SUSTAINABILITY ASSESSMENT: A REVIEW OF AN INTEGRATION OF LIFE CYCLE ASSESSMENT METHODOLOGIES –PRODUCT, PROCESS AND FROM COMPANIES PERSPECTIVE

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ABSTRACT

Terminology in the field of sustainability is acknowledged globally and at the national level along with its dimensions. Awareness regarding the importance of sustainability at a product level, process level and also from companies' perspective has increased rapidly and has gained much attention. To enhance the sustainability thought and to assimilate the aspects of the environmental, social and economic, different sustainability assessment tools are available to measure and compare the environmental impacts. An environmental impact includes those emissions into the environment that begins with a mining of the raw material till the product is being re-used. These emissions contribute to an extensive scope of impact in the context of change in climatic condition, pollution etc.

Now, these days assessment of the life cycle also known as life cycle assessment (LCA) is carried out to analyze the impacts on the environment of the aforementioned sustainability indicators that are linked to a product or with the product life cycle. Sustainability indicators and impact assessment act as an important tool which is helpful in making the course of action and also exchanging the information in the context of the environment, social and economic ways. Similarly, for economic dimension life cycle costing analysis is done considering the total cost along with the product lifecycle and to consider the social impact at company level or at product level social life cycle (SLCA) assessment is carried out.

The paper introduces the notion of sustainability with the life cycle assessment tools along with the methodology at a product level, process level and also at a company level. The core aim is to explain the concept of sustainability followed by the brief explanation of sustainability metrics or indicators in this review paper. In the next section Sustainability assessment with the tools and methodology is discussed. Lastly, Implications, Conclusion and future research is mention.

KEYWORDS: Sustainability, Sustainability Indicators, Sustainable Metrics, Sustainable Business, Product Life Cycle, Assessment of life cycle (LCA) or Environment life cycle assessment(ELCA), life cycle costing (LCC)& Social life cycle assessment (SLCA)

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1. INTRODUCTION

Development at the organization level, the business level is the important topic which is being discussed on almost all the platforms and currently it has been put into practice into many levels of society. This concept is known as “sustainable development” and is important from the decision making perspective in the industry both directly and indirectly in the course of their operation or through their interlinked value-adding activities of their business. The most appropriate definition presented by the Brundtland Commission in many available works of literature, "to make development sustainable and in order to meet the need of the present without compromising the ability of

future generations" (WCED, 1987) forms a preliminary point to discuss and define this concept. To assess the sustainability there are numbers of methodologies existing in practice to evaluate the performance of industries (Ramachandran N, 2000). Sustainability indicators, the standard set for organizations or industries were developed which covered all those important characteristics of sustainable development (Krajnc, D., Glavic, P., 2005) which was crucial. Indicators are useful and which acts as an important tool that helps in policy making and communicating the information with respect to presenting the concept in various fields, namely environment, society, economy and also advanced technology (Technology Development) (K.E., 2005).

According to Meadows, D., (1998), "Indicators is a set of measure (values) and they create values from the measure (what we measure). Due to this ability to summarise, focus and reduce indicators are adopted by many companies or industries in order to minimize the intricacy of our challenging environment into the information which is beneficial for all (Godfrey, L., Todd, C., 2001). In the dynamic environment, there is a need for the individual, society, and organizations to find out the models, standard set of measurement, and tools used for articulating the ways and also, inquire about the activities those are unsustainable (Bebbington, J., Brown, J., Frame, B., 2007).

As per Ness.B.et al. (2007) "The main aim of the sustainability assessment is to contribute decision-makers with respect to evaluation of global to local context and also long-term perspective in order to help them to find out which actions must be taken or must not be taken in an attempt to make society sustainable". Sustainability assessment has turned out to be the swiftly growing region. The records of tool those are available claims to provide enhanced application guiding principle, facts, and figures with case study experiences. Sustainability assessment tools collectively used with the evaluation of the impacts known as impact assessment tool with respect to the environmental context thereby assessing the environmental strategically (Devuyst.D., 2000; Pope et al., 2004). Assessing the life cycle or Life cycle assessment (LCA) is extensively utilised in making conclusions and supporting the conclusions, but earlier LCA used to considers only the environmental impacts (Dreyer et al., 2006). Due to this LCA fails to attend all dimensions of the sustainability simultaneously during the process of a product lifecycle. Now the question arises about the ability of the LCA's weather helps in decision making or not, that specifically aims sustainability and it also incorporates others dimension of sustainability in companies. Life Cycle Costing (LCC) considers monetary aspects similar to the LCA mentioned above during the life cycle of a product. Similarly, social life cycle assessment is carried out to evaluate the company performance in the context of social issues; however, research is still carried out on Social LCA.

2. LITERATURE REVIEW

2.1 Sustainability

Sustainability as defined in ample ways in various works of literature and in actuality it is not defined as a new concept; it does have a comprehensive history and has gained attention over a period of time (Kidd, C.V., 1992). The most important thing to look into this is that the sustainability attention that has been gained over a period of time is being pretentious by diverse "intellectual and political streams of thought that have moulded concepts of sustainability" (Kidd, C.V., 1992). There is unprecedented attention gained by the topic "sustainability" by the practitioner and researcher in recent years. Referred by the World Commission on Environment and Development, (i.e. Brundtland's Commission, WECD, 1987) defined "Development that meets the needs of the present without compromising the future needs" (Adams, W.M., 2006; Dresner, S., 2002). In Figure 1, Adams, W.M., (2006) explained the concept of three dimensions of sustainability named as three pillars.

Figure 1: Sustainability – Three Pillars

Sustainability from business perspective is defined as “Triple Bottom line” (Harris,Wise, Gallagher & Goodwin, 2001) (Dyllick, T.,&Hockerts, K., 2002) (Pava, M.L., 2007) (Goel, P., 2010) and it is a sustainability construct which includes three significant dimensions: environmental quality, social equity, economic prosperity (Elkington, J., & Rowlands, I. H. (1999).The basic thought of the triple bottom line named as (People, Planet, and Profit) is mostly used with respect to business.Table 1 illustrates the sustainability dimension definition from business perspective given by different authors.

Table 1: Sustainability Dimensions

Year	Author	Dimension Definition
1995 2005 2009 2010	SL Hart Bansal P, Yan, Chen, Chang P Goel	Environmental Dimension focuses on the natural resources.
1991 1998 2005 2008 2010	D J Wood John Elkington D.N.Santos and AlmeidaFilho M Bibri A Goel	Social Dimension focuses on the impact on the society (Sustainable Society)
1995 2005 2007	Clarkson Bansal P, Spangenberg Collins, Steg, & Konan	Economic Dimension focuses on creating an importance, in addition, to enhance the financial performance.

This section focuses on the relevant literature available on the concept of sustainability along with its applications. Sustainability with the well-built environmental concept, explains the "ability to reduce the long-term risk that is associated with the resource depletion, fluctuation in energy cost, product liabilities, and pollution and waste management" (Shrivastava, P., 1995). The concept of sustainability and sustainable development describe the development of the society considering the financial concern, by means of respect to environment along with interaction among the processes. (Peter Glavic, 2007). It has now become an important factor for companies. Due to the fact companies have started integrating the concept of sustainability into their business and developmental activities (Haaneas et al., 2011; Dyllick, T., and Hockerts, K., 2002; Jones, T.M., 2003, Bielak, D. et al., 2007; Bonini, S.M.J.,et al., 2006). Companies aim at satisfying the user needs by attaining the principle, thereby reducing the environmental and communal influence of products with the motive of providing the economic value to the company considering the complete life cycle of a product which is the main aim of

the sustainable development (Hseuh, Che-Fu., 2011). It is due to sustainability, companies are able to gain the competitive advantage (Campbel, J.L., 2007). According to (Lorek, S., and Spangenberg, J.H., 2014) sustainability involves two key concepts, the needs, as well as the technological and social limitations. Sustainability has always been an important aspect for all divisions of the economy. Most of the businesses have to work according to a wide-ranging set of directions plus policies that is concerned about the CO₂ emission, polluting the environment and emissions product from noise, safety aspect in context to product and components, reusability of the products, recyclability, and recoverability (Petrescu-Mag et al., 2015). Table 2 illustrates the sustainability definition given by various authors in the literature. Different concepts with respect to sustainability are explained in the literature and are being cited by different authors. Table 3 explains the concept of sustainability illustrated below (M. Høgevold, N. Svensson et al., (2014).

Table 2: Defining Sustainability

Year	Author	Definition
1988	John Elkington	Defined Sustainability from companies perspective those only have a focal point on financial benefits, as well as a focal point on the environment and social factors too known as Triple Bottom Line.
1992	Charles V.Kidd	Sustainability defined in terms of intellectual and political streams of thoughts
2000	Clift, R., Allenby, B., & Ayres, R.	Sustainability concept describes as a goal and sustainable development explains a process of fulfilling it.
2007	Joel P. Engardio Glavic and Lukman	Sustainability acts as a way that firms are progressively adapting to carry out business processes, assessed the various explanation of the concept of sustainability.
2008	Peter Senge	Sustainability defined beyond the regulatory compliance.
2010	R .Guest	Summarised economic sustainability, with respect to climate changes.
2012	Høgevold and Svensson	Sustainability acts as a streamlined process.

Table 3: Different Concepts of Sustainability (M. Høgevold, N. Svensson et al., (2014)

Concepts	Definitions	Source
Sustainability	"Sustainable economic development meets the needs of the present without compromising the ability of future generations to meet their own needs".	WCED (1987)
Sustainability - Business	"An organization's attempts to not only focus on profitability but to efficiently and effectively manage and integrate its environmental, social and broader economic impact". Organizations find out the ways to deal with the influence that has an effect on the universe and ecological unit along with the entire company association.	Ludeke and Freund F. (2009) Svensson and Wagner (2012)
Sustainability-Triple bottom line-	Activities of organizations those are intended or administered reveals about their capability which belongs to their organization in order to maintain its operations (Business) that includes (financial status) and considers the fact that no harmful impacts should be there on society and eco-system.	Peter and Smith (2011)

Sustainability Metrics or Indicators

Sustainability metrics or parameter is a property that can be calculated or analyzed (OECD, 2005). Let us briefly explain the parameter by taking an example of the environmental dimension of sustainability. Quantity in which CO₂ is produced in "kg" belongs to the parameter of an environmental dimension under pollutant (Shaw C. Feng et al., 2010). Indicators must possess these features: It must be simple, a wide-spread possibility should be there covering all the aspects, which must be quantifiable, consider the tools which are susceptible to change, and must have the ability to identify the trends timely (Harger, J.R.E., Meyer, F.M., 1996). "Indicators arise from values and they create values (Meadows, D., 1998). The indicator which is also being known as a parameter provides information about the situation of the environment with an importance that is further directly associated with the parameter assessment (OECD., 2005). An indicator acts as a detailed tool that makes the availability of information regarding the organization's environmental performance, influential factors that influence the circumstances of the environment. It can be better illustrated by quoting an example, that CO₂ which acts as the parameter can be described as an indicator which specifies the amount of CO₂ produced by the industry during a particular time. Indicators help in simplifying, quantifying, analyzing the concerns and also helps in communicating the multifaceted and problematical information (Warhust, A., 2002). According to the literature specified by (Subhas, K. Sikdar., 2003), there are various classes of metrics developed to specify the situation (The state) and the outcome of the system (In terms of performance), but only two classes have been mentioned. The one that specifies the situation of a particular organization called as content indicator whereas the one which measures the behaviour of the organization is known to be performance indicators (SubhasK.Sikdar., 2003). Measuring and tracking an indicator is a standard means of Performance Metrics (Shaw C.Feng., et al., 2010). Most of the research attempts have been made in measuring the performance of three groups of metrics equivalent to three dimensions of sustainability those are ecological metrics, economic metrics, and sociological metrics. The aspects of the metrics can be measured in terms of dimensions explained in table 4 adapted from (SubhasK.Sikdar., 2003).

Table 4: Sustainability Metrics – Dimensions

One Dimensional (1 – D)	Two Dimensional (2-D)	Three Dimensional (3-D)
Ecological Metrics	Eco-Efficiency Metrics	The intersection of one dimensional along with two-dimensional metrics leads to – True sustainability metrics
Economic Metrics	Socio-Ecological Metrics	
Sociological Metrics	Socio - Economic Metrics	

With reference to the processes those are related to chemicals that belong to manufacturing unit or a manufacturing enterprise dozens of sustainability indicators have been recommended by (AIChE (2003), IChemE (2003) Though a sustainability indicator is used to measure the improvements but in context to sustainability metrics considerable studies was accomplished by centre with respect to technologies that can be used in reducing the waste for AIChE in order to assess the process alternatives. In their conducted study indicators or metrics used were utilization of material, usage of energy, use of water, diffusion of toxins, dispersal of pollutant, and emission of greenhouse gases (Beloff, B., J. Schwartz, and E. Beaver (2001); Schwartz, J., B. Beloff, and E. Beaver (2002). Among resources there are some important indicators suggested by the IChemE are the use of energy, materials that are being used, the quantity of water used, and the different ways of use of land. From environmental impacts perspective, decrease in pH of the earth's ocean, change in climatic condition concern, human health issues, increase in the amount of UV radiations, the formation of photochemical smog, and also the ecological concern. An economic indicator includes measures related to research and development expenditure

and other value-added measures. Finally, Social indicators include employee benefits, safety, and treatment of the employee in the workplace (SubashK.Sikdar., 2003). Various literature reviews are there on the dimensions of sustainability but the open attentiveness in various research papers is on 2-D (Two-dimensional Metrics) improvement is described by Baden Aniline and Soda Factory (BASF) (Saling and Wall., 2002; Saling et al., 2002). The eco-efficiency created by the BASF is used to determine the performance of ecological and financial factors of a product or process. As clearly explained by the BASF method, there are five indicators (ecological indicators) which collectively provide idea for "ecological footprint", which is graphed with the cost that is an outcome of the life cycle of process and then makes a final decision about the process which has a lowest among both the method, and have better-quality eco-efficiency. Table 5.Outlines the available sets of sustainability and environmental indicators (Shaw C. Feng., Che-Bong Joung., and Gang Li., 2010).

Table 5: Sustainability Indicator Set

Indicators	Description
Dow Jones Sustainability Index (DJSI) (Dow Jones,2009)	This measures the financial ability and also considers the sustainability performance. This assessment is divided into 12 criteria.
<i>OECD Core Set of Environmental indicators</i> (OECD,2000)	This includes 50 indicators which are correlated with environmental conditions and trends those are observable.
<i>Organisation for Economic Cooperation and Development (OECD Toolkit)</i> (Bordt, M., 2009)	Main aim of the toolkit helps in calculating and interpreting the 18 core indicators for measuring the performance of the sustainability with respect to raw materials and the procedure they use.
<i>Product Sustainability Index of Ford (Ford PSI)</i> (Ford ,2009)	This focuses on an environmental, social and economic characteristic which is based on externally check from an environmental and cost perspective. Its Product Sustainability Index has eight indicators.
<i>Metrics for Sustainable Manufacturing of General Motors</i> (Dreher, J., Lawler et al.,2009)	This reviews the state of the metrics on sustainable manufacturing which is elaborated by the General Motors in one of their project. The company recommends 30 metrics under impact on environmental, amount of energy consumed, issues in the context of personal health, occupational safety measures, management of waste content and cost occurred during manufacturing.
<i>Wal-Mart Sustainability Product Index Questions</i> (Walmart,2009)	This index focuses on to help the customer in making decisions related to the purchases and also encourages the dealer to meet the requirement of sustainability. They are provided with 15 questions to suppliers

Need to Measure Sustainability

Currently, a number of manufacturing industries or companies demand to quantify the sustainability of the products and processes used by them. They are into sustainability accounting (measures the utilization of the resource, waste generated, emission of pollutants from the activities which are involved in manufacturing and document these for evaluating the performance of sustainability) and analysis of the impact caused by them (Impact Analysis) (How much people well being gets affected, considering the environment) (Shaw C. Feng., 2010)

4. LIFE CYCLE SUSTAINABILITY ASSESSMENT METHODOLOGY

The term life cycle sustainability assessment (LCSA) is moderately a novel method which further needs improvement and clarification in the context of methodological developments (JeroenGuinee., 2016). Interpretation phase is very challenging

in the application of LCSA, where results obtained from the three tools should be based on LCSA guidelines and must be interpreted in a combined way. The first conceptual idea on LCSA approaches of today can be endorsed to the German Oeko-Institute which defined their method known as "Product Line Analysis" (Matthias Finkbeiner et al., 2010). O'Brian et al., in the year 1996 used this approach. LCSA framework was put into the conceptual framework by Klopffer, W. in the year 2007 which was further improved in (2008) in a successive manner as mentioned below.

$$\text{LCSA} = \text{LCA} + \text{LCC} + \text{SLCA} \text{ (Klopffer, W. 2008)}$$

The state-of-the-art with regards to environmental dimension (LCA), the economic dimension of life cycle costing (LCC) and the social dimension (SLCA) of life cycle sustainability assessment (LCSA) is clearly elucidated in the following section.

4.1 Life cycle Assessment (LCA)

There has been increasing complexity in context to Society, environment and economic impacts from society unsustainable perspective that has directed to expansion of increasing number of tools and techniques which deals with the situation – each with its own perspective and statements. (Henrik Ny, Jamie P MacDonal et al., 2006). LCA is used for decision support and has been widely used, but earlier it considers only environmental impacts (Guinée, J.B., 2001) (Goedkoop, M. et al., 2000) (Udo, de. et al., 2002) and further to add on is on working environmental impacts (Wenzel, H. et al., 1997) (Antonsson et al., 1995). Therefore LCA failed to address the issues with respect to the protection of the environment considering both the concerns with respect to social and economic conditions during the entire life cycle of a product. (Dreyer et al., 2006). With the increase in awareness on environmental issues, industries are now assessing their activities that affect the environment (EPA, 2006). Now companies are doing way beyond the compliance using pollution prevention strategies and environmental management systems to improve their environmental performance. One such influential tool that will be discussing in this paper is Life Cycle Assessment (LCA) that considers the entire life cycle of the product (Lindfors et al., 1995, Curran M. A., 1996, ISO 1997). Earlier LCA research was rooted in energy requirements (Curran, 1996) but in the year 1970s, the pollution prevention was formally initiated (Royston, M.J., 1979). It is a procedural framework which helps in measuring and calculating the impact on the environment considering the life cycle of a product (G. Rebitzer et al., 2004). A detailed description of the development, about the procedures, and the relevance of LCA is explained by professors Henrikke Baumann and Anne-Marie Tillman in the year 2004 and the same has also been explained in the effective guiding principle as per the ISO standard on Life cycle assessment (Guinée et al., 2002). Life cycle assessment is the most important and often used tools, focusing on the main idea that evaluates the impact of resources along with products starting "cradle" (which means resource extraction) to "grave" (after end use) (Henrik Ny, Jamie P MacDonal et al., 2006) and also it covers all the important environmental impacts into account, both from input side (resource use) and output side (air emissions, water, soil, and waste as well) (Matthias Finkbeiner et al., 2010). Life cycle thinking is the requirement of any sustainability assessment (Walter Klopffer, 2003). The principle of the sustainability assessment (SA) is to evaluate the global and local integrated nature-society system with respect to short term and long term perspective in order to find out which actions should be taken and should not be taken to make society sustainable (Ness, B., et al., 2007). The decision that considers sustainability from industrial, regional, national and globally are very important from sustainability assessment (SA) perspective (Bare J.C., 2014). LCA is a standardised framework with the main objective to consider the environmental impacts of the products by considering all the inputs impacts which are associated with the product life cycle, starting from the resource extraction of all the material and various sources of

energy used in preparation of a product, use of the product and ultimately final discarding a product (Wesley Ingwersen et al., 2014). LCA works on the main objective that defines to use the most effective strategy that improves and avoids changing of the burden from one environmental impact to another. In this, one must consider the entire impacts which occur all through the value chain. (Supply chain and disposal phase) (Hellweg S. et al., 2014). LCA usually take account of a life cycle impact assessment (LCIA) and is a multiple step process, being approved by the international standard guidelines (ISO 14044 2006, Vinodh et al., 2012). Originally four methodological components of LCA was distinguished by "The Society of Environment Toxicology and Chemistry's" (SETAC) (Consoli, F., 1993) mentioned: the goal and defining the scope, life cycle inventory analysis, life cycle impact assessment and life cycle improvement assessment. But in ISO 14040(1997) life cycle improvement assessment was no longer regarded as a phase instead of that life cycle interpretation was added. Depending upon the how comparison has to be made different types of LCA are possible (Laszlo, C., Christensen et al., 2010). In quantitative LCA study, calculations are done based on the impacts on the environment of the product system, while in qualitative LCA; they categorize and evaluate the impacts on the environment through the checklist. However, LCA is based on only environmental parameters (MarwaHannouf et al., 2017).

Figure 2: Showing Interactions Between Stages: Life Cycle Assessment Framework Adapted from (Robert A.Witik Et Al., 2011)

Defining the Goal and Scope

The foremost stage of LCA begins with defining its goal and scope. It acts as an important phase where purpose gets clearly defined and also where the restrictions related to the production system is well explained within context to the aspect those affects the time constraint, availability of data and in-depth study required (GoranFinnveden et al., 2009)

Analysis of Inventory or Inventory Analysis (LCI)

This second stage of the LCA is known to be about collecting the data with respect to input and output of the systems explained above in the "goal and definition" (Robert A.Witik et al., 2011). The amount of raw material (quantification),

Refusal flow and emission produced during the life cycle of a product is calculated and assigned in the direction of the defined functional unit (G. Rebitzer et al., 2004). Life cycle inventory (LCI) databases collect the data on the energy required and material supply, chemical, metals, raw material extraction, transport used and management the waste content (Robert A. Witik et al., 2011).

Life cycle Impact Assessment (LCIA)

The life cycle impact assessment stage determines the potential impact of the environment from the emissions contribution to waste and the resources determined in the inventory analysis (Pennington et al., 2004). Life cycle impact assessment results are an evaluation of a product life cycle.

Interpretation

The last stage of the LCA interprets the results observed during the different stages. Interpretation of the life cycle seems to be done at every stage in an LCA (G. Rebitzer et al., 2004). The results are interpreted based on outcomes, summarised in an effective manner, and discussed, based on all these conclusions are drawn. Keeping all in mind, then recommendations are made based on initial goals.

With the advancement of time International and drafts standards explained in ISO 14000 series is widely acknowledged as providing a framework for LCA (Consoli F., (1993), Guinee. JB., et al., (2002), Hauschild and Wenzel (1998), Heijungs et al., (1992) and Wenzel H, Hauschild M, Alting L (1997). Table 6. provided the complete description of the framework used as per ISO standards.

Table 6: Description of Framework used as per ISO Standards

International Standard	Year	Description
International Standard ISO 14040	1997	Describes Principles and Framework
International Standard ISO 14041	1998	Defined Goal and scope definition and inventory analysis
International Standard ISO 14042	2000	Describes Life Cycle Impact Assessment
International Standard ISO 14043	2000	Life Cycle interpretation

4.1.1 Life Cycle Costing (LCC)

As discussed the entirely the environmental dimension above, likewise the economic matching part of LCA is described as Life cycle costing (LCC), Full Cost Accounting (FCA), Total Cost Assessment (or Accounting) (TCA) (White AL et al., 1996) (Hunkeler, D., & Rebitzer, G. (2003). Total Cost Assessment explained by White et al. as a 'long-standing, wide-ranging investigation of all the internal costs involved in the process and the savings resulting from prevention of pollution and also the projects undertaken by the firm with respect to an environment. The economic or financial benefits with respect to the pollution control method are integrated into the LCC, whereas in conventional or predictive accounting only that cost would be taken into an account which is related to the preventing the pollution. This stated economic or financial 'life-cycle' is even shorter as compared to the physical life cycle ('cradle to grave') in some products as compared used in LCA (Norris, G.A., 2001). Even the external cost that occurs due to ecological damages associated with the products are integrated into this (White, AL., et al., 1996, Shapiro, K.G, 2001). LCA is an older technique and has been used since the 1930s but LCC is not yet standardized (Lichtenvort, K. et al., 2008). The working group SETAC on LCC mentioned that there are three types of LCC refers to environmental life cycle costing: Conventional, Environmental, Societal ((Lichtenvort, K. et al., 2008). Environmental life cycle costing is defined as "an evaluation of the cost those are directly associated with the life cycle of a product (from the Supplier side, Manufacturer side, User or consumers side) which helps

in taking further future decisions (Hunkeler, D. et al., 2008). A working group SETAC has written a book and they have defined the term "Environmental life cycle costing" with respect to ... "an assessment of all the costs those are associated with the life cycle of a product that covers entirely all actors in the product lifecycle which further includes external factors that help in future decision making". (p.173). ISO 14040 has shaped 'environmental' LCC as per the structure of LCA. As compared to LCA, LCC has no Impact assessment due to which aggregated result is calculated, which includes cost per functional unit expressed in currencies (Kloepffer, W., (2008).

4.1.2 Social Life Cycle Assessment (SLCA)

Until the year 2003, SLCA was the least developed lifecycle method indicating a research gap (Walter Kloepffer., 2003). It is still considered to be the very new topic but the idea is not new (O'Brian et al., 1966). Social life cycle assessment is a way through which influence on product and services can be measured with respect to the social impact which is further used to evaluate and make out the comparison between the products or identifying the hotspots covering all of its stakeholders during the life cycle of a product. (Benoit and Mazijn, 2009). Stakeholders those are associated with the product life cycle consists of the those groups and individual which are part of product lifecycle and also directly involved with the production phase, use of raw materials and disposal are being affected by all the activities in these stages of the product lifecycle (Jorgensen A et al., 2012). The social conditions regarding the working of the workers in or affected by the product lifecycle can be improved through three types SLCA (the consequential, educative and lead firm SLCA) (Jorgensen. A., et al., 2012). Together with, the entire product life cycle in the assessment, the SLCA has an additional impact on products as compared to other social assessment tools (Jorgensen. A., 2013). The UNEP (2009) group published the conception and methods in the context of social life cycle assessment which acts as a guiding principle. The last component of the Lifecycle sustainability assessment (LCSA) is the Social Life Cycle Assessment "the assessment of all social and economic aspects of products and also their positive and negative impacts on the product lifecycle" (SETAC, 2009). In the context of the relation of the processes with respect to the social impact, there is no direct relationship between them; rather it is more closely related the way companies carry out the processes, which means that fundamental association is from conduct of the company to the social impact rather than process to social impact (Dreyer et al., 2006, Spillemaeckers et al., 2004). Social Impact is more about the impact on people which then focus on all those activities performed in the life cycle effects people (Dreyer et al., 2006). Generally, companies measure the overall impact which is created by them those are implicated in context to product system and must be allocated in a way the products and services get assessed. (Dreyer et al., 2006). Value creation, number of labours hours spent could act as an allocation principle for SLCA in one way. In another way, socio-labelling inventiveness carried out by (Spillemaeckers et al., 2004) mentioned that every business those who have incorporated themselves in the evaluation have to meet the standards described by the labels and in case the standards are achieved by them, then the label is being achieved by them. Identifying the way of improvement during the product life cycle or life cycle associated with providing services is proposed under the SLCA approach. (Manhart and Griebhammer (2006). The estimation of the social dimension is done by analyzing the effects of organization on stakeholders covering locally, nationally and at the global level (GRI: Sustainability reporting guideline, 2002). Jorgensen. A., et al., (2009), conducted SLCA with respect to the company demonstrating about the ethical or social performance which can be seen as related to CSR activities. Méthot. A., (2005) stated that only the company and its close suppliers, as well as distributors, are assessed. The extent to which societal values and goals in a particular area of life and policies can be achieved is measured by the majority of social indicators. However, performance measurements on social issues are not easy to quantify due to this number of social indicators are based on qualitative standards which include

operating principles, procedures, and management practices (Matthias Finkbeiner et al., 2010). SCLA approaches are differentiated according to impact categories are mentioned starting from the type of indicators for each impact categories. With respect to SLCA approaches some uses midpoint indicators and some endpoint indicators, due to the fact that diverse elements can be included (Jorgensen.A, et al., 2008). Thus in this example job creation act as a midpoint indicator and in the context of health-related concern, it is an endpoint indicator. These two categories of the indicator are correlated and known as an impact pathway which describes a causal relationship. This causal association between the midpoint and endpoint indicators is difficult to express due to this both SLCA approaches are always presented separately (Jørgensen. A. et al., 2008).

With respect to mid-point based approaches, a variety of issues are being discussed and included to create comprehensive impact categories which are enthused from Global Reporting initiatives (GRI, 2007). Indicators are defined keeping in mind at the level of an organization rather the level of the individual (Nazarkina and Le Bocq (2006). For example, in SLCA the conflict between the higher authority and employee are not generally considered because they are at the individual level. Some SLCA uses midpoint indicators and other uses endpoint indicators. As mentioned above as well, the Indicator types refer to qualitative or quantitative. Measuring the quantities that come crossways during the scientific studies, to evaluate the relationship between the scores and the outcome, or yes/no scores can be based on quantitative indicators (Jorgensen.A. et al., 2008). Indicators which can be directly measured is quantified indicators (Barthel et al. (2005), for example, for measuring the impact category, two indicators are proposed 'health and safety'. Both can be measured as they are based on statistical score (lethal or non-lethal. Indicators which can be assessed in an exploratory manner without having any restriction on the type of information is a qualitative indicator (Gauthier, G., 2005), for example, indicators those follow impact category concern related to 'excellence, wellbeing, and security-related issues at work describes the fact that during the various stages in the life cycle a product must be able to accomplish all the concerns with respect to excellence or wellbeing and security. As explained above, how LCA inventory analysis, is done by capturing of data with respect to input and output of the system (Robert A.Witik et al., 2011) Similarly in SLCA data collection is the most challenging aspect apart from creation of impact categories and indicators Dreyer et al., (2006) and Spillemaeckers et al., (2004). As discussed above that, they measure the impacts as a result of the outcome of the company instead measuring the impact on the individual basis. Social impact assessment in LCA is well explained in a framework suggested by (Dreyer et al., and Weidema et al., 2006) which determines the damage categories, categories which get impacted and have also given suggestion on category indicators or inventory data. Social impacts follow benchmark LCA approach to develop impact method and inventory data for new impacts. Below are the mentioned conventional steps to method development (Dreyer et al., and Weidema et al., 2006).

- Need to establish indicators (endpoint indicators or midpoint indicators) as explained above. Endpoint indicators are also known as (Safeguard subjects). For example. Health (Life expectancy and morbidity), autonomy, participation, influence etc.
- Establish 'social inventory data', which is assessable and reported at process level in terms of units. For example, total wages paid occupational injuries, child labor. These all are reported with respect to output i.e. per unit of the process.
- After collecting the 'social inventory data', the empirically based quantitative model is applied where data in context to inventory relates to the endpoint indicators and articulate these by means of characterization aspects.

- Lastly, entire data is gathered and estimation is done on an inventory per process and finally, this data is used to build up the social inventories and social impact assessment for product lifecycle, using the same computational framework that is used in today environmental LCA.

5. CONCLUSIONS

This article has presented the review on sustainability with the life cycle assessment methodologies. Sustainability concept is being followed by most of the companies depending upon the business context. In this article, we have tried to cover the entire life cycle perspective with the emphasis on companies, industries and also on products. Extensive perspectives on LCA, SLCA, and LCC have been defined. Environmental life cycle assessment is being followed by most of the companies from an environmental perspective and methods are available to assess the environmental factors starting from raw material extraction until use of the products or process. LCC is being explained from the economic perspective considering all the costs that incur while considering the life cycle, but from SLCA perspective, we can conclude that SLCA is very new to discuss in the early phase of progress, considering the fact that impact categories and indicators have been developed and is being experienced on industries. SLCA measure the social impact of the companies depending upon the context of the business. From a qualitative view, SLCA is very much explainable but from the quantitative perspective, collecting the data and interpreting the results is still underdeveloped.

6. FUTURE RESEARCH

As mentioned above, from my view, for the SLCA to work availability of data is the main concern which forms the basis for decision making suggests future research. LCA fails to address the combined effect of LCC and SLCA in lifecycle which could be another factor for considering the life cycle assessment.

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