Master Thesis Exposé

Life Cycle Sustainability Assessment of Products for Small Businesses – A Literature Review

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ABSTRACT

Title – Life cycle sustainability assessment of products for small businesses – a literature review

Background - In present times, sustainability is becoming imperative for all types of business organizations, across all industries. Sustainability in business organizations is associated with creating long-term value by having positive impacts on society and the environment. To reach sustainability goals, first businesses must assess their current operations. Sustainability assessment in business organizations can be performed in a variety of ways but focusing on products has proved to be a good start for these types of organizations. Products throughout their entire life cycle – from the extraction of raw material, production, usage to ultimate disposal have a profound impact on society and the environment. Life cycle sustainability assessment (LCSA) is an evaluation framework that assesses product sustainability performance along the product's entire life cycle journey. This framework is comprehensive and reliable because it considers all three sustainability dimensions of the triple bottom line approach i.e. environmental, social, and economic dimensions along the product’s total life cycle. LCSA (Life Cycle Sustainability Assessment) consists of three components viz. LCEA (Life Cycle Environment Assessment), SLCA (Social Life Cycle Assessment), and LCCA (Life Cycle Costing Assessment).

Aim – LCSA is a broad and complex topic. Different aspects related to LCSA are studied in the past but there is not enough concise literature available about LCSA for small businesses. The primary research questions of this review are what kind of issues are faced by small businesses in applying the LCSA framework and how can they simplify and successfully implement LCSA in real life. The key aim of this thesis is to provide a synthesized review of existing literature to find answers to the research questions.

Methodology – This literature review is a systematic type of analysis of extant literature. The research methodology is primarily based on a research paper published by Snyder, H. (2019). The overall methodology consists of four phases viz. design phase, conduct phase, analysis phase, and writing the review phase. The relevant literature is obtained from the Web of Science database by inserting suitable queries in the search bar of the database. Then, given literature is filtered out using relevant factors, and only relevant literature related to this research topic is
selected. Finally, selected research papers are analyzed and useful information is extracted from these papers.

**Contributions** – This literature review will have significant academic, practical, and social contributions. The review aims to synthesize previously studied literature in such a way that it creates unique value for business owners and potential researchers. The research will not only benefit small business owners in identifying sustainable issues but also their respective stakeholders throughout the product value chain.

**Keywords** – Life Cycle Sustainability Assessment, Life Cycle Assessment, Life Cycle Costing Assessment, Social Life Cycle Assessment, Small Businesses
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List of Abbreviations

LCA – Life Cycle Assessment
LCC – Life Cycle Costing
LCCA – Life Cycle Costing Assessment
LCEA – Life Cycle Environment Assessment
LCSA – Life Cycle Sustainability Assessment
SLCA – Social Life Cycle Assessment

TBL – Triple Bottom Line

WoS – Web of Science

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1. INTRODUCTION

Our common future, also known as Brundtland Report published in 1987 by the World Commission on Environment and Development introduced the concept of sustainable development and proposed long-term strategies about how sustainability could be achieved. According to the report, “Sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland et al. 1987). Sustainability and sustainable development are seen in different ways by different people (Johnston et al. 2007) but sustainability in general from a business point of view is a holistic approach that considers three interdependent dimensions: environmental, economic, and social (Dyllick et al. 2002). Increasing population along with a tremendous rise in anthropogenic activities like rapid urbanization, deforestation, inefficient land use, industrialization, etc has raised serious sustainability questions in front of us (Kumar et al. 2020; Arora et al. 2020). In response to this urgent call for sustainability, the United Nations in 2015 introduced “The Sustainable Development Goals” comprising 17 key goals and 169 specific targets designed to achieve a better and more sustainable future for all (Salvia et al. 2019). The 17 goals are at the heart of the 2030 Agenda for sustainable development, adopted by all UN member states for global peace and prosperity. To achieve sustainable goals, governments, businesses, civil societies, and individuals must come and work together (United Nations. 2020).

It is well recognized that sustainable development would only be successful if there are strong commitment and contribution from the business sector side (Pedersen et al. 2018) and the importance of sustainability in business organizations is growing day by day (Bergquist et al. 2017). Small businesses play a critical role in the economic and social development of countries (Edmiston et al. 2007; Ribeiro-Soriano et al. 2017) and they have an important role to play in achieving sustainability by promoting sustainable growth, providing employment opportunities and good work-life to all, reducing income inequalities, innovating and developing value-based solutions for society (OECD. 2017). Sustainability assessment is a methodology that helps decision-makers decide which set of actions they should take to make their organizations more sustainable (Devuyst et al. 2001; Sala et al. 2015). There are various assessment tools available for businesses to measure sustainability performance (Singh et al. 2009) and one important way
through which small businesses can assess their sustainability is focusing on their products (Moreno et al. 2011). Consumers are nowadays becoming more responsible and are demanding more sustainable products (Zamagni et al. 2013). Products throughout their entire life cycle – from the extraction of raw material, production, usage to ultimate disposal have a profound impact on society and environment (Bevilacqua et al. 2017; Valdivia et al. 2013) and sustainability can be measured along the whole life cycle of a product taking into consideration various indicators (He et al. 2019).

The triple bottom line (TBL) approach is an excellent framework that incorporates three dimensions of sustainability performance: environmental, social, and financial (Slaper et al. 2011). Sustainability of products can be assessed through a variety of ways, and one of them is Life Cycle Sustainability Assessment (LCSA), which studies environmental, economic, and social dimensions of products through products’ entire life cycle journey (Finkbeiner et al. 2010). LCSA consists of three major assessment tools i.e. LCEA (Life Cycle Environment Assessment), LCCA (Life Cycle Costing Assessment), and SLCA (Social Life Cycle Assessment). LCEA assesses the environmental impact of the product, LCCA is an assessment tool for the economic evaluation of the product and SLCA evaluates the societal impacts of the product throughout its total life cycle (Kloepffer et al. 2008). It is stated that when three tools are simultaneously applied to products, these tools can provide more relevant results in the overall context of sustainability (Parent et al. 2013).

Life cycle thinking has gained significant importance over the past years (Azapagic et al. 2004). “The International Journal of Life Cycle Assessment” (Int J Life Cycle Assess) is a dedicated journal devoted entirely to life cycle assessment and its related topics. A research paper published by (Fauzi et al. 2019) shows that publications related to LCSA are steadily growing in the past years. From 2007 to 2018, the Authors found 124 papers by putting the keywords “Life Cycle Sustainability Assessment” and/or “LCSA”, into both the Scopus database and Google Scholar. Also, one research article by (Zamagni, 2012) shows that between 1974 and 2010, around 600 articles were published that included the terms “sustainability” and “LCA”. This shows that LCSA as a concept has been widely studied and applied.
The concept is broad and has large implications, and in the last decade, various researchers studied different aspects related to LCSA. Different aspects include a brief introduction of LCSA and its related topics (Kloepffer, W. 2008; Zamagni et al. 2012), an In-depth elaborative study of LCA methodology (Heijungs et al. 2002), a study of the specific part of LCSA (Jørgensen et al. 2008; Rebitzer et al. 2003; Rebitzer et al. 2004), application prospects of LCSA for different types of products (Cabeza et al. 2014; Zhou et al. 2007; Atilgan et al. 2016; Stamford et al. 2004), historical & current developments of LCSA, anticipated future developments of LCSA (Finnveden et al. 2009; Guinee et al. 2011; Onat et al. 2017), and possible limitations related to LCSA (Reap et al. 2008; Pizzirani et al. 2014).

LCSA in small businesses, as compared to large businesses has not been popular despite increasing interest and importance of sustainability in small businesses (Baumann et al. 2012; Frankl et al. 1999; Rex et al. 2004). The research paper by (Kurczewski et al. 2014) shows reasons why small businesses are unable to apply life cycle thinking and LCA-related approaches in their strategy and operations. Reasons include costs of LCA assessment, costs of change in routine practices, complicated methodological assessment tools, shortage of qualified staff to carry out actual LCSA, and related assessments. In a research publication by (Rubik et al. 2000), the authors concluded that large businesses as compared to small businesses have strong resources (financial, human, research and development) to apply LCSA and related tools in their organizations. LCSA and related techniques are not that much widely used in small businesses, but their use is becoming popular and common nowadays (Schischke et al. 2012; Ansems et al. 2005).

This research paper aims at finding out issues faced by small businesses while applying LCSA related principles and how can they simplify and successfully implement LCSA. This research will not only benefit small businesses but also their different stakeholders throughout the product value chain.

The Exposé is divided into eight chapters as follows:

1. Introduction – Introducing the research context and thesis overview
2. Theoretical framing – Theories fundamental to conduct this review.
2. THEORETICAL FRAMING

The purpose of this section is to introduce theoretical frameworks, which will form the foundation of this research paper. There will be three key theoretical models viz. TBL framework, Stakeholder theory of Corporate Social Responsibility, and Discounting theory. There will be no alternative theories, but since this research topic is broad and complex while conducting the actual research, any other alternative theory can be found in the future. First, each of the theoretical frameworks will be introduced, then their justification of choices will be presented, then their relationship with the actual research paper and how they will be implemented in the research paper will be established.

2.1. Triple Bottom Line (TBL) Framework

TBL is an accounting framework that considers financial, environmental, and social factors to evaluate a firm’s sustainability performance. It is also called PPP (People, Planet, Profit) model (Slaper et al. 2011). Sustainability in business shows that apart from profit maximization, firms have social and environmental obligations (Dyllick et al. 2002). Freer Spreckley (1981) introduced the idea of TBL in a paper in which he specified what organizations should incorporate in their performance evaluation. He said firms should measure and report on financial performance, social wealth creation, and environmental responsibility. John Elkington (1997) in his book said It's a bottom line that continues to measure profits, but also measures the organization's impact on people and the planet. TBL is a way of expressing a company's impact...
and sustainability on both a local and a global scale. The United Nations 2005 World Summit Outcome Document clarifies sustainability. It refers to the “interdependent and mutually reinforcing pillars” of sustainable development as economic development, social development, and environmental protection. The TBL approach forms the foundation of the sustainability of business operations (Gimenez et al. 2012).

Figure 1. TBL framework. Adapted from (Chen et al. 2014).

\[
\text{LCSA} = \text{LCEA} + \text{SLCA} + \text{LCCA}
\]

Equation 1. is a standard equation of Life cycle sustainability assessment. LCSA consists of three components viz. LCEA (Life Cycle Environment Assessment), SLCA (Social Life Cycle Assessment), and LCCA (Life Cycle Costing Assessment). This integrated assessment framework is based on three sustainability pillars (environment, social, and economic) and each component is constructed on each sustainable pillar of the TBL (Sala et al. 2013).

2.1.1. Life Cycle Environment Assessment (LCEA)
Also known as Life Cycle Assessment (LCA), LCEA is an assessment framework that analyses the environmental impacts and resources used along a product’s entire life cycle, i.e. from raw material extraction, production, usage to disposal of the product (Finnveden et al. 2009). It represents the environmental dimension of sustainability in LCSA.

Figure 2. The simple life cycle of a product. Retrieved from (Curran et al. 2012).

Figure 2. represents a simple diagram of the life cycle of a product. A product passes through a variety of processes before it is ready for use to the final consumer. A consumer uses the product until the useful life of the product, and finally, he disposes of it. In all the processes, there is either consumption of resources (it can be in form like raw material, energy, etc) or emissions of waste (like the release of toxic water, release of harmful gases) or both at the same time. These emissions and consumptions contribute to a wide range of impacts, such as climate change, pollution, eutrophication, acidification, human toxicity, depletion of resources, water use, land use, noise, and radiation among others (Rebitzer et al. 2004).

2.1.2. Social Life Cycle Assessment (SLCA)

SLCA integrates the societal aspects of LCSA. It is based on the social pillar of the TBL. There are various stakeholders involved in the life cycle journey of a product and this assessment tool collects data on social issues associated with different stakeholders and reports on the overall social aspects of sustainability (Wu et al. 2014). According to (UNEP et al. 2009), there are five key stakeholder categories, which include workers, local community, society, consumer, and other value chain actors.
Table 1. Considered stakeholder groups and subcategories in SLCA recommended by the UNEP/SETAC (2009) guidelines for S-LCA. Adapted from (Mair-Bauernfeind et al. 2020).

<table>
<thead>
<tr>
<th>Worker</th>
<th>Other value chain actors</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Freedom of association and collective bargaining</td>
<td></td>
</tr>
<tr>
<td>• Child labor</td>
<td>• Respect for intellectual property rights</td>
</tr>
<tr>
<td>• Fair salary</td>
<td>• Promoting corporate social responsibility</td>
</tr>
<tr>
<td>• Working hours</td>
<td>• Healthy competition</td>
</tr>
<tr>
<td>• Forced labor</td>
<td>• Suppliers relations</td>
</tr>
<tr>
<td>• Equality/discrimination</td>
<td>• End-of-life</td>
</tr>
<tr>
<td>• Health and safety</td>
<td>• Feedback mechanism</td>
</tr>
<tr>
<td>• Social benefits and social security</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Local Community</th>
<th>Consumers</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Access to material resources</td>
<td>• Indigenous people’s rights</td>
</tr>
<tr>
<td>• Access to immaterial resources</td>
<td>• Community engagement</td>
</tr>
<tr>
<td>• Delocalization and migration</td>
<td>• Local employment</td>
</tr>
<tr>
<td>• Cultural heritage</td>
<td>• Secure living</td>
</tr>
<tr>
<td>• Safe and healthy living conditions</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Society</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Public commitment on sustainable development issues</td>
<td>• Health and safety</td>
</tr>
<tr>
<td>• Contribution to economic development</td>
<td>• Feedback mechanism</td>
</tr>
<tr>
<td>• Prevention and mediation of armed conflict</td>
<td>• Consumer privacy</td>
</tr>
<tr>
<td>• Corruption</td>
<td>• Transparency</td>
</tr>
<tr>
<td>• Technological development</td>
<td>• End-of-life responsibility</td>
</tr>
</tbody>
</table>

Figure 3. Considered stakeholder groups and subcategories in SLCA recommended by the UNEP/SETAC (2009) guidelines for S-LCA. Adapted from (Mair-Bauernfeind et al. 2020).

In figure 3., each stakeholder has various impact subcategories through which social positive and negative data can be gathered. Information provided from subcategories can be used to assess the overall social impact using various methods (Benoît et al. 2010). In SLCA, data types and collection methods always remain questionable (Dreyer et al. 2006; Wu et al. 2004).

2.1.3. Life Cycle Costing Assessment (LCCA)

LCCA is a framework that evaluates economic burdens derived from a product during its life cycle. The cost evaluation can be done from point of view of two players i.e. producer and consumer. From a producer’s point of view, it involves the total manufacturing costs and from a consumer point of view, it means how costly is the product to the consumer during its total life until it is finally disposed of (Finkbeiner et al. 2010). LCCA is concerned with reducing the
2.2. Stakeholder Theory of Corporate Social Responsibility

Stakeholder theory states that a firm should create value for all stakeholders, not just shareholders (Freeman et al. 2010). Stakeholders are the ones who have a direct or indirect stake in the business. Stakeholders can be divided into two groups: 1. *Internal stakeholders* are the ones who are directly involved in the firm’s operations. Examples include shareholders, employees, managers, etc. 2. *External stakeholders* are the ones who are indirectly involved in the firm’s operations. Examples include customers, society, government, suppliers, media, creditors, media, pressure groups, etc (Freeman et al. 2001).

![Diagram of Stakeholders](image)

Figure 4. Various stakeholders of a company. Adapted from (Gurzawska et al. 2017)

R. Edward Freeman’s Stakeholder theory
R. Edward Freeman (1984) in his famous book “Strategic management: A Stakeholder Approach” introduced the concept of stakeholders, emphasized the importance of stakeholders, and gave ideas on how a firm can achieve long term goals considering various stakeholders.

Figure 5. Product life cycle diagram. Obtained from (UNEP. 2019)

Stakeholder theory is at the center of the life cycle sustainability assessment of products (Kozlowski et al. 2012). In LCSA of small businesses, the process starts from raw material extraction, where the assessing firm has to collect data from the raw material producers (suppliers), incoming raw materials are transformed into the intended product through a production process (producer), then the final product is transported to distributors and retailers, and then it is finally sent to the customer. The customer uses the product and then disposes of it. In the whole process, there are a lot of stakeholders involved and conducting the assessment requires inputs from respective stakeholders (Halog et al. 2011).

LCEA aims at collecting input data from various stakeholders that are directly or indirectly concerned with environmental impacts, but challenges always remain about the quality and reliability of data (Guinée et al. 2002). Although various dedicated databases of Life cycle assessment are available, it is still insufficient, and global alliances are emerging to solve problems related to databases (Curran, M. A. 2012). LCCA helps in estimating the overall cost
of ownership from consumers or producers' point of view. There are a lot of methods already available to estimate the costs and revenues of products (Heinzle et al. 2007). As compared to LCEA, LCCA is less costly. SLCA accounts for assessing the impact of products on society. The societal impacts can be measured by analyzing the effects of stakeholders at local, national, and global levels (GRI, 2002). Measuring social impacts involves different dimensions to choose from and which dimensions to include in the assessment always remain a question and depend on a lot of factors (Petti et al. 2018).

2.3. Discounting
Discounting is a process to determine the present value of a payment that is to be received or to be paid in the future (Boardman et al. 2017).

**Present Value of Discounted Cash Flows**

\[ PV = \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \frac{CF_3}{(1+r)^3} + \cdots + \frac{CF_n}{(1+r)^n} \]  

Where

- CF equals cash flow for a period
- r equals the discount rate
- n equals the number of periods

The future cash flows \((CF_n)\) are discounted at interest rate \(r\) till period \(n\) to get the present value. This concept is also called the Time value of money. Money has time value, which means that \(x\) amount is more valuable now than \(x\) amount in the future if \(r>0\).

In the context of the LCSA of products, discounting is used in LCCA. LCCA seeks to optimize the cost of acquiring, owning, and operating the product over its useful life by attempting to identify and quantify all the significant costs involved in the life cycle, using the present value technique. LCCA aims to minimize the overall costs (Woodward et al. 1997).
In the research paper published by (Kaufman et al. 1969), researchers significantly contributed to the LCC methodology, whereby they developed a systematic framework. The framework consists of eight key steps – 1. Establishing the profile, 2. Establishing the utilization factors, 3. Identify all cost elements, 4. Determine the critical cost parameters, 5. Calculate all costs at current prices, 6. Increase current costs at estimated inflation rates, 7. Discount all costs to the present base time and 8. Add up all discounted costs to get a total present value. In figure 5. All steps can be seen and different costs that can occur in the life cycle are also presented. The framework was primarily developed to evaluate different capital asset options for the purchasing department of the organization.

There are a variety of ways to conduct an LCCA depending on industry type and are firm specific (Korpi et al. 2008). LCCA attempts to identify total costs across the life cycle, and some costs are borne by different stakeholders with very different perspectives of the costs and potentially conflicting goals. It is conducted to inform decision making to one specific actor, but data can be used by different actors as well (Swarr et al. 2011). The main problem in LCCA evaluation is data estimation and allocation of costs to different activities in the life cycle. This topic is widely studied in LC related methods (Schaltegger et al. 2017). Discounting in the
context of small businesses seems practical and easy to implement. LCCA can be conducted from the producer's point of view and consumer point of view. LCCA from the producer point of view analyses whether any project/product is economically sustainable or not (US EPA, 2010). In this analysis, in period $t_0$ (initial period), the initial cash flow is negative, meaning the producer will be spending money for the production, but in future periods, the producer will receive revenue (positive cash flows) from customers. If the sum of positive discounted cash flows is greater than the sum of negative discounted cash flow, then it can be said that the product is sustainable. Here the objective of the producer is to maximize the difference to get more profits.

LCCA from a consumer point of view has a different purpose. Here the purpose is to communicate to the customer how much the product will cost from the entire life cycle approach (Elsayed, E. A. 2014; Woodward et al. 1997). Here the objective of the producer is to minimize life cycle total costs (from the consumer point of view) so that producers can communicate cost savings ideas to consumers. The producer can minimize the cost in two ways - first by increasing the time for which the product will last (durability), the other is by reducing the related costs of products in its usage and disposal phase. LCC is used as a marketing tool for producers, producers communicate to the buyers that their products are more sustainable in economic terms (after doing LCCA of their products). It becomes simpler and more practical for buyers to evaluate and make informed decision making while choosing products from various other product alternatives (Brown et al. 1979).

3. **RESEARCH PROPOSITIONS**

A research proposition is a statement about topics that may be judged as true or false in an observable situation (Cooper et al. 2014). This thesis is supported by several key propositions. Several researchers in the past convincingly argued that sustainability is critical for business organizations in current times (Schaltegger et al. 2017). A recent study by (Bonini et al. 2014) argues that global corporate trends towards sustainability are changing rapidly and sustainability is becoming a more integral and strategic part of the businesses. Implementation of sustainable strategies in business provides not only competitive advantages to firms but also better financial
returns (Sharma et al. 2010; Engardio et al.2007; Esty et al. 2009; Hart et al. 1995). This seems that business organizations in the future will move towards more sustainable strategies and will adopt green practices. This leads to the formulation of this proposition:

**P1: Sustainability is critical for business in present times**

Consumers in all parts of the world are becoming more aware of their environmental impacts. They are demanding more green products than before, moreover, studies conducted in several regions of the world suggest that they are willing to pay more for green products (Laroche et al. 2001; Kang et al. 2012; Nomura et al. 2004). This explains that the demand for green products is going to increase in near future, and to take advantage of that, businesses have to make their products greener. This leads to the following proposition:

**P2: Customers are demanding greener products**

Small businesses face various resource constraints as compared to large firms and do not take proactive steps towards sustainability (Del Brío et al. 2003). In the short run, a small business faces risks of survival (Ye et al. 2013), but in the long run, integrating sustainable policies gives more edge to these types of firms (Dillard et al. 2010). This conveys that more and more businesses are adopting long term strategic business models, in which sustainability plays a central role. For this reason, the following proposition is formulated:

**P3: Sustainability creates long term value for small businesses**

LCSA as compared to other sustainability assessment frameworks is more comprehensive because it considers all three sustainability dimensions throughout the product’s total life cycle (Kloepffer et al. 2008). The assessment of the entire life cycle implies that no processes connected with the product system boundary directly or indirectly are missed out during the evaluation process. Governments all around the world are recommending the use of LCSA and are adopting LCSA related principles in their environment policies (Guinee et al. 2011). Although there are various limitations of LCSA, effective LCSA within a defined goal and scope of the study can yield impressive results. The following proposition is established in the context of the above information:
P4: LCSA is a more comprehensive sustainability assessment framework than other sustainability assessment frameworks

There are various reasons why LCSA despite being a holistic sustainability assessment framework, is not being used that much in small businesses (Kurczewski et al. 2014). One of the reasons is its complexity. LCSA involves gathering data of various sub-product systems or product-processes along the product life cycle. Primary data collection is too costly and secondary data collection has a higher degree of risk of incorrect allocation to the product that needs to be studied (Curran et al. 2012). Also, there is a lack of guidance for small business owners to implement LCSA into their businesses (Suhariyanto et al. 2017; Kurczewski et al. 2014). It is argued by researchers in a paper published by (Witczak et al. 2014) that LCSA application in small businesses requires a special approach taking into consideration various factors that are specific to small businesses. Therefore, it can be argued that the critical problem in the application of LCSA is its complexity, if LCSA becomes simpler then it can be said that its usage will increase proportionately. This leads to the following proposition:

P5: Simplified version of LCSA in the context of small businesses can significantly increase the use of LCSA among small businesses

3.1. Relevant Literature Review

The table consists of the most important literature to be used in this thesis.

Table 1. Literature Review Table

<table>
<thead>
<tr>
<th>Title</th>
<th>Author(s)</th>
<th>Year of Publication</th>
<th>Journal/Textbook</th>
<th>Content/Relevance</th>
</tr>
</thead>
<tbody>
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<td>Towards Life</td>
<td>Matthias</td>
<td>2010</td>
<td>Sustainability</td>
<td>In depth</td>
</tr>
<tr>
<td>Title</td>
<td>Authors</td>
<td>Year</td>
<td>Journal/Publication</td>
<td>Summary</td>
</tr>
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</tr>
<tr>
<td>Cycle Sustainability Assessment</td>
<td>Finkbeiner, Erwin M. Schau, Annekatrin Lehmann, Marzia Traverso</td>
<td>2018</td>
<td>The International Journal of Life Cycle Assessment</td>
<td>discussion of each components of LCSA</td>
</tr>
<tr>
<td>Social Life Cycle Assessment: An Insight</td>
<td>Muthu, Subramanian Senthilkannan</td>
<td>2015</td>
<td>Textbook</td>
<td>In-depth study of SLCA</td>
</tr>
<tr>
<td>Life cycle thinking in small and medium enterprises: the results of research on the implementation of life cycle tools in Polish SMEs—part 1: background and</td>
<td>Przemyslaw Kurczewski</td>
<td>2013</td>
<td>The International Journal of Life Cycle Assessment</td>
<td>Study of Life cycle thinking in SMEs</td>
</tr>
<tr>
<td>Framework</td>
<td>Authors</td>
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<tr>
<td>Life Cycle Management</td>
<td>Guido Sonnemann, Manuele Margini</td>
<td>2015</td>
<td>The International Journal of Life Cycle Assessment</td>
<td>Improving products and services while enhancing the overall sustainability performance of a business and its value chains</td>
</tr>
<tr>
<td>Determinants of a sustainable new product development</td>
<td>Harald Gmelin, Stefan Seuring</td>
<td>2014</td>
<td>Journal of Cleaner Production</td>
<td>Linking sustainability and new product development by providing a conceptual framework</td>
</tr>
</tbody>
</table>
4. METHODOLOGY

Literature reviews are fundamental for knowledge building and help identify areas in which further research would be beneficial (Rowley et al. 2004). LCSA as a concept is broad and complex, and a considerable amount of literature is available in this field. This literature review will be systematic type, which means existing literature will be synthesized in a systematic way (Davis et al. 2014). The primary research questions of this review as identified earlier are “what kind of issues are faced by small businesses in applying LCSA framework” and “how can they simplify and successfully implement LCSA in real life”.

The methodology of this literature review is primarily based on a research article published by (Snyder et al. 2019). In the paper, the authors gave an overview and guidelines for conducting a literature review in studies related to business context. The process of conducting a literature review is divided into four phases viz. 1. Design phase, 2. Conduct phase, 3. Analysis phase, 4. Writing phase. Each phase is discussed in detail below:

1. **Design Phase** - The design phase is the first and preliminary step of the process. The topics that need to be answered in this phase are identifying the needs and potential contributions of the review, recognizing the potential audience of the review, finding a specific purpose, selecting an appropriate method to use, defining the search strategy for the review.

2. **Conduct Phase** – The questions that need to be answered in this phase are developing a search plan, creating a strategy of selecting relevant articles, assessing the quality of selected articles.

3. **Analysis Phase** – This phase is concerned with analyzing the data previously collected. The key areas to focus on here are abstracting useful information from selected articles to fulfill the specific objective, documenting, and reporting the overall procedure in the review.

4. **Writing Phase** – The final phase is all about structuring and writing the actual review. The key points to be answered here is establishing enough motivation for the reader, drawing standards of reporting, filtering the information that needs to be documented on the final review and communicating the conclusion and results.
4.1. **Search Strategy and Data Collection**

Collecting data in the literature review is a complicated and long process. It starts from searching the extant literature, screening for inclusion and exclusion of articles, assessing the quality based on various indicators, extracting data into a well-managed database, and finally analyzing the data (Templier et al. 2015). In this review, the “Web of Science” database is chosen as a reliable source for the data collection process. The search strategy of the literature review is established on basis of the research questions, relevant keywords are identified from research questions, from relevant keywords, search queries are constructed and tested in the journal search engine to look for suitable literature.

Research questions of this literature review are as follows:
Q1. What kind of issues are faced by small businesses in applying the LCSA framework?
Q2. How small businesses can simplify and successfully implement the LCSA framework in real life?

Relevant keywords identified from research questions include “issues”, “small businesses”, “LCSA”. Constructing effective search query is difficult since different researchers define different concepts in different ways, e.g. researchers studying issues encountered in applying LCSA in a small firm and researchers studying problems faced by small businesses in applying LCA are the same. Therefore, search queries must be carefully composed. To figure out these kinds of problems, a conceptual framework is developed. The conceptual framework essentially presents different concepts determined from the research question and looking for related terms of concepts. The conceptual framework of this review is below:

<table>
<thead>
<tr>
<th>Related terms</th>
<th>Concept 1 (LCSA)</th>
<th>Concept 2 (Issues)</th>
<th>Concept 3 (Small businesses)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Life Cycle</td>
<td>Problems</td>
<td>SMEs</td>
</tr>
<tr>
<td></td>
<td>Sustainability</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Life Cycle</td>
<td>Concerns</td>
<td>Small and Medium</td>
</tr>
<tr>
<td></td>
<td>Assessment</td>
<td></td>
<td>Enterprises</td>
</tr>
<tr>
<td>3.</td>
<td>Life Cycle</td>
<td>Complications</td>
<td>Small Firms</td>
</tr>
<tr>
<td></td>
<td>Thinking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Life Cycle Analysis</td>
<td>Obstacles</td>
<td>Small Companies</td>
</tr>
<tr>
<td>5.</td>
<td>Life Cycle Evaluation</td>
<td>Troubles</td>
<td>Small Corporations</td>
</tr>
<tr>
<td>6.</td>
<td>Social Life Cycle Assessment</td>
<td>Challenges</td>
<td>Small Organizations</td>
</tr>
<tr>
<td>7.</td>
<td>Life Cycle Costing Assessment</td>
<td>Limitations</td>
<td>Small and Medium Sized</td>
</tr>
<tr>
<td>8.</td>
<td>Environment Assessment</td>
<td>Drawbacks</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Life Cycle Management</td>
<td>Hurdles</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Product Life Cycle</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. The Conceptual Framework

In Table 2, the conceptual framework exhibits three key concepts and related terms of each concept.

Search queries are fundamentally based on the conceptual framework. Different databases have different search rules, and in this specific case, the search rules (Capitalization, Boolean search operators, Phrase searching, Limiters, Parentheses, etc.) and recommendations (Truncation, Wildcards, Plural terms, etc) provided by the WoS database were taken into consideration while constructing search queries.

Initially, it was thought that there would be only one search query for this review, but after initial trials and errors, it was found that a single search query can’t deliver the required outcomes. Therefore, two different search queries were designed. The first query focuses on LCSA and its related issues and the second query concentrates on LCSA and small business prospects.

The first query after several trials is identified as below:

```
["Life cycle sustainability assessment" or "life cycle assessment" or "life cycle thinking" or "life cycle evaluation" or "life cycle analysis" or "social life cycle assessment" or "life cycle costing assessment" or "environment assessment" or "life cycle management") AND ("problem$" or "concern$" or "complication$" or "obstacle$" or "trouble$" or "challenge$" or "limitation$" or "drawback$" or "hurdle$" or "issue$")]
```

In this review process, the basic search function of the WoS is adopted. Search query related to concept 1 (LCSA) was inserted in the first row of the database and it was searched using the
topic field (Title, Abstract, Author Keywords, Keywords Plus) function. The search query related to concept 2 (Issues) was inserted in the second row and it was searched using the Title field function. Both concept 1 and concept 2 were joined using “AND” as a Boolean operator.

The initial search query inserted in the database gave a total of 702 results. Only research literature from 2005 onwards was selected, the amount of literature reduced to 640 results. The majority of the literature was in the English language, literature in other languages (5 results) was also excluded. Filtering out using “WoS Categories” function, literature which was not at all relevant to this research topic, for instance, literature in the category of optics, microbiology, mathematics, international relations, etc. and filtering out using “Document Types” function, letters, meeting abstract, correction were also excluded giving a total of 460 results. Further, filtering out using the “Research Areas” function, literature related to material sciences was ignored giving a total of 452 results. Refining the literature using “Source Titles” function, all remaining literature was analyzed after going through their titles, abstracts, and keywords. Literature not relevant to this research field was excluded and the results were reduced to 216. Further refining literature using Source Titles was not possible, because several source titles had few articles relevant to this topic but also at the same time, several articles were irrelevant. Finally, the literature was filtered using the “Organizations Enhanced” function, irrelevant articles were removed after analysis and the results dropped down to 46 results. The results were consistent with the research objective and all those final results were exported in an Excel file.

The second query after several trials and errors is described as follow:

\[ ("Life cycle sustainability assessment" or "life cycle assessment" or "life cycle thinking" or "life cycle evaluation" or "life cycle analysis" or "social life cycle" or "life cycle costing" or "environment assessment" or "life cycle management" or "product life cycle") AND (SME$ or "small and medium enterprise$" or small firm$ or small compan* or small corporation$ or small organi?ation$ or small business* or "small and medium sized") ]

In the basic search bar of the WoS database, a search query related to concept 1 (LCSA) was inserted in the first row and a search query related to concept 3 (small businesses) was entered in the second row. Both search queries (concept 1 and concept 3) were searched using the topic field and joined using “AND” as a Boolean operator.
The introductory search query yielded a total of 452 results. Only literature of the past 15 years (from 2005 onwards) were included, the amount of literature reduced to a total of 403 results. Literature in languages other than the English language was excluded, giving a total of 400 results. Filtering out using the “Document Types” function, editorial materials, and book chapters were omitted, reducing the amount of remaining literature to 393 results. Literature in categories irrelevant to the research topic like medicine general internal, statistics & probability, sociology, soil science, etc. were removed, presenting a total of 322 results. Filtering out using the “Research Areas” function, literature results related to material sciences were excluded, giving a total of 314 results. Further, filtering out using “Source Titles” and “Organizations Enhanced” functions, all literature was analyzed by their titles, abstracts, and keywords. Irrelevant literature was excluded, the amount of literature decreased to a total of 80 results. The outcomes (80 results) were exported in an Excel file as well.

4.2. Analysis

Selected research papers are analyzed by extracting useful information from the selected articles database. The final database consists of results from the first query (46 results), second query (80 results), and results of relevant literature as identified in the relevant literature table (9 results) giving an aggregate total of 135 results. Results from relevant literature are included because they form the foundation of this research and they are of utmost importance, especially in introducing the general topics and underlying principles related to LCSA for this thesis.

For the analysis process, “Citavi 6” software is used. First, a new project is created for this thesis and hypothetical categories and subcategories are established. Second, final research papers (135 results) are downloaded from respective sources and imported into the Citavi 6 software. Reference research papers from final research papers are vital for this thesis. These papers can be either imported from the local computer or can be searched and imported directly through the software. Third, the available text is analyzed and evaluated through various means including annotating and highlighting important sections, quoting relevant ideas, commenting on the selected text, and developing own ideas. Finally, actual writing with the help of the “Citavi Add-in” function for Microsoft Word and other functionalities is performed.
5. EXPECTED CONTRIBUTIONS

5.1. Academic Contributions

As discussed above, the key aim of this thesis is to systematically synthesize existing scattered literature in a way that produces a unique value to the audience. The intended audience of this thesis is small business owners, managers, and employees. Small firms are less likely to perform sustainability assessments as compared to big firms because of a lack of knowledge and financial constraints (Labonne et al. 2006). Also, small business organizations have a reactive attitude towards sustainability, they tend to care less about sustainability unless pressure is applied from stakeholders (Bianchi et al. 1999). This trend is changing, more and more small businesses are applying sustainability principles, moreover, a new breed of entrepreneurs is emerging called “sustainable entrepreneurs” (Gibbs et al. 2009). To apply sustainability principles, sustainability assessments must be made. In the context of LCSA, there is no concise and comprehensive (at the same time) research paper available for small businesses. The thesis will significantly contribute to concisely organizing relevant information so that it can be beneficial for not only small businesses but also for potential researchers.

5.2. Practical Contributions

Customers are increasingly becoming aware of environmental and sustainability issues. They are demanding more green and sustainable products, hence opportunities are arising for small businesses to take advantage of it (Belz et al. 2010). Various sustainability assessment tools have been designed, but they were mostly developed for large-sized firms (Jones et al. 2003; Bradford et al. 2008). LCSA requires a vast amount of reliable data and expert guidance. Moreover, it is time-consuming and costly (Lu et al. 2007; Kim et al. 2010). Small businesses cannot perform primary data collection process for each functional unit of product, they rely on secondary data. In one study of LCA of windmill turbine, 3931 functional units of product that needs to be individually assessed were found (Wiedmann et al. 2011). One of the key problems small businesses face in the LCA context is the availability of reliable data (Heidrich et al. 2013). Various initiatives have been taken on the global, regional, and local levels to create interconnected public databases related to LCA so that small businesses in their respective category of products can obtain data according to product type (Curran et al. 2012). This thesis
aims at simplifying and making LCSA more practical to use for small businesses. The thesis will discuss basic problems which small businesses face in applying LCSA in their organizations and what small businesses can do about it.

5.3. Societal Contributions

Small businesses contribute significantly to the global economy, not only in terms of GDP but also in terms of employment generation (Ye et al. 2013). Sustainability drives innovation, ethics, long term profitability, and gives a competitive advantage to firms (Wilshusen et al. 2017; Dyllick et al. 2016). LCSA helps businesses to find out sustainability issues in the product life cycle. The feedback generated from the assessment not only helps the firm itself but also helps its stakeholders along the value chain. Suppliers will be encouraged to produce greener and environmentally friendly raw materials; customers will be provided with more sustainable friendly choices. LCSA will not only help businesses to design existing products more environmentally friendly and sustainable but will also contribute significantly towards green research & development ideas for new products.

6. THESIS CHAPTERS OVERVIEW

The literature review will be divided into three chapters namely:


6.1. Introduction

The introduction part is the first part of the thesis. This part includes discussing LCSA as a topic in brief and giving background information related to the topic.

6.2. Body

The body part consists of the majority of the thesis. This part will be divided into four parts according to the components of LCSA.

LCSA – Life cycle sustainability assessment
LCEA – Life cycle environment assessment

SLCA – Social life cycle assessment

LCCA – Life cycle costing assessment

Each chapter will be studied in detail.

6.3. Conclusion

This is the final part of the thesis. This part includes conclusion remarks, possible limitations of the study, future research opportunities related to this topic.

References

All references used in the study will be systematically displayed according to relevant standards.

7. WORKPLAN

01.10.20 – 13.10.20 – Preliminary broad study of all related aspects of LCSA, primarily all three components

14.10.20 – 20.10.20 – Searching for relevant literature according to the criteria identified in the methodology section

20.10.20 – 20.11.20 – Analysis of literature, transferring literature idea into the thesis

20.11.20 – 10.12.20 – Writing the thesis

13.01.21 – 31.12.20 – Refinement and correction

13.01.21 – Final submission
8. REFERENCES


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