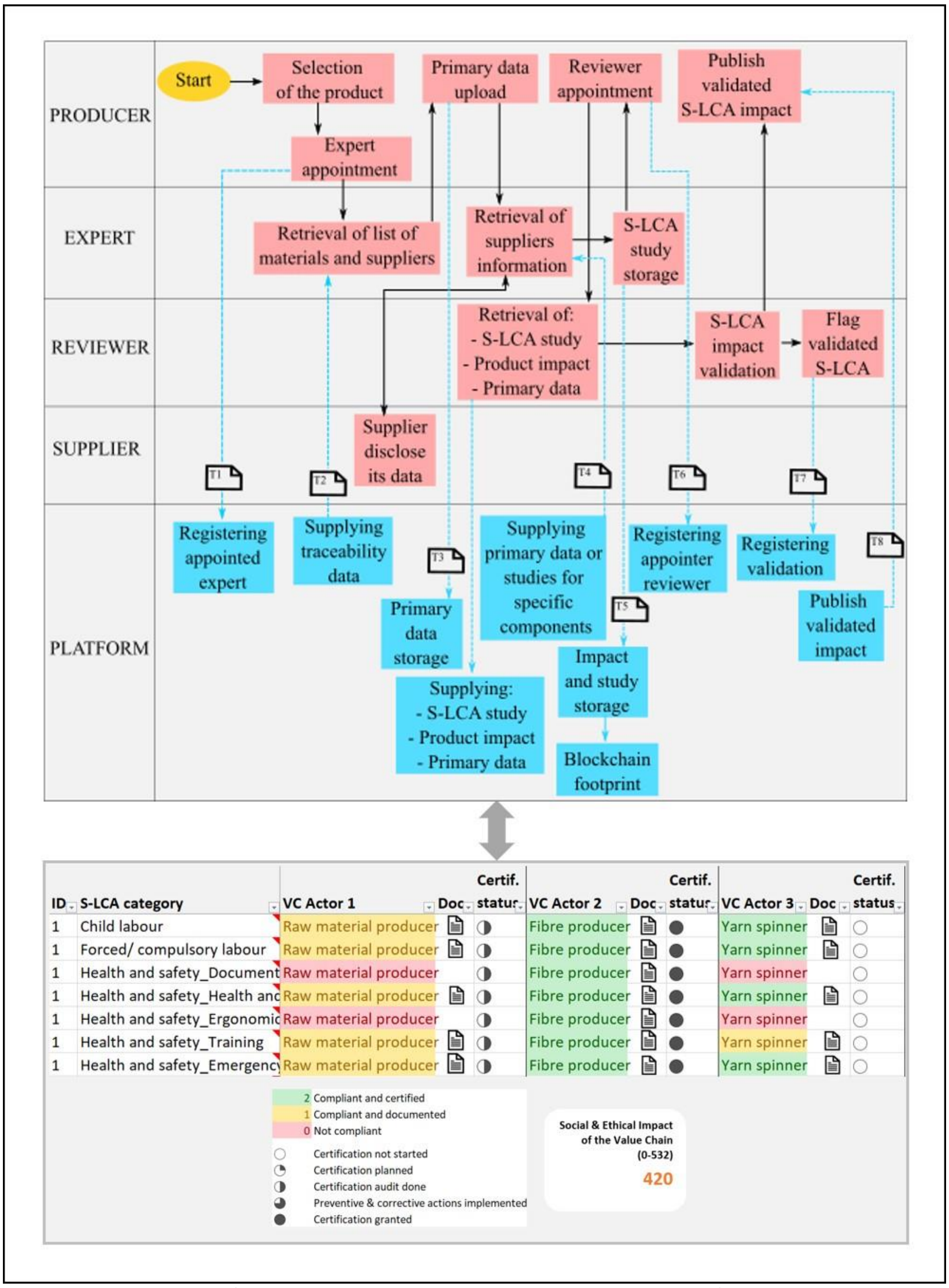

Fig. 1. The workflow (up) and preliminary S-LCA service interface (down); VC-value chain

Table 1. Categories of necessary data for a site-specific S-LCA and potential indicators for a general S-LCA (based on [19] and [20])

DATA CATEGORY	POTENTIAL INDICATOR
Child Labor: Verifiable proof of age documentation for every worker. No children under 15 years in work areas (or the minimum age by local law, if this is over 15y).	-Female personnel ages 7-14 [%] -Male personnel ages 7-14 [%] -All personnel ages 7-14 [%]
Forced or Compulsory labor: No involuntary work under threat of punishment/ retaliation or demanded as debt repayment. No human trafficking. Security measures do not unduly restrict worker's movement.	-No. of goods produced by forced/ compulsory labor -Cases of forced labor/ 1,000 inhabitants in the country -Tier placement (referring to trafficking in persons)
Health and Safety: Addresses the topics, 'Documents/ licenses/ permits/ certificates', 'Health and Safety (HS) committee', 'Ergonomics', 'Training', 'Emergency preparedness', 'Fire extinguishers', 'Alarm system', 'Personal Protective Equipment (PPE)', 'General working environment', 'Water, air, noise and temperature', 'Electrical safety', 'Machine guards and safety', 'Chemical and hazardous waste handling and storage', 'Medical care', 'Restroom facilities', 'Kitchen, cafeteria and canteens', 'Dormitories', and 'Childcare facilities'	-Fatal accident cases/ 100,000 employees and year -Accident cases/ 100,000 employees and year -Disability-adjusted life years (DALY)/ 1,000 inhabitants in the country -Workers affected by natural disasters [%]
Freedom of association and right to collective bargaining: Workers, trade union and other worker representatives indicate that workers can freely form, join and organize trade unions of their choice, and collectively bargain with the organization.	-Employees organized in trade unions [%] -Right of association [0-3 scale] -Right of collective bargaining [0-3 scale] -Right to strike [0-3 scale]
Discrimination: The organization shall not engage/ support discrimination in hiring, remuneration, etc., based on race, political orientation, etc. Incidents and their remediation are documented.	-Females in the economically active population [%] -Ratio of women in the sectoral labor force -Gender wage gap [%]
Disciplinary practices: The org. shall not engage in the use of corporal punishment, or mental/ physical coercion. All disciplinary actions are documented and signed by affected workers.	-
Working hours: The work week shall not exceed 48h. Overtime shall not exceed 12h. Timecards/ electronic bar card system/ attendance sheets (signed by workers) are used to measure actual working hours and break times.	-Hours of work/ employee, per week
Remuneration: Addresses the topics, 'Living wage estimate', 'Living wage step-approach', 'Wage payment', and 'Payroll documentation'	-Living wage/ month -Minimum wage/ month -Sector average wage/ month
Management system: Addresses the topics, 'Policies, procedures, and records', 'Social Performance Team (SPT)', 'Risk identification and assessment', 'Monitoring', 'Internal involvement and communication', 'Complain management and resolution', 'External verification and stakeholder engagement', 'Corrective and preventive actions', 'Training and capacity building plan', and 'Management of suppliers and contractors'	-

likelihood-impact risk matrix [21], the selected scale in this concept is from 'not compliant'/ 0/ red color, to 'compliant and documented'/ 1/ yellow, and 'compliant and certified'/2/green. Based on this method, one can also get a broad overview of the *'product life-cycle impact'* [11]. For ex., a value chain with 7 actors, which are all evaluated as 'compliant and certified' on all the 38 categories in Table 1, would get the maximum score of 532 (i.e. 7*x*2*x*38). Thereafter, the expert asks the *suppliers/ subcontractors* to disclose their primary data, unless this is already on the platform, and repeats the same procedure as for the producer. When completed, the report consisting of the S-LCA study, 'social impact' and the expert's recommendations is stored on the platform and secured through a Blockchain footprint. Then, the expert appoints accredited SA8000 *auditors* to review the report and primary data, and to visit and audit the value chain actors. When the S-LCA is validated and a value chain actor is certified, the auditor flags the certification, and the platform publishes the results. As the SA8000 certification can be a lengthy process, the user interface has a status function. Based on Deming's popular Plan-Do-Study-Act circle [22], the options are 'certification not started', 'certification planned', 'audit done', 'preventive/corrective actions implemented' and 'certification granted'. Finally, apart from the qualitative SA8000 categories, Table 1 includes relevant quantitative indicators based on the PSILCA database. Since these are generic indicators, for an entire country, region, or sector they are not sufficient for a SA8000 certification. However, they can be used to quickly assess potential suppliers from different countries/ regions before selecting them.

To conclude, the purpose of this study was to investigate how sustainability assessments can be conducted to increase the reliability of sustainability claims. The paper proposes a concept of a S-LCA service that is integrated with the international certification system, SA8000 and a Blockchain-enabled platform, in order to increase the reliability of sustainability claims. The service also addresses the entire value chain, assessing organization-specific data. The concept is based on a literature review and is developed in close collaboration with the project participants in a Horizon 2020 EU project, representing the whole TC value chain. It consists of a workflow diagram, a preliminary user interface, data collection template and an overview of critical data to be secured by Blockchain. The concept is arguably comprehensible and easy to replicate in future studies. As it has a low maturity level, the concept should be further validated with case companies within various industries, and from both high- and low-cost countries. As part of the EU project, the service is to be finalized, implemented at the case companies, and refined by August 2023.

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