Sustainability performance of an Italian textile product

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Abstract:
Companies are more and more interested in the improvement of sustainability performance of products, services and processes. For this reason, appropriate and suitable assessment tools supporting the transition to a green economy are highly necessary. Currently, there are a number of methods and approaches for assessing products' environmental impact and improving their performances; among these, the Life Cycle Thinking (LCT) approach emerged as the most comprehensive and effective to reach sustainability goals. Indeed, the LCT approach aims to reduce a product's resource use and emissions to the environment and it can be used as well to improve its socio-economic performance through its whole life cycle. Life Cycle Assessment (LCA), Life Cycle Costing (LCC) and Social Life Cycle Assessment (S-LCA) are undoubtedly the most appreciated to assist product-related decision-making activities, from the extraction and processing of raw materials, manufacturing, distribution, use, reuse, maintenance, recycling and final disposal. LCA is already an internationally standardized tool (ISO 14040, 2006), on the contrary LCC (except for the ISO related to the building sector) and S-LCA still lack of international standardization (even if guidelines and general frameworks are available). The S-LCA is still in the experimental stages for many aspects of its methodological structure and its practical implementation.
This study presents an application of LCA and S-LCA to a textile product. The LCA and S-LCA are respectively implemented following the ISO 14040-44:2006 and the guidelines from UNEP/SETAC (2009). The main goal is to assess and present the sustainability values of a textile product produced in a particular region, where the presence of this textile industry represents the main source of employment. In the implementation of the S-LCA, attention is paid to identify the positive impacts and to highlight the strengths and weaknesses of the methodology when applied in this specific sector. The functional unit of the study is a cape knitted in a soft blend of wool and cashmere produced by a textile company located in Sicily (Italy). The system boundary of the study includes all phases from cradle-to-gate, from raw material production through fabric/accessory production to the manufacturing process of the product itself at the Sicilian company. Background and foreground processes are taken into account using primary and secondary data. The analysis carried out on the functional unit of the study allowed us to assess environmental and social performance related to the specific textile product, but also to outline the general behaviour of the company. The case study allows understanding pro and cons of a combined LCA and S-LCA to a textile product in a regional contest.

Introduction.
One of the main productive sector in Italy and consequently strategic for overcome the crisis is represented by the textile compartment. In fact, it seems to not being affected by the economic crisis according to the latest data (source the Italian Fashion System - SMI),

this sector has more than 400,000 employees and nearly 50,000 companies in the industry, report about a turnover of €52billion (+1.8%) in 2016 [Il Sole 24 Ore, 2017]. Traditionally, the sector generates a trade surplus second only to that of the mechanical industry. One of the reason of its success is due to innovation and research as well as to the tradition of certain phases of the production process, know-how and synergistic collaboration among the various stages of the supply chain. Another important role is played by its customers that, thanks to years of success, see "Made in Italy" label as a guarantee of quality. On the other side, globalization has played an important role for this sector and the compentition among companies of different countries has grown more and more in the last decades. But it led to the necessity to reduce the production costs to the detriment of quality and/or force labour costs. The first effect was to move the production phases to countries where the labour fource's costs are lower and less restrictive norms on the environmental emissions are settled. An example is the jeans production that arise with the labour conditions. People have to work hard for low wages in so called sweat shops. A few years ago the video China Blue was broadcasted, showing the working conditions in a Chinese factory. Another example is the disaster in Bangladesh in November 2012 where a clothes factory collapsed in Dhaka killing 112 people, because the building was not adeguately restored. Other examples are the H&M that occurred in a scandal in its supply chain with factories in Myanmar employed 14-year-old workers (The Guardian, 2016). Fortunately, customers interest, as in any other compartment, is changing and more interest is paid to the sustainability performance of each product included the fashion ones. It is also testified by the proliferation of labels to guarantee ethical and sustainable production of fashion products, but this huge amount of labels sometimes confuses the customers.
Surely, the textile industry has a complex supply chain, with raw material often produced in Asian or African countries where the labour conditions are not necessarily conformed to ILO conventions and only the finishing phases are made in Europe including the labelling. This complexity of the textile and clothing industry has made difficult assessing the social and environmental issues along a product life cycle.
This study focuses on the environmental and social life cycle assessment of a garment knitted produced in a textile factory (San Lorenzo Group), located in San Marco d'Alunzio, Messina (Italy). a village situated in the Nebrodi (Sicilian mountains), in an area that does not have adequate infrastructure. San Marco d'Alunzio is an agricultural reality, characterized by farmhouses.
The choice was not random, indeed social and environmental assessment and reporting is still an uncommon business practice in Sicilian companies (Italy). By the way this company plays a meaningful role for the local community in terms of offering jobs and added value to the region. This study is part of a PhD Thesis and a bigger project to develop a life cycle sustainability assessment of an Italian textile product. The life cycle sustainability assessment will be implemented according to Finkbeiner et al. 2010 and UNEP 2012. The social LCA has been already detailed presented in the conference paper Lenzo et al. (2017), but the combination of the two sustainability dimentions in the product life cycle is here presented.

Goal, scope, system boundary and assumptions of the study

The goal of the study is to carry out the environmental and social assessment of a life cycle of a garment knitted from cradle to gate.
The functional unit of the study is one garment knitted in a soft blend of wool and cashmere (60% wool and 40% cashmere). The flow unit for the LCA consists of 495 capes. The whole manufacturing process of the order of the garment (495 pieces) was carried out

from August 2016 to October 2016. This garment was randomly chosen by the authors in order to represent general manufacture of the company. It has the function of protect the body against of cold in winter and in the same time with his elegance has an esthetic value (Fig 1). The product analysed contains characteristics common to almost all the products manufactured within the San Lorenzo Group and it involves all the process units of the company, (cutting, ironing, etc.) common to almost all the products manufactured within the San Lorenzo Group. While, the raw materials (fabrics and accessories) are the only elements that differentiate one garment from another.

Fig 1 the object of the study, a garment 60% wool and 40% cashmere.

All data on the environmental inputs and outputs of the manufacturing phases realized in San Lorenzo Group, have been collected according to the flow unit.
The stages of the production process that characterize the company production refer to the following sub-processes:

- Cutting - in this phase, priority is given to the organization of the material needed to prototype and sample. The orders are processed through the cut bubble, i.e. a card that indicates the number of accessories, the fabric, the measurements and the number of products necessary to meet the customer's order. The cutting bubble is sent to the CAD, where the paper patterns, sent by the clients, are scanned. After checking the technical-design features of the various pieces that make up the model, it passes to the placement of the paper patterns on the fabric. Successively, it proceeds to cutting techniques: automatic cutting and manual cutting.
- Stitching – this phase assumes features details, because the company makes several types of seams. The most widely appreciated seam is “Double-Face”. The “Double-Face” stitching finish present in the product analysed consists in blind-stitching by hand of the internal seams and of the external finishing of a garment along the hems of the fabric whose width is split in half for a depth of about 12 millimetres. Blind-stitching is what gives the product its high artisan quality and takes up about 75% of the time necessary to make a garment. It is carried out entirely by hand, with needle and thread, by seamstresses living in the towns of the Nebrodi area who preserve and renew the ancient art of tailoring in this day and age of industrial modernity. This procedure is what gives company's products absolutely extraordinary quality and fineness. With this technique the company offers a high quality artisan and inimitable garment. It makes a high added value to the product that was cathed by the social impacts.
- Ironing - this is the final phase in the garment finish. The function of this phase of the process is to give the final look to the clothes.

- Quality check - the garment is subjected to a quality check to verify that no mistakes were made during the previous processes.
- Distribution – Shipment, human labour force is involved in this stage. First of all, preparing the tag which indicates the type of fabric, the work order, the size and the customer, along with the single garment accessories. The finished garment is then identified by the tag. Clothes are arranged according to size, they are then divided according to the number of sizes required by the customer and packaged. Thanks to the delivery note, the target countries of prepared garments for that particular customer are identified. Once these operations are completed, shipping takes place, almost alwaysusing a private carrier.

The system boundaries of both the LCA and S-LCA studies are reported in figure 2.

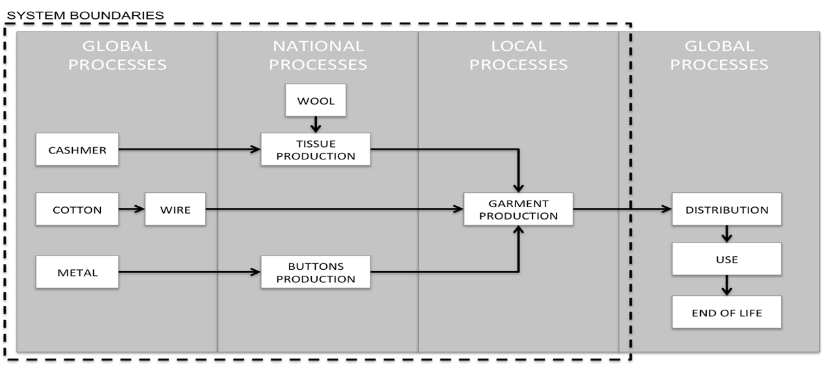

Fig 2 system boundary of both LCA and S-LCA.

The system boundaries selected to carry out both the assessments (LCA and S-LCA) follow a “cradle to gate” approach. Thus, the analyses are performed, on the one hand, by excluding the distribution phase, on the other, by including, at least for the LCA, the transport of the raw materials (wool and cashmere) and others important elements (such as the buttons). Regarding the social LCA the authors have not considered the transport system because the data on transport in Social Hotspot Database are too generic (Lenzo et al. 2017). Primary and secondary data have been collected for both the assessments. The primary data were obtained by using questionnaire and by collecting data from the bills in the company. The LCA, and in particular the Life Cycle Impact Assessement (LCIA) phase, was carried out by means of Simapro software and Ecoinvent database; while, the S-LCA was performed by using the Social Hotspost Database (Norris and Bonoit-Norris, 2015), in order to perform a Risk assessment of the production phases upstream the San Lorenzo Group (Lenzo et al. 2017).

For the LCA study, due to a lack of specific secondary data, the following assumptions were made:

- according to the S-LCA performed in Lenzo et al. (2017), cashmere is produced in Mongolia (the main producer of cashmere worldwide) and wool in Italy. Due to a lack of inventory data for Mongolian productions, in the LCA here presented the production processes related to the cashmere and wool are considered as the same and data related to wool production in New Zealand is assumed the same for the production in Mongolia and in Italy,
- processes related to material recycling are not considered in the system boundaries and only their transport to the recycling plant is considered,
- for raw material production and some of the manufacturing material plants, hypothetical locations were considered.

LCA Data sources are detailed in Table 1.

LCA phase	Sub-processes	Data sources
Raw material	Greasy wool	Primary data, Cardoso (2013)
	Steel	Primary data, Ecoinvent, Steel, low-alloyed, at plant/RER U
	Cotton	Primary data, Ecoinvent, Cotton fibres, at farm/US U
	Polyethylene	Primary data, Ecoinvent, Fleece, polyethylene, at plant/RER U
	Cardboard	Primary data, Corrugated board, mixed fibre, single wall, at plant/RER U
	Plastic (PP)	Primary data, Ecoinvent, Polypropylene, granulate, at plant/RER U
Manufacturing material	Wool yard	Primary data, Cardoso (2013)
	Textile production	Primary data, Ecoinvent, Textile refinement, cotton/GLO U
	Buttons	Primary data, Ecoinvent, Steel product manufacturing, average metal working/RER U
	Cardboard boxes	Primary data, Ecoinvent,Packaging, corrugated board, mixed fibre, single wall, at plant/RER U
	Cotton wire	Primary data, Ecoinvent, Textile refinement, cotton/GLO U
	Label production	Primary data, Ecoinvent, Fleece production, polyethylene terephthalate/RER U
	Paper (CAD)	Primary data, Ecoinvent, Paper, woodfree, uncoated, at integrated mill/RER U
	Tissue paper	Primary data, Ecoinvent, Kraft paper, bleached, at plant/RER U
	Plastic bags	Primary data, Ecoinvent, Extrusion, plastic film/RER U
Cloth production	Cutting (CAD + Cutting)	Primary data, Ecoinvent, Electricity, low voltage, at grid/IT U
	Stichting	Primary data, Ecoinvent, Electricity, low voltage, at grid/IT U
	Ironing	Primary data, Electricity– Ecoinvent, Electricity, low voltage, at grid/IT U + Water, decarbonised, at plant/RER U
	Packaging	Primary data, Ecoinvent, Electricity, low voltage, at grid/IT U
	Waste production	Primary data
Transport raw materials (T1)	Greasy Wool	Primary data, Ecoinvent, Transport, lorry 3.5-7.5t, EURO5/RER U
	Greasy cashmere	Primary data, Ecoinvent, Transport, lorry 3.5-7.5t, EURO5/RER U + Transport, transoceanic freight ship/OCE U + Transport, lorry 3.5-7.5t, EURO5/RER U
	Steel for buttons	Primary data, Ecoinvent, Transport, lorry 3.5-7.5t, EURO5/RER U
	Cotton for wire	Primary data, Ecoinvent, Transport, van <3.5t/RER U
	Polyethylene for labels	Primary data, Ecoinvent, Transport, van <3.5t/RER U
	Plastic for packaging bags	Primary data, Ecoinvent, Transport, van <3.5t/RER U
	Cardboard for packaging boxes	Primary data, Ecoinvent, Transport, van <3.5t/RER U
Transport manufacured materials (T2):	Woven transport	Primary data, Ecoinvent, Transport, lorry 3.5-7.5t, EURO5/RER U + Transport, barge/RER U
	Buttons	Primary data, Ecoinvent, Transport, lorry 3.5-7.5t, EURO5/RER U + Transport, barge/RER U
	Wire	Primary data, Ecoinvent, Transport, van <3.5t/RER U + Transport, barge/RER U
	Labels	Primary data, Ecoinvent, Transport, lorry 3.5-7.5t, EURO5/RER U + Transport, barge/RER U
	Paper	Primary data, Ecoinvent, Transport, lorry 3.5-7.5t, EURO5/RER U + Transport, barge/RER U
	PP bags	Primary data, Ecoinvent, Transport, van <3.5t/RER U + Transport, barge/RER U
	Cardboard boxes	Primary data, Ecoinvent, Transport, van <3.5t/RER U + Transport, barge/RER U
	Tissue paper	Primary data, Ecoinvent, Transport, van <3.5t/RER U + Transport, barge/RER U
Transport waste (T3)	Cardboard waste	Primary data, Ecoinvent, Transport, lorry 3.5-7.5t, EURO5/RER U + Transport, barge/RER U.
	Plastic waste	Primary data, Ecoinvent, Transport, lorry 3.5-7.5t, EURO5/RER U
	Paper waste	Primary data, Ecoinvent, Transport, lorry 3.5-7.5t, EURO5/RER U + Transport, barge/RER U
	Textile waste	Primary data, Ecoinvent, Transport, lorry 3.5-7.5t, EURO5/RER U + Transport, barge/RER U

Life cycle impact assessment of an Italian made garment.

Life cycle assessment results are calculated through the impact assessment method ReCiPe Midpoint (H) V1.09 allows to obtain a high level of detail by including eighteen different impact categories. The characterization results are reported in figure 3. It is evident that the main impacts are caused by the transport phases and the cloth production. The transport should be deeply investigated to have more detailed information in accordance with the further investigation on the social impact of the San Lorenzo group supply chain. Indeed, no primary data on transport were available in order to carry out a detailed assessment of the social and environmental impact. For example, a research on where the raw materials are mainly produced was carried out to estimate the social risk of the raw materials, e.g. cashemere is mainly produced in Mongolia. These assumptions were used as well to calculate the impact of the transport of those raw materials. A depth analysis of the LCA results underscores that the contribution of the transport phases to the environmental impacts ranges from 90.2% for water depletion to 27.6% for urban land occupation. In particular, the transport of the manufactured material (T2) shows the highest contribution in all the impact categories. Regarding the cloth production phase, the highest environmental impacts are connected to the electricity consumption during the stitching sub-process.

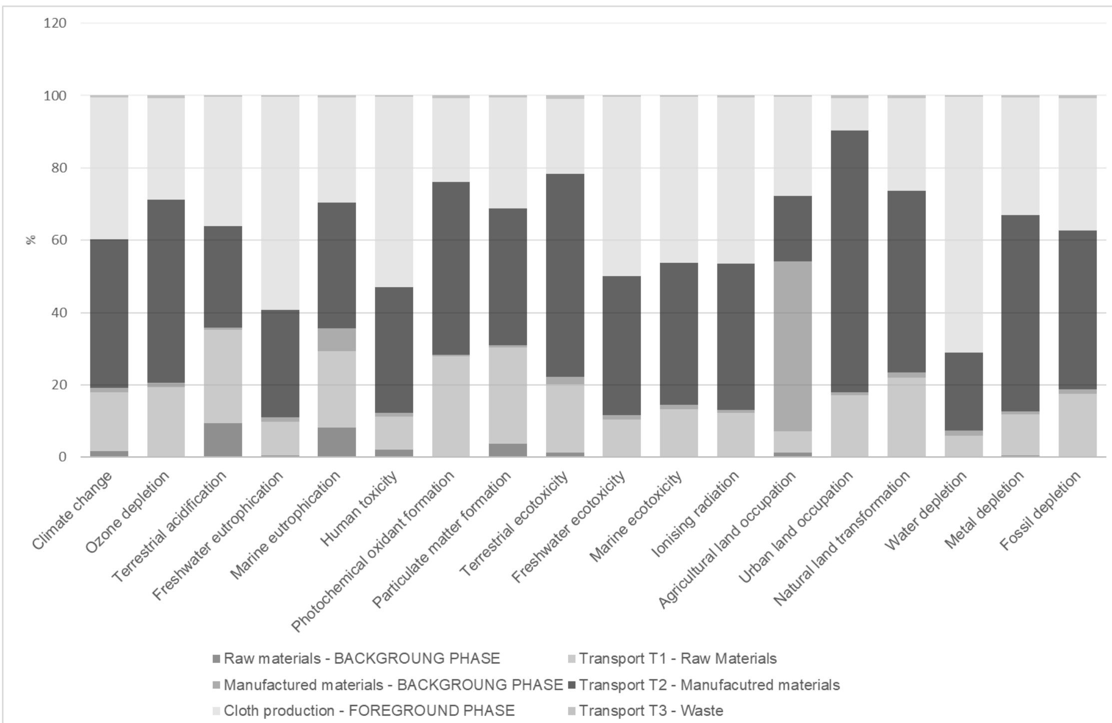

Fig 3 Contribution analysis related to the functional unit of one garment knitted in a soft blend of wool and cashmere (characterization results)..

Combining the S-LCA to the LCA of a garment.

The S-LCA's reference framework for the study is defined by the Guidelines for Social Life Cycle Assessment of Products (UNEP/SETAC, 2009), which reflects the structure of the standardized LCA method.

The S-LCA presented here assesses the social performance of a selected textile product and its impact, by adopting, for the characterization phase, the SAM method (Subcategory Assessment Method). The SAM method allows to compare the obtained results with the reference point of the International Labour Organization Standard to score the results between A (good performance) and D (bad performance) (Ramirez et al. 2014).

According to the results reported in Lenzo et al. (2017), the S-LCA results showed a good social performance of the manufacturing phase at San Lorenzo Group, with the necessity to investigate further on the freedom of bargaining and freedom of association of the workers where the indicator used can not really give back a clear result (Figure 4). For the Social Risk assessment of upstream processes, the main risks were identified relatively to the cashmere production in Mongolia (Fig. 5). A further assessment on the social impact of the transport should be made or at least a risk assessment to understand if this process unit is relevant for the S-LCA.

Stakeholders	Subcategory	Level	Assessment
Worker	Freedom of Association and Collective Bargaining	C	2
	Child Labour	B	3
	Working Hours	B	3
	Forced Labour	B	3
	Equal Opportunities/ Discrimination	A	4
	Fair Wages	B	3
	Health and Safety	A	4
	Social and Social Security Benefits	A	4
Local Community	Commitment To Local Communities	B	3
	Cultural Heritage	A	4
	Local Employment	B	3
	Access to Intangible Resources	A	4

Fig 4 results of the S-LCA of a garment produced at San Lorenzo Group.

More in details the study showed that the textile company is a socially responsible company, and it takes into account the expectations of its workers meeting their needs relatively to health and safety, salary and career development. It is also showen by the company in considering the staff as a component of its competitive advantage. For manufacture of the garment, the company has developed a path of social responsibility, establishing a strong relationship with its employees and the territory, e.g. the company hires home workers, meeting the necessity of older workers or people who are not able to move to maintain their economic independence, carrying on the tradition of “double-face” needlework. The good performance on health and safety procedure is verified by the fact that no accidents have been recorded in the past five years. The organization not only respects the national law on health and safety, but it does provide, an additional health benefits to older employees and their families. The company is also engaged in activitites and events for the local community.

Theme	Characterized Issue	Country-specific sector	Risk Value	Characterized Results
Labour rights& Decent work				
Working Time	Risk of excessive working time by sector	Mongolia	No data	No Data
		Italy (wool)	1,000	Medium
		Italy (Metal production)	1,000	Medium
		Germany (wire)	1,000	Medium
Freedom of association and collective bargaining	Risk that a country lacks or does not enforce Freedom of Association rights	Mongolia	5,333	High
		Italy (wool)	1,000	Medium
		Italy (Metal production)	1,000	Medium
		Germany (wire)	1,000	Medium
Labour Laws	Risk that country does not provide adequate labour laws	Mongolia	5,202	High
		Italy (wool)	0,753	Low
		Italy (Metal production)	0,505	Low
		Germany (wire)	0,505	Low
Child labour	Risk of Child Labour in sector, Total	Mongolia	7,500	Very High
		Italy (wool)	No data	No Data
		Italy (Metal production)	No data	No Data
		Germany (wire)	No data	No Data
Forced Labour	Risk of Forced Labour by Sector	Mongolia	1,000	Medium
		Italy (wool)	0,258	Low
		Italy (Metal production)	0,258	Low
		Germany (wire)	0,258	Low

Fig 5 Some figures on the S-LCA of garment upstream processes.

For the upstream supply a social risk assessment has been carried out by Social Hotspot database (Norris and Benoit-Norris, 2015). The results showed that the main social risks occur for the cashmere produced in Mongolia. The main risks are related to the child labour and corruption.
As mentioned by Lenzo et al. (2017) it is difficult to summarize the social results without having primary data for the upstream process. Further researches are currently made to have a more transparent supply chain.
Combining both assessments, it is clear that further attention has to be paid to improve data quality related to upstream processes in order to better assess the social and environmental dimension of the investigated system. Indeed transport is the main hotspot highlighted in the LCA analysis, but the social impact of the transport phases have not been considered yet in the upstream risk assessment, on the other side the main social risks are associated to the production of cashmere in Mongolia, but the assumption made in the LCA (due to the lack of inventory data specifically related to Mongolian production) may limit the environmental results.
However, by combining the two implementations, the company has a relevant source of inputs useful to improve its environmental and social performances, but collecting primary data from the whole supply chain remain the main obstacle to carry out a complete life cycle sustainability assessment.

Conclusions and Discussions.
The first LCA and S-LCA on an Italian made garment is the focus of this study. Primary and secondary data were collected to obtain the first estimation of the social and environmental impact caused by a wool/cashmere garment made in Italy, from raw materials' extraction to the gate manufacturing processes at the San Lorenzo group

company. The garment has an important social and economic value because it is hand made and it is produced in an Italian region with a high unemployment rate where this company represents the main employment source. This analysis is part of a bigger study which aims to develop a methodology to assess the sustainability performances of textile products by broading the environmental aspects including the social and economic benefits of a production made in Italy. The first results on the social and environmental performance reported in this study show that the transport phase and the upstream phases need further evaluation. The results obtained could present some limitations which are related, in particular, to the different assumptions made to carry out the analysis due to the lack of primary data of some processes. Thus, these further evaluations are mainly connected to the collection of primary environmental and social data that can allow a higher level of the analysis' detail.

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