

# Chapter 11

## Sustainable Value Creation with Life Cycle Management

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**Abstract** Life cycle management has gained traction in the last decades. However, even today it is not yet implemented in all companies due to lack of the connection between sustainability and value creation. In fact, managers are pressed to deliver value, and their performance is measured on how well they deliver the value. In this chapter the authors contribute to bridging the gap between sustainability science and business management by application of life cycle assessment (LCA) in corporate sustainability and aligning it with business activities/functions and value creation. They illustrate the context of corporations, sustainable value creation opportunities and the role of different business functions in integrating sustainability in the core business. Two cases demonstrate how business functions can use LCA-based insights for business decisions and how they are directly connected with value creation opportunities.

**Keywords** Corporate sustainability • Life cycle assessment • Life cycle costing • Life cycle management • LCM toolbox • Product sustainability • Social life cycle assessment • Sustainability • Value creation

### 1 Introduction and Objective

The relevance of the various sustainability aspects differs from company to company depending on the context, the type of product systems, geographical scope, and related social and environmental problems/drivers. Thus, the integration of sustainability in business is difficult and inherently complex. It requires a

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holistic understanding of the interdependence of industrial systems. To this end, sound tools are needed that can capture the complexity and provide metrics to embed sustainability in different business decisions. Systems thinking helps to understand the different parts within the system and their relation to other systems. Life cycle assessment (LCA) is a systems analysis tool that can assess and help improve the environmental performance (one of the three pillars of sustainability) of products and processes by providing powerful insights into the whole value chain (ISO 2006a, b; ILCD 2010). By doing this, LCA provides an understanding that allows avoiding shifting impacts from one process step/industry to another, from one impact category to another and from one place to another. LCA supports businesses in making various decisions such as the selection of processes, materials, and supply chains. By supporting these business decisions and actions, LCA can offer value creation opportunities to business and improves shareholder and stakeholder value simultaneously. Similarly, other tools such as Life Cycle Costing (LCC) and Social Life Cycle Assessment (Social-LCA) can be used to understand the economic costs (externalities can also be included) and social impacts and risks (both positive and negative) throughout product life cycles. The authors focus on environmental LCA and combine other tools wherever possible.

LCA has been applied in companies and in public policy making. When applied in companies, LCA has often been seen as a mere auxiliary technical tool and the insights were limited to the impact quantification, which is the major strength of the tool, without actively involving business functions. Many companies are not implementing LCA in their day-to-day business due to its resource-intensive nature, complexity and the difficulty of contextualizing the relevance of LCA for the circumstances of companies. There has hardly been any exploration of how LCA can offer advice to existing corporate structures through decision support of business functions. And most importantly, the insights of LCA have by far not been fully exploited for the potential value creation opportunities in companies. There is little research to understand the role of LCA in supporting business functions (Sandin et al. 2014) and consequently linking it with sustainable value creation opportunities (UNEP/SETAC 2009; Rebitzer and Buxmann 2005; Gloria et al. 2014).

The objective of this chapter is to bridge the gap between sustainability science and business management by contextualizing the application of LCA in corporate sustainability and aligning it with business activities/functions and business priorities (value creation). This alignment can mainstream and advance the implementation of LCM in business.

In order to fulfill the above mentioned objective, the authors explain the context of corporations, the opportunities for value creation, and the role of different functions in integrating sustainability in day-to-day business. Case studies show how LCA can be contextualized in business and connected to value creation opportunities. Based on case studies, the authors offer an iterative procedure to conduct LCAs and create sustainable value.

## 2 Background and Literature Review

### 2.1 *Context of Corporations and Products*

Corporations are among the main actors which can profoundly influence sustainability through their products and services that span across different locations through their supply chains and markets. There are broadly five forces requiring corporations to improve their sustainability performance more than ever before. These are megatrends (environmental, social, demographic), regulatory pressure, stakeholder pressure, supply chain risks and competitive pressures (Manda 2014). The developments underlying the megatrends are population growth and rising disposable income, increasing urbanization, growing share of elderly population, climate change, water scarcity, bio-diversity loss, resource scarcity, poverty and inequity (UN 2012; GSSD 2014; WWF 2012; UN DES 2013; Rockstrom et al. 2009). The regulations on corporate and product sustainability, emission standards and trading schemes are growing in many countries and regions (e.g. the USA, EU, China and India) (US-EPA 2014; World bank 2014; EC 2014; EDF and IETA 2013). The number and activity of global NGOs targeting the working standards among suppliers and the pollution they are causing is increasing year by year (O'Rourke 2005; Economist 2014; Jun 2014). Consequently, the interest of investors in sustainability aspects of corporations is growing. Companies are trying to reduce risks, reduce costs of scarce resources, and develop new products that can improve their sustainability performance and provide competitive advantage in the market.

Despite these pressures, managers in companies are still pressed to deliver value, and their performance is measured on how well they deliver the value. Therefore, managers often face the challenge of addressing stakeholder concerns in day-to-day business while simultaneously improving value and thereby financial performance of companies (Hart and Milstein 2003).

### 2.2 *Opportunities for Sustainable Value Creation*

It was found that the improved environmental and social performance of companies can have a positive impact on the financial performance through reduced costs, improved revenues, and avoidance of risks (Epstein 1996; Eccles et al. 2012; Hart and Milstein 2003). For example, process improvements could lower energy and water usage and save operational costs (Worrell et al. 2003); and improved raw material utilization not only decreases raw materials costs but also reduces costs for handling and disposal of waste while simultaneously reducing the environmental footprint. There are several risks that can be avoided by sustainability performance improvements (Koplin et al. 2007). Increased scarcity of raw inputs such as water can lead to disruption of operations, i.e. lost production activity, which will impact the revenue earning capacity. Companies have to increasingly pay higher

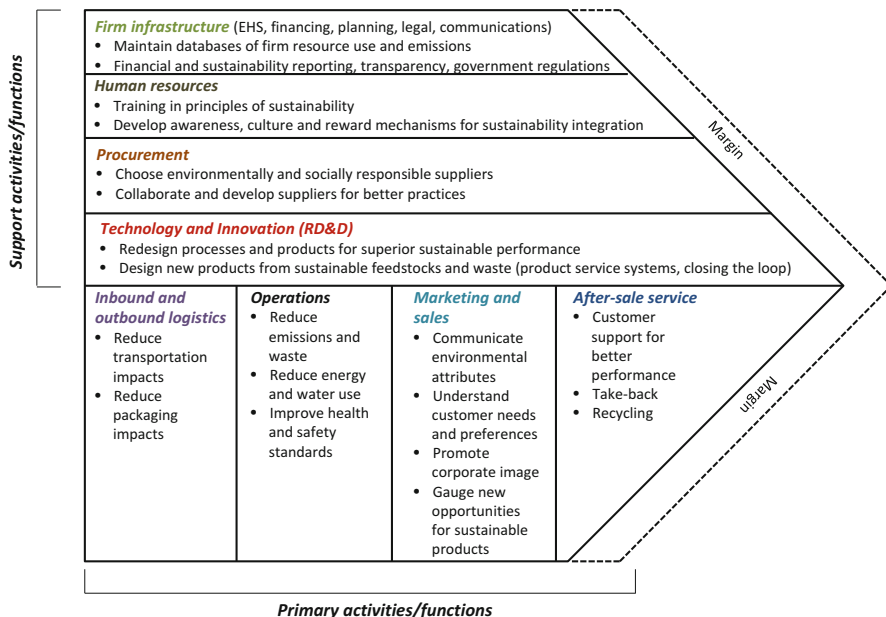
finances for violations, they need to compensate wrongdoings, and need to earn the license to operate from the local communities by avoiding negative impacts. These are called regulatory and legal risks. There are possibilities for damaging corporate reputation, i.e. reputational risks, from media and NGO campaigns for not meeting stakeholder expectations such as workers' health and safety and labor practices, and safe living environments for local communities. Market and product risks can also occur when customers move to other products with better sustainability performance or when governments and organizations impose sustainable procurement policies.

On the other hand, there are several value creation opportunities for companies with superior sustainability performance for each risk category mentioned above. It is possible to obtain additional revenues from environmentally and socially superior products through a premium. Moreover, high sustainability performance of companies can positively influence the desire of customers to buy their products (brand image), the desire of employees to work for them (preferred employer) and the desire of investors for providing long-term capital (blue chip status or good rank in indexes such as Dow Jones Sustainability Index). Companies with superior sustainability performance can differentiate their products in the market against competitors to attract new customers and, consequently, create a competitive advantage. Business to Business (B2B) companies can help their customers, i.e. end-producers, to meet their sustainability goals by supplying superior intermediate products. In essence, the existence of a company or its profit making capacity can be affected by several ways described above through various risks and opportunities created by sustainability performance and stakeholder reactions. This shows the overlap between shareholder and stakeholder value which are interdependent and interrelated.

### ***2.3 Business Functions/Activities***

Businesses deliver products and services through the co-ordination of various activities. The main activities are innovation, business development, procurement/sourcing, marketing and sales, and production/operations. Figure 11.1 shows business functions and their contribution to sustainability in a company. Every activity of the organization has an influence on its sustainability performance. Therefore, integration of sustainability in business requires understanding of various business functions that deliver specific business activities in a company, and proper metrics should be developed to support decision-making.

The main activities of innovation are developing new products with novel, additional or improved functionality, improving existing products (e.g. by implementation of alternative process/manufacturing routes), and developing new processes to recycle waste. Business development is mainly involved in finding new applications or opportunities in different markets through collaboration with existing or prospective customers or by means of strategic alliances with other companies. It also defines the final product and positioning strategy and finds opportunities for the



**Fig. 11.1** Value chain of a company with business functions and relation to sustainability (Manda 2014) (Adapted from Porter (1985), Epstein and Roy (2001) and Porter and Kramer (2006))

development of new business models. In some companies business development is part of innovation.

Procurement/sourcing is involved in finding the right suppliers who can provide quality inputs at the right time. It also negotiates pricing and keeps track of the production timeline. Sourcing also conducts supplier environmental and social audits and deals with supplier certifications. Sourcing is responsible for avoiding any risks arising from supplier practices, including compliance with local laws and child labor. It can go further by not only looking at sustainability performance of suppliers but also at the influence of purchased items in the final product life cycle of customers. This would help close the information cycle between suppliers and final customers and may bring collaborative opportunities for future sustainable business development.

Marketing and sales is responsible for communicating the product attributes and differentiating their products against those of their competitors. It conducts market research to find opportunities for market growth and expansion to new markets. For Business to Consumers (B2C) companies, it also handles communication with consumers. Marketing conducts research to acquire the consumer intelligence related to how customers/consumers make trade-offs between price, environmental performance and other quality parameters.

To improve sustainability performance of processes and products, all these business functions need concrete guidance and insights on the product’s impacts throughout its life cycle. This calls for sound tools to support business functions in decision-making.

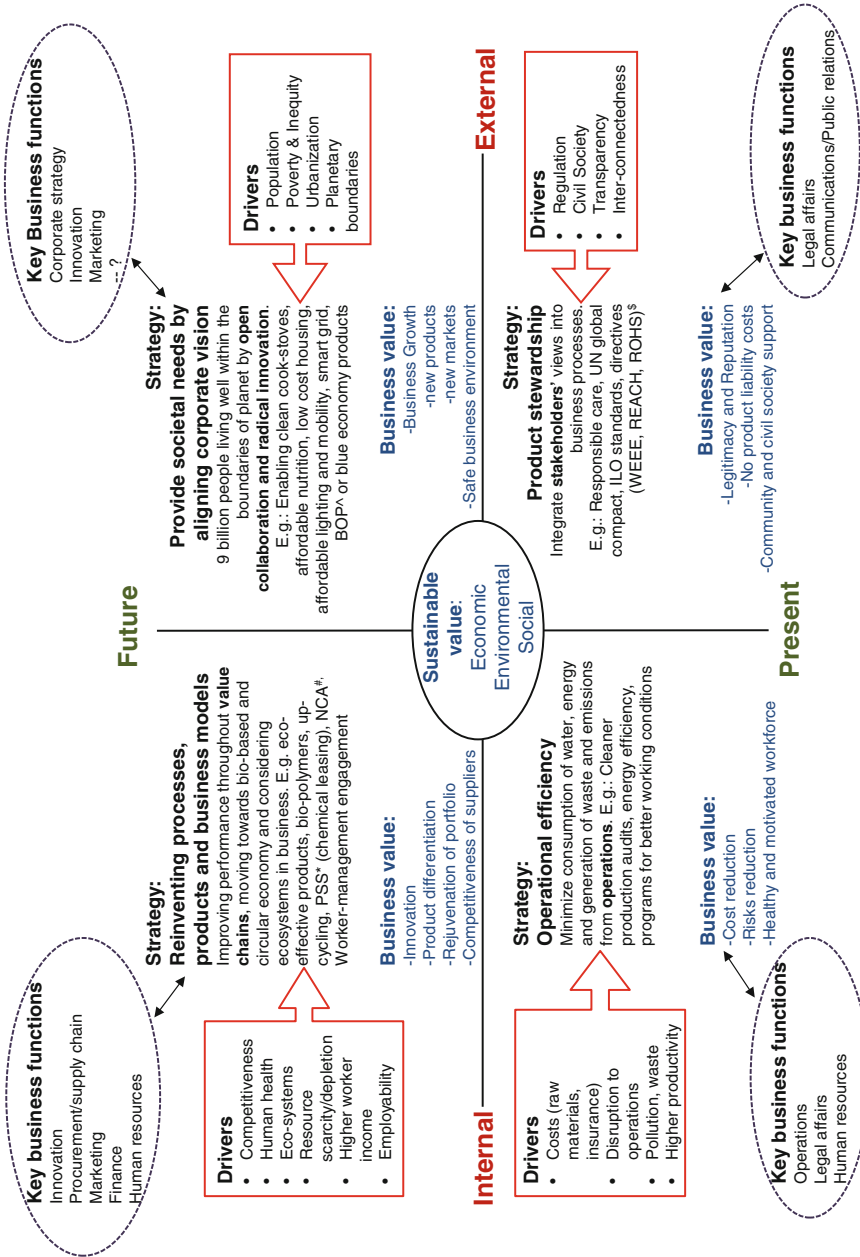
### 3 Methodology

We use a framework which captures all the important elements presented in the above sections. It provides the applications of LCA in different contexts of companies for various purposes. This framework provides guidance for the description of case studies. A case study approach is recommended to investigate the value creation with sustainability (Reed 2001). Thus, the descriptive case study approach (Scapens 1990; Jupp 2006) was employed with two chemical companies. This enabled us to investigate the phenomenon of value creation with sustainability, especially LCA, in real-life contexts. The main elements of case studies are the drivers, the communication, embedding sustainability in business decisions, and sustainable value creation. Each case study focused on a specific example to study the similarities and differences of approaches between different companies with different examples. Multiple case study approach can confirm the reproducibility of the proposed approach (theory) and its practical implementation in real life situations. Therefore, a multiple case study approach is employed. This can provide stronger evidence than a single case study with regard to creation of value with LCA and its implementation in companies (Eisenhardt and Graebner 2007).

#### 3.1 *Description of Sustainable Value Framework for Chemical Industry*

In order to integrate sustainability in the core business, functional managers, top management and investors need to be convinced of value creation from sustainability. The sustainable value framework, see Fig. 11.2, helps to link sustainability and value creation.

Figure 11.2 shows the multidimensional construct of the sustainable value framework that blends two dimensions. The vertical axis is about balancing the short term results such as financial improvements while making progress for the long term business growth and success in a competitive and disruptive technological landscape. The horizontal axis shows the firms' need to manage and grow internal organizational skills and capabilities while capturing the new perspectives, knowledge, and challenges posed by external stakeholders. Strategies on the left side are within the purview of a corporation, and the strategies on the right side are mostly driven by other stakeholders or changing environmental, social, and market circumstances. There are four sets of sustainability drivers that are also found in literature (Lozano 2013; Epstein and Roy 2001; UNEP/TU Delft 2007). The first set of drivers (lower-left quadrant) is pollution, waste and higher productivity, the second set of drivers (lower-right) is transparency and regulations, the third set of drivers (top-left) is growing environmental footprint, resource depletion, higher worker income and employability, the fourth set of drivers (top-right) is megatrends such as population, inequality and planetary boundaries. Addressing these drivers with a proper strategy



**Fig. 11.2** Sustainable value framework (Adapted from Hart and Milstein (2003) (Manda 2014)). (\*PSS is Product Service Systems, #NCA is Natural Capital Accounting, ^BOP is Base Of the Pyramid, §REACH is Registration, Evaluation, Authorization of Chemicals and ROHS is Restriction Of Hazardous Substances, WEEE is a directive on Waste Electrical and Electronic Equipment)

could lead to business value. For example, an operational efficiency strategy can address drivers such as raw material costs and pollution and can create business value such as reducing costs, avoiding risks and motivated workforce due to better working conditions.

Though the environmental drivers in top-left and top-right appear similar, their influence on businesses is different. In the top-left quadrant, businesses deal with the resource constraints and product impacts with a piecemeal approach. Whereas in the top-right quadrant businesses are aware of the limited capacity of our planet and its influence on their long term existence and, thus, openly collaborate with others to radically transform whole systems for planetary sustainability. Implementing strategies in each dimension needs the involvement of several specific corporate functions in order to reap the business value. In order to be successful in the short and long term, companies need to devise strategies in all quadrants to create sustainable value.

The ovals in Fig. 11.2 show various business functions that either take part in the implementation or benefit from the corresponding strategies. Depending on the structure of the company there might be differences in involvement by specific business functions in each quadrant. The environmental management or sustainability departments are not separately shown because they either implement the projects or they are involved in all quadrants depending on the type of project and they can also be part of operations, innovations or marketing in many companies. The role of various business functions is illustrated with real life case studies in Sect. 4 results and discussion. For a detailed description of framework with LCA examples from all quadrants, please refer to Manda (2014).

## 4 Results and Discussion

In this section, two case examples are described with two main aspects. First, the context of companies is provided in terms of different sustainability challenges, drivers and market situation such as customer needs and demands. Second, it is delineated how LCA insights and consequent business decisions are translated into value creation for the company. The two case studies mainly belong to the top-left quadrant of the framework shown in Fig. 11.2, i.e. reinventing processes, products and business models. The case study on vitamin C also has aspects from the lower-left quadrant, operational efficiency. Further, an implementation procedure is presented to translate LCA insights into value creation opportunities for business.

### 4.1 Case Study of Spun-Dyed Modal Fibers from Lenzing AG

The spin-dyeing case study is conducted for Lenzing, a bio-based fiber producer based in Austria. This company wants to further strengthen its position as a sustainable fiber producer by providing solutions to the challenges faced by textile industry and



customers. Textile wet processing, i.e. dyeing and finishing, is known to cause environmental impacts such as water pollution. Spun-dyed fibers are developed against this background since these fibers avoid the conventional dyeing process of fabrics. A detailed LCA for the environmental impacts of conventionally dyed fabrics and spun-dyed fabrics made of wood-based modal fibers can be found in literature (Terinte et al. 2014).

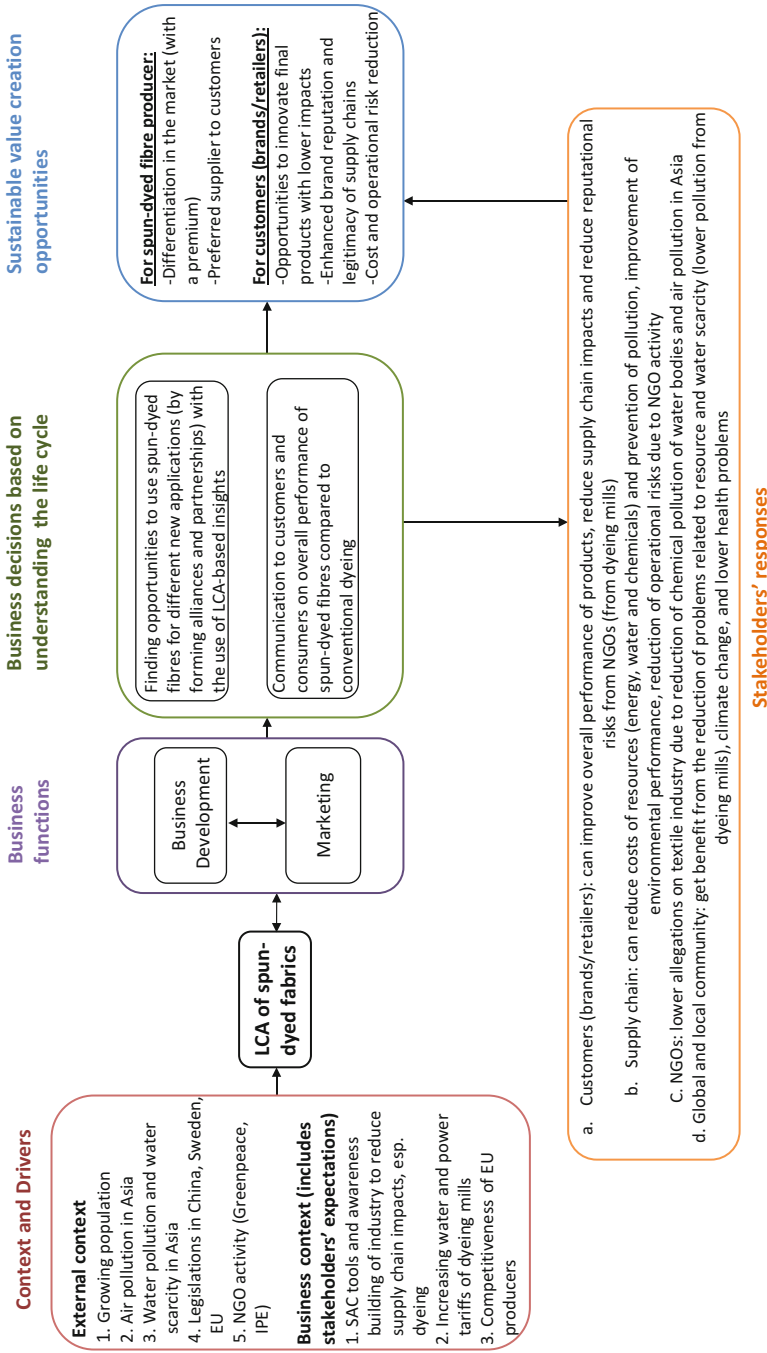
#### 4.1.1 Context and Drivers of Spun-Dyed Modal Fabrics

Figure 11.3 shows the relevant context and drivers of the spun-dyed fiber innovation. The most important driver is global population growth, which creates more demand for clothes with lower environmental impacts. The textile supply chains are mostly located in Asia where air pollution, water pollution and water scarcity problems are rampant. There is an increasing number of legislations targeting the textile industry in Asia (in order to raise the standards of practices), from the EU (e.g. REACH) to prohibit certain dyes and from selected European countries like Sweden that is planning to impose taxes on chemicals in textiles. International NGOs such as Greenpeace have criticized international apparel brands and retailers for the poor performance of their supply chain partners such as laundries and dyeing mills. The business context of the textile industry is also changing due to the initiatives such as Sustainable Apparel Coalition (SAC) that creates tools and awareness to reduce textile supply chain impacts. These initiatives and visibility to NGOs and consumers have created impetus for brands and retailers to be more sustainability oriented. Consequently, the sustainability agenda of B2B companies such as fiber producers are primarily driven by customer (brands and retailers) demands rather than consumers and NGOs. Increased scarcity raises the costs of water and power in Asian countries, increasing production costs. Since most of the textile industry has moved to Asia, EU producers need to find innovative ways to be competitive in the global market. All these drivers are important for the business functions of the fiber producer because they influence business decisions and help to contextualize the spin-dyeing innovation.

With these issues in mind, the LCA on spun-dyed fabrics can help business development and marketing.

#### 4.1.2 Results of the Spun-Dyed Fabrics LCA Study

From the LCA it was found that, across all impact categories studied, spun-dyed fabrics cause only half to one third of the environmental impacts compared to conventionally dyed fabrics. Sensitivity analyses showed that the relative benefits of spin-dyeing, that nowadays takes places in Austria, are higher if it replaces conventional dyeing in countries like China or the USA where electricity grids and heat sources are predominantly coal-based. The liquor ratio and the number of washing cycles influence the results but do not alter the conclusions. Due to the comparatively very



**Fig. 11.3** LCA-based value creation approach for spun-dyed fabrics (relation between context/drivers and LCA of spun-dyed fibers and its support in business decision-making, key stakeholder responses to improved environmental performance and resulting value creation opportunities) (Manda 2014)

low amount of pigments required and entrapment of the pigment in the fiber structure, the spun-dyed fabric can be expected to cause substantially lower human and eco-toxicity impacts compared to conventionally dyed fabric. From a gate (fiber)-to-gate (dyed fabric) comparison, it was found that the spun-dyed fabrics need 60–90 % less water, chemicals, electricity and heat and generate 60 % lower wastewater emissions than conventionally dyed fabrics. These savings can reduce production costs. All technical details of the spun-dyed fabric LCA can be found in Terinte et al. (2014).

#### **4.1.3 Business Decisions Supported by LCA**

The business development department is reaching out to potential new customers to make new products/applications, such as fabrics for automobiles, based on the environmental performance of the spun-dyed fibers compared to conventional dyeing of different materials. The marketing department has been using the insights provided by LCA to communicate to textile brands and retailers. These business functions decided to use sustainability as a value proposition on par and without compromising other aspects like quality, functionality and price. By this means, sustainability is integrated into day-to-day business.

#### **4.1.4 Stakeholders' Responses and Sustainable Value Creation**

The innovative fiber production process triggered positive responses from various stakeholders. Due to the improved performance of the supply chains, there would be fewer allegations from NGOs against supply chain partners and thus lower operational risks. The customers (brand and retailers) can improve the overall performance of their products and they can reduce the reputational risks from supply chain partners such as dyeing mills. This would help brands and retailers to create value such as innovative products (garments) with lower impacts, enhanced brand reputation, and legitimacy (The Cambodia Daily 2014). The spin-dyeing needs fewer resources than conventional dyeing and thus reduces the variable production costs of final products. The local community can benefit from these improvements due to lower water pollution and reduced pressure on water resources. Owing to all the above aspects, the fiber producer could differentiate the spun-dyed fibers in the market and be a preferred supplier to brands and retailers.

This LCA was conducted during the business development stage. The innovation was accomplished before the LCA study was started. This LCA was used to quantify the environmental improvements which will be useful for developing new applications and attract new customers. Therefore the innovation department of fiber producer participated in the LCA to provide data and necessary information.

## ***4.2 Case Study of Vitamin C Business Development by Royal DSM NV***

Vitamin C, or L-ascorbic acid, was discovered as the nutritional factor lacking in the diets of sailors suffering from scurvy. It naturally occurs in fresh fruit and vegetables. The first industrial preparation of L-ascorbic acid was developed by Tadeus Reichstein for F. Hoffmann-La Roche in 1934. DSM acquired this business from Roche in 2003. Figure 11.4 shows the overall context, LCA-based insights, supported decisions and value creation opportunities of Vitamin C product.

### **4.2.1 Context and Drivers of Vitamin C**

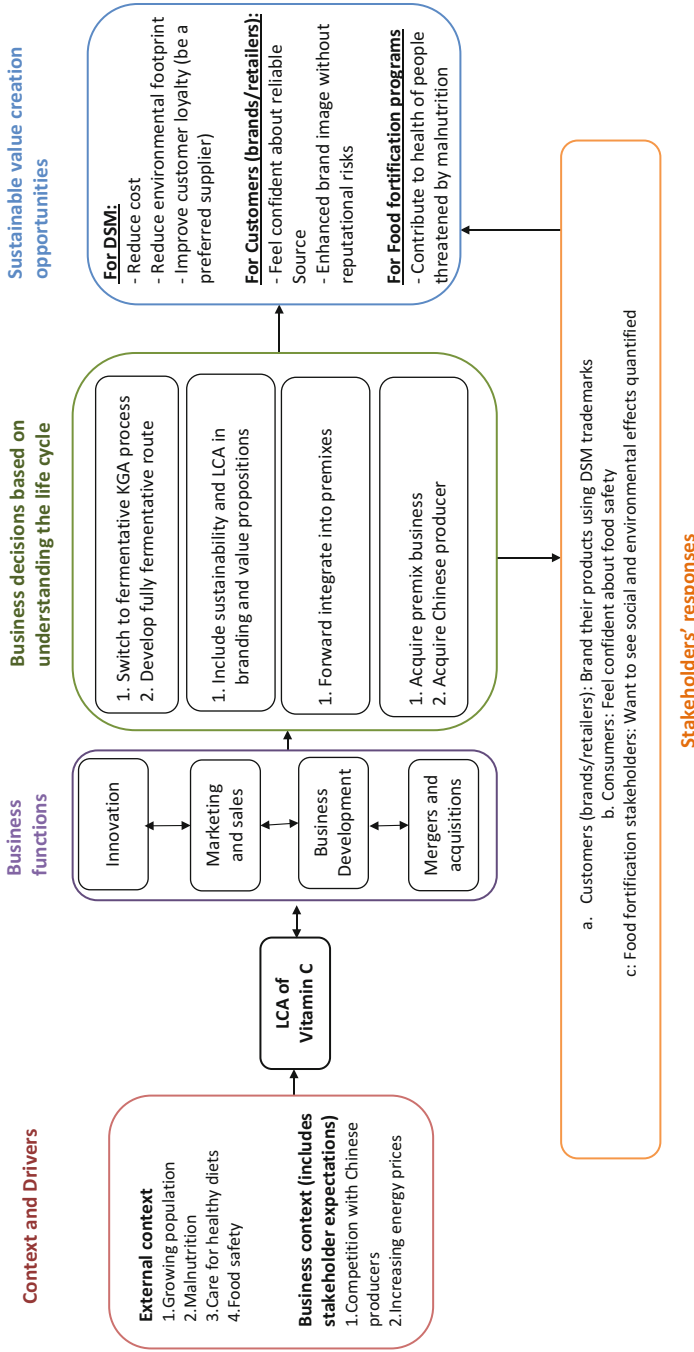
The world's population is still rapidly growing and expected to peak at nine billion people around 2050. Presently large groups of people in poor countries already suffer from malnutrition. Even if they have sufficient energy in their diets, these are deficient in micronutrients, just like sailors' diets did. Even in wealthy countries there are deficiencies of micronutrients, and people concerned about their health take precautionary supplements of micronutrients. Hence there is a large and growing demand for micronutrients, including Vitamin C. All over the world, even in developing countries, concerns about food quality and food safety are increasing, so food additives and supplements have to comply with high standards of quality and safety. Finally there are concerns about the environmental impact, including land use, of the activities required to feed the growing population. These concerns also lead to questions about the contribution of additives and supplements to food (environmental) footprint. There is strong competition and price pressure from China in the vitamins market. DSM has the only non-Chinese production site for Vitamin C in Dalry, Scotland.

The DSM Quality for Life™ program symbolizes quality, reliability and traceability. Quality for Life™ also means sustainability.

As part of the program DSM licenses the Quali-C® trademark to customers for positioning their consumer products. Quality for Life™ and the Quali-C® brand are integral parts of DSMs value propositions.

### **4.2.2 Results of the Vitamin C LCA Study**

DSM carried out an LCA to determine the carbon footprint as a pilot in the UK carbon trust program. One of the key results was that energy contributes more than 50 % to the footprint of the product, even with the very low energy footprint, produced in a combined heat and power plant fired with natural gas. This high energy consumption was related to the production of the intermediate 2-ketogulonic acid (KGA) in an oxidation reaction. The oxidation can only be executed selectively if groups that should not be oxidized are protected by addition of acetone, which has



**Fig. 11.4** LCA-based value creation approach for Vitamin C products (relation between context/drivers and LCA of Vitamin C and its support in business decision-making, key stakeholder responses to improved environmental performance and resulting value creation opportunities)

to be removed and recovered after the oxidation. In addition to the large energy requirement, this complicated procedure requires chemicals and produces waste.

DSM did not carry out a social LCA. The potential benefits to people taking vitamins as supplements or additives are very well known to customers and consumers, so there is no need to emphasize these. Production, starting from agriculture and fuel generation is completely European based, so there is little risk of social issues in the value chain.

### **4.2.3 Business Decisions Supported by LCA**

Because of the cost and the high footprint of the KGA production DSM switched to the fermentative production of KGA. A complete fermentative route to further reduce cost and footprint is also considered. DSM has recently forwardly integrated into premix companies, who supply premixes of additives to the food and feed industry. This allows to actively influence the footprint of vitamin additives used. For strategic reasons DSM is acquiring a Chinese production site. The LCA was extended with an assessment of other environmental impacts and used to check the footprint of the Chinese product, and will be used to identify and assess initiatives to reduce the footprint.

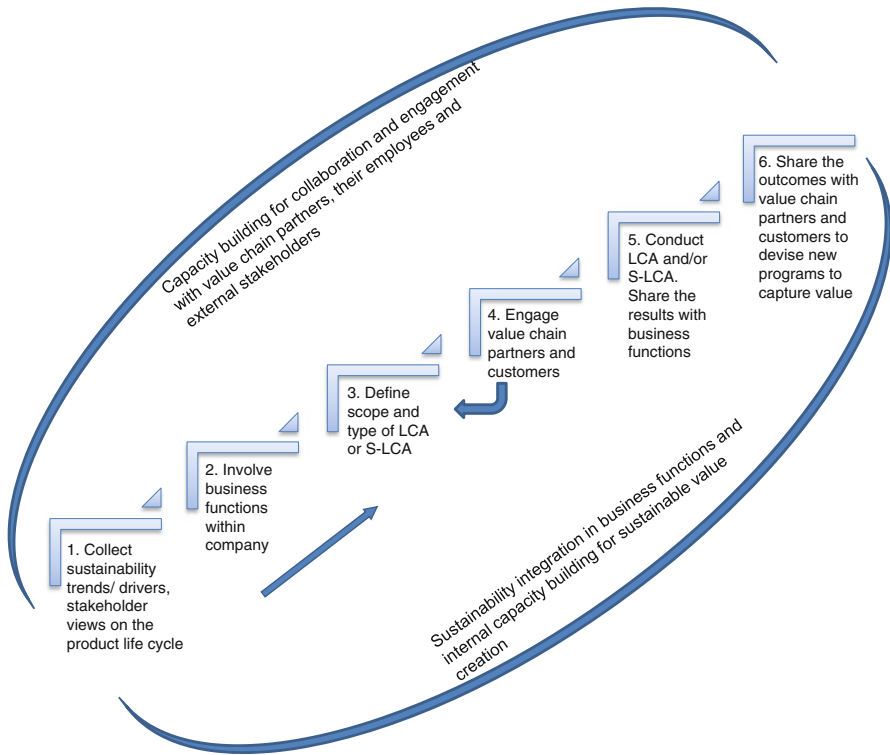
### **4.2.4 Stakeholders' Responses and Sustainable Value Creation**

Customers respond positively to Quality for Life™. They prefer products from a reputable and reliable source, with an undisputable track record in food safety, environmental performance and sustainability image. All these contribute to reducing their operational risks. This is valid in the western world, but certainly also in Asia.

Particularly in food fortification programs within the area of malnutrition, social LCA makes the benefits more tangible, and DSM is piloting this use. In addition, stakeholders in these programs are interested in environmental impacts, including those of small packaging sizes and distribution.

## ***4.3 Implementation Procedure for Business Value Creation Based on Life Cycle Assessment in Companies***

UNEP/SETAC has proposed the application of life cycle management (LCM) capability maturity model for developing the capacity of small and medium sized companies to achieve their sustainability goals (UNEP/SETAC 2009). The authors propose an implementation procedure for business value creation based on the insights gained from LCA studies and its integration in business functions (see also UNEP/TU Delft 2007; UNEP/SETAC 2009). This is an iterative procedure of various steps as shown in Fig. 11.5.



**Fig. 11.5** Iterative procedure for translating insights from the LCA and S-LCA into value creation adapted from Manda et al. (2014)

The steps of the iterative procedure are:

1. Understand the context of the product by collecting information on various drivers and stakeholder views/concerns
2. Involve the relevant business functions within the company
3. Define the goal, scope and type of LCA and/or S-LCA
4. Engage the value chain companies and customers
5. Discuss the results of conducting LCA and/or S-LCA internally
6. Share the outcomes of the process with value chain companies and customers to capture value

#### **4.4 Limitations of the Suggested Approach and Life Cycle Management**

While implementing the suggested approach, practitioners would face some barriers and challenges.

We acknowledge the limitations of the LCA approach in terms of the development of methods for impacts such as biodiversity and toxicity, lack of inventory, uncertainties in data and methods, limited guidance on allocation for different product categories, etc. (Finnveden et al. 2009). Resource requirements are also acting as limitation for implementing LCA. Companies can also create value with customer experience, products with superior aesthetics, feel, etc. These aspects might not be captured by LCA, if its unit of analysis, i.e. the functional unit, cannot take these aspects into account. LCA is not easily able to capture the perception and preferences of people, taste, and emotional value attached to products, hence it cannot help companies to create value in terms of these aspects.

## 5 Conclusions

The main contribution of this chapter to the field of sustainability, especially corporate and product sustainability, is twofold. First, the authors have presented an approach to embed LCA in the corporate context and align environmental sustainability with business priorities. Second, they have shown how to synthesize and communicate all the different aspects in a coherent way, presenting LCA results to the managers of different business functions using an LCA-based value creation approach. This communication approach is a combination of “drivers-LCA metrics business decisions-stakeholder responses-value creation opportunities”. There could be different barriers and challenges while implementing the presented approach. The barriers and challenges need further attention in future research. The integration of social aspects in the framework and in the case studies can be further improved. Matured approaches for social-LCA to address this issue are needed. The approach shown here is applicable to all other LCM tools such as S-LCA and LCC. Additional case studies can demonstrate the integration of the LCM tools using the approach described.

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