Framework for Classifying Sustainability Oriented Cost Management Tools

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إطار مقترح لتبويب أدوات أدارة التكلفة الموجهة نحو الاستدامة

ملخص:

علي الرغم من وجود عدد من الدراسات التي تبنت المدخل العملي لتطبيق أدوات إدارة التكلفة المرتبطة بأبعاد الاستدامة في الفكر المحاسبي، إلا إن هناك مازال ندرة في الدراسات التي تحاول بناء علاقات روابط بين أدوات إدارة التكلفة الموجهة نحو الاستدامة والمجالات القرارية لإدارة أداء الاستدامة. هذا البحث يقترح إطار لتصنيف أدوات وأساليب إدارة التكلفة المرتبطة بأبعاد الاستدامة والمقترحة في الفكر المحاسبي طبقاً لبعدين: الأول . أنواع قرارات الاستدامة التي لها الأثر علي ارضاء احتياجات أصحاب المصالح في المنشأة، الثاني . المجالات القرارية المشتركة لإدارة أداء الاستدامة (الاقتصادية،والاجتماعية،والبيئية) وهو مايطلق عليه "مثلث الاستدامة". وتمثل المساهمة الاساسية لهذا البحث في تقديم إطار تحليلي تصنيفي للخصائص القرارية لأدوات إدارة التكلفة الموجهة نحو الاستدامة وهو مايساعد علي ادماج أبعاد الاستدامة داخل عملية اتخاذ القرارات وتحقيق التكامل بين المجالات القرارية للاستدامة. أضف الي ذلك، فأن الإطار المقترح يوفر هيكل منطقي لتحديد ملاءمة كل أداة للموقف القراري الملائم، وهو ما يساعد علي توفير إطار عياري لادوات إدارة التكلفة لتدعيم اتخاذ قرارات الاستدامة في المنشآت.

المصطلحات الرئيسية: إدارة التكلفة لأبعاد الاستدامة، اتخاذ قرارات الاستدامة، المجالات القرارية لإدارة اداء الاستدامة، تصنيف أدوات إدارة التكلفة المرتبطة بالاستدامة.

Framework for Classifying Sustainability Oriented Cost Management Tools

Abstract

Despite the existence of a fair number of studies that adopted a practical – oriented research approach to implementing sustainability-related cost management tools, there is still no publications have existed on which approaches and tools are suitable for decision domains of sustainable cost management (SCM) and different types of sustainable decision making. This work suggests a typology of sustainability-related cost management tools based on sustainable decisions making context and decisions domains of sustainable cost management which SCM literature has tended to overlook. The proposed framework in the study serves both descriptive and normative purposes. It draws on literature regarding SCM tools, types of sustainable decisions and decision domains of SCM. The primary contributions of this paper lie in the suggested typology of sustainability-related cost management tools, which has a positive effect on the integration of sustainability issues into decision-making and on the contextual integration of sustainability decision domains.

Keywords: Sustainable cost management (SCM); Sustainable decisions making; Decision domains of SCM; A typology of sustainability-related cost management tools.

1. Introduction

Recently, sustainability[1] accounting has gained increased importance in practice, of which the sustainable cost management (SCM) receives the most attention. The term sustainability cost management (SCM) is an umbrella term for a large set of different tools for enhancement sustainable decision-making. (Milne 1996) criticized the fact that traditional management accounting potentially provides insufficient information to decision-makers for making informed decisions by failing to include environmental and social impacts.

To integrate these into decision-making, a multitude of theoretical and practical approaches and tools to sustainable cost management has been developed in the last 25 years. The increasing number of methods makes it difficult for managers to choose the appropriate method or combinations of methods and deduce the managerial implications of applying these tools (Schaltegger and Wagner 2005). (Burritt 2004) clarifies that the issue is not only what tools to use in SCM, but also the identification of the circumstances in which they should be utilized and should be of benefit to the business.

There are so many research projects at the level of professional association, for example, the Consortium for Advanced Management-International (CAM-I) Environmental Sustainability Interest Group (ESIP) seeks to leverage existing best practices of sustainable cost management tools to help companies understand and manage the assets and liabilities associated with their sustainability initiatives (Malone 2015). In Japan, work was being done on approaches to company environmental cost management to constitute Japanese manual for the introduction of environmental accounting (Loew 2003). Also, the German Environmental Protection Agency and the German Ministry for the Environment awarded a research project in which a manual on “Operational Environmental Cost Management” was to be compiled. This guide presents those approaches to environmental cost accounting, which is suitable for the company practices, and describes how they can be used.
In preparation for the manual and as a contribution to the international debate on environmental cost accounting, a study (Loew et al. 2001) has been produced

[1] We take a broader view of sustainability that extends beyond an organization’s environmental and social responsibility. We view sustainability as responding to various stakeholder needs in a manner that leads to long-term value creation.

which systematically compares the approaches to environmental cost accounting which are known in German regarding their suitability for practical application Loew (2003)

Despite the existence of a fair number of studies that adopted a practical-oriented research approach to implement sustainability-related cost management tools (e.g. Onishi et al. 2008; Seuring 2003; Heupel and Wendisch 2003), there is still no publications have existed on which approaches and tools are suitable for different types of decisions and decision domains of sustainable cost management (SCM). However, the literature points out that the accounting profession has not played a significant role in the development of sustainable cost management systems (Bebbington et al. 1994; Parker 2000).

The central question of the paper is: what are the links between SCM tools and different types of decision-making? It seeks to classify decision characteristics of SCM tools according to decision domains of sustainable cost management system and types of decisions within sustainability decisions making context. Typology of sustainability–related cost management tools can be derived that facilitates the integration of sustainability issues into management decision-making.
The paper divided into three main sections, the first section after introduction gives a review of the literature of the sustainability and cost management tools. The second section includes a proposed framework for classifying sustainability cost management tools for enhancement decisions making. Finally, conclusions are drawn and some suggestions for future research outlined.

2. Sustainability and cost management tools

2-1 Literature review

Over the last 25 years, several management accounting systems and cost management tools specifically tailored to the sustainability challenge have been proposed.

Research on the topic has to date mainly focused on performance measurement, with particular attention paid to hybrid performance measurement systems (Epstein and Roy 2001; Rouse and Putterill 2003). Specifically, many authors have suggested the use of some modified versions of the most prominent hybrid performance measurement system the balanced scorecard (BSC) as an effective manner for embedding sustainability principles within organizations' strategies and business processes (Dias-Sardinha et al. 2002; Epstein and Wisner 2001; Figge et al. 2002; Hubbard 2009). Different approaches to the design of sustainability BSC (SBSC) have been suggested, depending on how the relationship among business strategy and sustainable strategy has been conceptualized (Songini and Pistoni 2012).

With the intention of broadening the functionality of this and other extant frameworks of sustainability performance measurement, (Bonacchi and Rinaldi 2007) suggest a performance measurement system that includes two complementary instruments, called Sustainability Dartboard and Sustainability Clover. This multidimensional and multilevel model attempts to measure the three dimensions of sustainability (economic, environmental, social) through a set of primary and secondary measures connected with stakeholder satisfaction and able to detect and articulate both win-win and trade-off situations.

Moving beyond hybrid performance measurement systems, other streams of SCM research investigated financial performance measurement systems. Over the last years research has in particular elaborated a plethora of social value model for stakeholders (Retolaza et al. 2016).
The stakeholder-centric Polyhedral Model suggested by Retolaza et al. (2016) solves the problem usually found in socio-economic impact analyses, which tend only to consider tangible costs and ignore other types of impact related to the various stakeholders or special interest groups. This model makes it possible to identify and then quantify the distribution of value between the various stakeholders of an organization. The consolidation of the value generated for the full set of stakeholders reflects the overall value generated by the firm.

Environment management accounting (EMA) was the mainstream of research in SCMS emphasized on two issues. First, developing environmental management accounting conceptual framework (Burritt et al. 2002). Second, developing an environmental budget (Ito et al. 2006).
The framework suggested by Burritt et al. (2002) classified the variety of EMA tools serving different management purposes. It systematically integrates two major components of EMA; monetary environmental management accounting (MEMA) that addresses environmental aspects of corporate activities expressed in monetary units, and physical environmental management accounting (PEMA) that analyses and measures a company's impact on the natural environment, expressed

in terms of physical units. To understand and assess the links between EMA tools and different business actors and decision-making contexts, the framework highlights the past/future and short/long-term time dimensions of the various tools as well as the regularity of information generation Burritt et al. (2002).

Some Japanese companies have introduced environmental management Systems (EMS) and environmental accounting, although most companies have focused only on the external reporting aspects of environmental accounting and do not consider any future action plans and budgets concerning their environmental management. To utilize EMS more effectively, an action plan that provides a map to drive activities, and a budget, which guarantees that the plan is put into effect, are essential for environmental management. The Green-Budget Matrix Model (GBMM), which is suggested by Ito et al. (2006), is a tool to support managers in identifying the type of activities that drive excellent environmental performance and in effectively allocating their economic resources. The process of preparing the matrix also generates useful information for analyzing the status quo, foreseeing the future of environmental management, and promoting a shared mutual recognition of their mission amongst members of the organization.
The primary objective of GBMM is to generate information, which will support the preparation of plans, such as for environmental investment projects or environmental conservation measures, to ensure that the economic and social benefits exceed the costs.

A variety of cost and performance management tools have emerged in recent years. Among them, the more popular techniques such as activity-based costing, quality costing and product/service costing tend to focus upon internalized, privately incurred costs rather than any imputed costs or measurement of external social and public costs (Buhr and Gray 2012). For example, by incorporating such internalized environmental costs into an activity-based costing methodology, it is possible to allocate the costs of treating toxic waste to the product that creates the waste Malone (2015). As already noticed, such costing techniques rarely extend to the whole supply chain (cradle to grave) or the whole of society (Caglio and Ditillo, 2008, 2012; Joshi and Krishnan, 2010; Burritt et al. 2011). Indeed, taking a broader view of a company's environmental impacts poses certain challenges, as it requires organizations to struggle with externalities that affect all stakeholders, even those as yet unborn as future generations. However, notwithstanding such (sometimes exceedingly complex) difficulties, accountants have also developed more comprehensive costing methodologies known as full-cost accounting, life cycle costing and cost-benefit analysis which include a monetization of externalities. (Bebbington 2007)

Regarding non-financial performance measurement systems, material flow/eco-balance analysis and eco-efficiency indicators represent two examples of tools advanced by the literature. Physical flow analysis is a non-financial quantification of organizational resource usage and outputs. It is a crucial first step in the management of an organization's environmental impacts given that to effectively control the environmental impacts of waste, effluents, and emissions; it is essential that the organization monitors the physical flow of these contaminants in the first place. Eco-efficiency indicators are meant to measure such things as energy and material intensity. They are expressed in non-financial ratios, for example; energy consumed by the company divided by a unit of output that can be used as benchmarks to improve the efficiency of resource usage by companies Schaltegger and Wagner (2005).

2-2 Research gap and hypotheses development

The majority of studies on SCM have focused on the application of a single tool (or in a few studies, a combination of two or more tools). The goal of these studies is to show that an SCM tool such as material and energy flow accounting or environment cost accounting can be applied in different companies, in an industry or country, how an internal implementation of a particular SCM tool can be undertaken, or what the costs and benefits of its application are.

Beside that, the studies on SCM neglect that the diversity of sustainability-related cost management tools suggested in the literature in a response to the wide variety of motivations. So, there remains concern about the usefulness of sustainability-related cost management tools to support different types of sustainable decisions and domains of SCM (e.g., eco-efficiency, socio-efficient and eco-justice).

In the paper, the proposed framework not only serves for conceptual classification purposes but also provides a logical structure for identifying the appropriate SCM tool for any given corporate sustainability decision setting. Furthermore, it provides a basis for managers and staff to reflect upon whether an SCM tool already in use is the most appropriate for the intended sustainable decision domains.

The availability and use of the wider set of accounting information relative to the economic consequences of the social and environmental position of a company can provide a more comprehensive view of the company's cost structure decisions, eco-efficiency decisions, risk management, and sustainable investment decisions. It will also affect disclosure practices and investor decisions.

The hypotheses were developed to confirm these relationships:
H_1: A typology of sustainability-related cost management tools has a positive impact on the integration of sustainability issues into decision-making.
H_2: A typology of sustainability-related cost management tools has a positive impact on the contextual integration of sustainability domains (Eco-efficiency, Socio-efficiency, and Eco-justice).

3. A proposed framework for classifying sustainability-related cost management tools

The proposed framework can be structured according to two dimensions:
The first dimension describes the types of different decisions that can be impacted on satisfying stakeholder needs (determination of environmental protection costs and regulatory compliance, risk management and sustainable investment decisions, product design & mix decisions, eco-efficiency decisions, and social benefits/costs analysis).

The second dimension emphasizes on the sustainability triangle approach and structures domains of sustainable cost management (SCM). The three domains of sustainability management can be met by systematic efforts to act in an eco- and socio-affective as well as in an eco- and socio-efficient manner. Contextual integration of the three characteristics (economic, ecological and social) in the sustainability triangle requires the simultaneous accounting for an improvement of the four challenges of ecological effectiveness, social effectiveness, eco-efficiency, and socio-efficiency.
Management of sustainable performance in all of its perspectives and facets requires a sound decision-making framework, which, on the one hand, links environmental and social management with the business and competitive strategy and, on the other hand, integrates ecological and social information with economic business information.

Taking two dimensions together, typology of the types of decisions, domains of sustainable cost management and the associated sustainable cost management tools emerge as in figure (1).

The strength of SCM tools typology lies in its explicit inclusion of the sustainable decisions making context and domains of sustainable cost management systems, dimensions which SCM literature has tended to overlook.

Types of sustainable decisions	Eco-efficiency	Socio-efficiency	Eco-Justice
Social Benefits/ costs analysis	• SBSC • Life-cycle assessment (LCA)	• SBSC • Social life-cycle assessment (SLCA)	• SBSC • Sustainability supply chain
Risk Management & Sustainable Investment decisions	• Sustainable investment appraisal methods • Life-cycle costing (LCC)	• Sustainable investment appraisal methods	• Life-cycle inventory analysis (LCIA)
Regulatory compliance & eco-efficiency decisions	• ABM for environmental sustainability • Life-cycle assessment(LCA) • Target costing • Material & energy flow accounting	• Social life-cycle assessment (SLCA)	• Life-cycle inventory analysis (LCIA)

Domains of sustainable cost management

Figure (1): Typology of the types of sustainable decisions, domains of SCM, and SCM tools

Types of information for sustainable decisions making

Most organizational decisions require a comprehensive consideration of environmental and social costs. In sustainable decisions making where sustainability-related information could have a material effect, the proposed framework identifies the type of sustainability information needed for effective decision-making. A sampling of such decisions scope and information requirements is summarized in the table (1).

Decisions Scope	Information needed
Pollution Control/Regulatory compliance: Compliance with relevant regulation, voluntary agreements (Such as covenants), and general codes of conduct voluntarily adhered to, based on pollution control	• Hazardous materials and wastes and permit violations; • Worker training; • Paying effluent fees and taxes; • Buying and selling tradable emission permits.
Eco-Efficiency: Resource intensity and minimization of environmental impacts pf production and products / services, together with value creation by continuous incremental improvements	• Costs of specific materials; • Substitute materials; Energy inputs; • Waste/ pollutant generation rate • Waste management options (recycling)
Product design/ mix/ pricing: decisions radical environmental improvements pertinent to products and services to achieve minimum environmental impacts	• Relative sustainability performance of alternative design choice • Full costs of production, including associated environmental and safety costs.
Risk management: Physical risk characteristics need to be translated into financial risk assessments by considering financial exposures from adverse impacts on human health and ecosystems.	• Potential liabilities from safety hazards to workers and the community at large; • Health and ecological risk arising from operational emissions of regulated and unregulated pollutants

	and hazardous materials; • Product safety-related issues.
Capital investment decisions: Assessing the economic value created by innovative environmentally friendly projects	• Social economic impact is amount of weight for each impact category such as GHG acid rain and so on and each harmful substance such as carbon dioxide (CO_2) nitrogen oxide (NOx) • Amount of weight of harmful substance.
Social benefits and cost analysis decisions: Measuring economic, social and environmental contributions made by the firm to stakeholders and adverse	• Value generated and distribution to each stakeholder. • Sharing resources and risks to generate value.

Table (1): Sustainable decisions scope and information needs

As shown in the table (1), some critical and strategic decisions require timely and comprehensive sustainability information. In the absence of such information, decision quality will suffer, leading to long-term adverse financial outcomes.

Structuring domains of sustainable cost management

The vision of corporate sustainability today is a broad approach relating to the contextual integration of economic, environmental, and social characteristics. It comes as a surprise to realize that the best-known aspect of accounting for corporate sustainability is the heuristic, multi-criteria triple bottom line perspective which aims to integrate the economic, social and environmental dimensions of business management (Schaltegger and Burritt 2006). Figure (2) illustrates the sustainability triangle approach and the related core contextual challenges of corporate sustainability.

The sustainability triangle visualizes the three perspectives of sustainability not just by plotting ecological, social and economic goals in a triangle but by also addressing the interrelationships between these three dimensions. The difference between focusing on a corner or a line between two corners of the sustainability triangle is defined by the distinction between effectiveness and efficiency. Effectiveness is the goal whenever management attempts to improve a single dimension of the sustainability triangle. Effectiveness – whether economic, environmental or social effectiveness – can be measured in absolute indicators, or figures. Efficiency, by contrast, describes the relation between different dimensions such as the ecological and economic dimension for eco-efficiency, or the social and economic dimension for socio-efficiency (even economic efficiency reflects the relationship between various economic issues such as assets, profit, time, etc.). Efficiency is therefore measured in relative indicators or ratios. Efficiency indicators are cross-indicators, which incorporate two separate units of measure unless both dimensions of an efficiency analysis are measured in monetary terms.

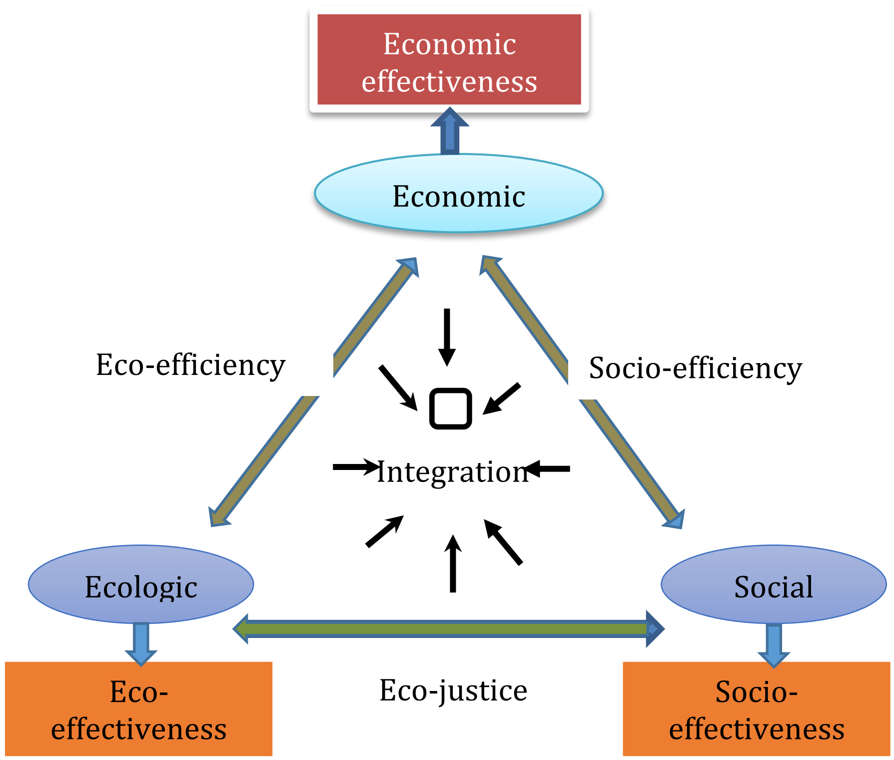

Figure (2): Structuring domains of SCM with the sustainability triangle
Source: Schaltegger and Burritt (2006)

Of critical importance is that efficiency indicators must be unambiguously defined in such a way that the economic, environmental and social dimensions measured are comparable and focused on the activities of concern to particular stakeholders (Schaltegger and Wagner 2006).

Apart from the need to concentrate on the conventional economic management of the business, the remaining, contextual corporate sustainability domains with which sustainable cost management (SCM) has to deal are the ecological, the social, the eco-efficiency and socio-efficiency, as well as the integration challenges Schaltegger and Burritt (2006).

To support management, sustainable cost management (SCM) must provide information on the company's performance and development concerning all corporate sustainability domains. The main reason for the corporate adoption of sustainable information in the internal decision-making processes is that it provides a framework for linking economic and social environmental decision-making to strategy.
This competing hypothesis challenges traditional cost management: it reflects an underlying "win-win" green paradigm. This logic is based on the idea of a possible reconciliation between economic (financial) objectives and social and environmental objectives. Improving the competitiveness of an organization deployed in the spirit of a win-win logic increases the likelihood of managers adopting the concept of the sustainability from a successful adaptation based on their criteria, which are often economic (Cho et al. 2013).

We will display the status of development for each tool.

3-1 Environmental sustainable cost management
Environmental management activities at the firm level can cause costs, can help to avoid costs and can create benefits. Environmental management accounting (EMA) analyses these aspects precisely. Its sub-discipline of environmental sustainable cost management focuses on the cost side of these activities regarding both costs created and costs avoided. However, it does not directly address the (monetarized or non-monetarized, i.e., physical) benefits from an improved environmental performance. This aspect on measuring improvements in environmental performance (i.e., the physical benefits of environmental management activities, which can also be subsequently monetarized, e.g., based

on an estimation or calculation of external costs related to specific aspects of environmental performance) is the focus of another newly emerging sub-discipline of EMA, that of environmental performance measurement.

The attributes of environmental and social costs

Through environmental cost accounting, the company collects data on its past and future environmental costs. The environmental costs measure private, internal or company costs. These are the costs that have a direct impact on a firm's bottom line. Alternatively, public, social or external environmental costs are environmental costs, social costs or economic costs, relevant to society as a whole (Schaltegger and Burritt 2000).

A common classification system of the tiers of environmental costs is suggested by the US office of pollution prevention (EPA). The EPA suggests mainly four layers (United States EPA 1992):

1- Conventional costs, which are "usual", costs of equipment, labor and material used in end- of- pipe activities.
2- Hidden costs which are costs of compliance, other hidden regulatory costs from activities such as monitoring and reporting of environmental activities and emissions, the costs of searching for environmentally–responsible suppliers.
3- Contingent costs which are liability – based costs such as costs arising from the failure to clean up contaminated sites, fines and penalties for non-compliance with regulations.
4- Relationship and image costs that are "less tangible" costs such as costs related to consumer responses and perceptions, employee health and safety, company's image and community relations.

The EPA also recognizes tiers 5 costs, societal costs that are generated by company environmental and societal impacts. They are difficult to measure because the cost of estimating these impacts and the awareness that company controllers should have about these impacts, cannot also be provided by law.

In figure (3) a relationship is described between the difficulties tracing these categories of environmental costs and the strategic relevance for improving future profit and reduces the numerous types of risks.

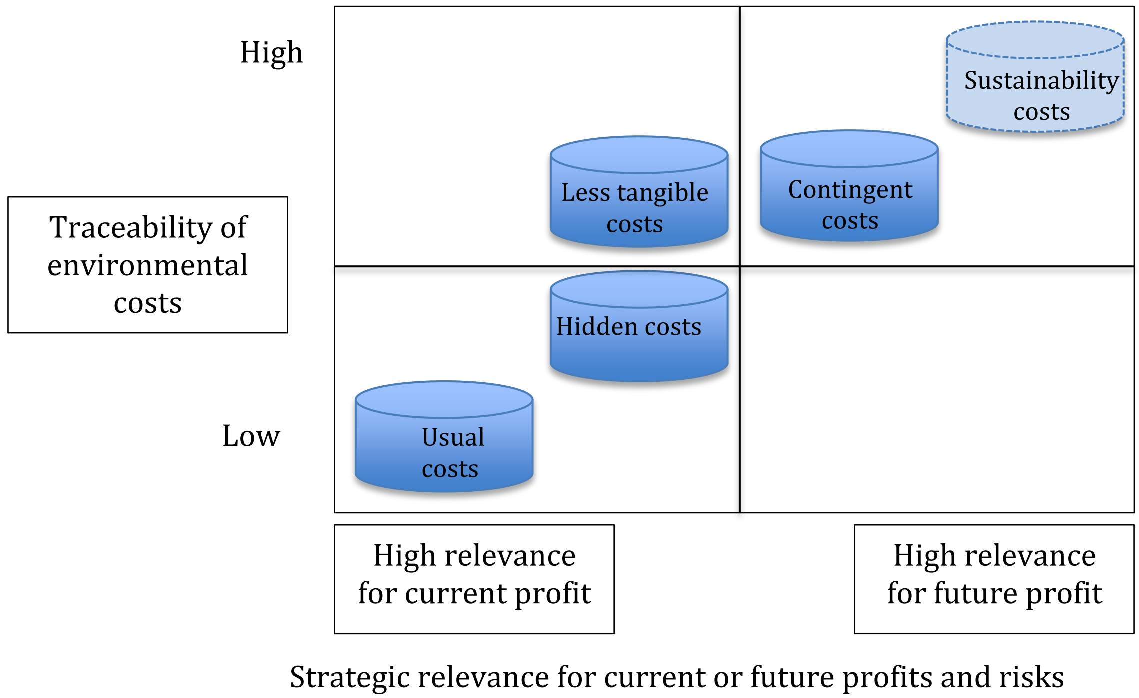

Figure (3): Trade-off between traceability of environmental costs and the strategic relevance for current and future profits / risks.
Source: Marelli (2013)

To date, attempts to concentrate on better tracking and allocating environmental costs within management accounting frameworks have predominantly focused on private costs because it is harder to evaluate external costs (Gray 2006).

However, some environmental impacts of current decisions and operations can be difficult to recognize and report because the future issued not yet known; in particular, many work practices will have future environmental and social impacts that we are not able to currently assess. The Future drivers for new environmental costs include a number of the growing risk (for example regulatory risk, supply chain risk, product and technology risk, litigation risk, reputation risk, and physical risk). Moreover, the practical usefulness of environmental accounting tools is constrained by it's oversimplification (Gluch and Baumann 2004).

A third generic category of environmental costs can be defined as the 'environmental opportunity costs.' These costs can be identified as the costs related to the best-unrealized pollution prevention alternative Schaltegger and Burritt (2000).

Environmental cost accounting permits the grouping together of the elements of the cost of resources employed in coping with environmental problems. They are cost items that entail a particular method of analysis, both concerning identification of the activities and regarding quantification of costs. The need arises to measure environmental costs on this different basis and method of analysis in order to identify them and extract them from the grouping of indirect industrial costs and overheads. So "environmental product costing" involves tracing direct and indirect environmental costs to products, and covers the costs of waste management, permits and fees, and recycling activities.

Tracing environmental costs permits the measurement of the use of resources and facilitates the interpretation of the economic results with greater clarity. The likely reason this is not commonly employed in practice can be attributed to the high administrative cost and complexity of costing systems. In fact, companies incur administrative costs not only in gathering data but also in taking the time necessary to educate management about the chosen system (Horngreen et al. 2005).

	Cost of environmental protection		Cost of material and energy flows	
	Past / present costs	**Future costs**	**Past / present costs**	**Future costs**
Full cost accounting	Full costs of environmental reduction (CICA 1997)	Consideration of the costs of environmental risk (Harading 1998)	Cost of remaining material (Schaltegger and Wagner 2005)	
Direct costing	Environmentally–oriented direct costing (Burritt and Luckett 1982)	Costing of future environmental costs (Schaltegger and Wagner 2005)		
Process costing	Activity-based costing (ABC) (Ditz et al. 1995) Environmental quality costs and activity-based costs(Russell Skalak and Miller 1994; Roth and Keller, 1997)	Activity-based budgeting (Borjesson 1997)	Material and energy flow-oriented costing (Schaltegger and Muller 1998)	Material and energy flow oriented activity-based budgeting (Schaltegger and Burritt 2000)
Target costing		Environmentally oriented target costing (Malone 2015)		

Table (2) Current environmental costing methods
Source: adopted from Schaltegger and Wagner (2005)

Current methods of environmental cost accounting

Current methods of ECA can be distinguished according to the definition used for environmental costs and the cost accounting method pursued. Table (2) provides an overview of current methods of ECA.

Environmental costs can either be viewed as costs of environmental protection or as costs related to material and energy flows that could be reduced to an increased level of environmental protection. This change of perspective from calculating costs of environmental protection to calculating costs of material and energy flows creating environmental impacts has substantial consequences for cost accounting.

Opportunity costs of unrealized environmental protection occur if the Net Present Value of pollution prevention measures is positive. These opportunity costs are included in the latter view of costs related to material and energy flows, which thus include the costs of unrealized pollution prevention. Another line of which environmental costs can be distinguished is whether approaches consider past and present costs, or if they also include future costs.

To date, four methods have been proposed to deal with environmental costs (see the first column of Table 2). Some of these methods have been designed to produce separate calculations, not integrated into established company management-accounting systems. Other methods proposed are intended to form an integral part of management-accounting systems and include full cost accounting, direct costing, process costing, and target costing. Only very recently have a process and target costing-based approaches been used in practice in a few companies Schaltegger and Wagner (2005).

Full costing and direct costing

Overall, the held view is that the conventional (full costing and direct costing-based) approaches to ECA are often too shortsighted since their understanding of corporate environmental protection is that of a mere cost driver. In addition to this, they tend to promote additive environmental protection activities rather than integrated activities based on clean technology or cleaner production. Viewing environmental protection as a cost-adding factor may, moreover, lead to a negative attitude towards pollution prevention. Furthermore, the opportunity costs incurred through the neglect of corporate environmental protection are not taken into account either. Hence, on the grounds of faulty decision-making and poor accountability, full cost accounting can be criticized if it does not try to identify costs that are specifically related to cost objects.

Conventional management accounting has also been criticized for being far too oriented towards past instead of towards present and (most importantly) future activities since a meaningful use of management accounting information is to assist planning for the future. Extending direct costing-based approaches to include future costs of environmental protection would, therefore, be desirable.

However, none of the approaches incorporating future costs have, as yet, been implemented. The consideration of future costs faces quite substantial problems when trying to estimate future costs. Estimation of the future costs of pollution prevention and environmental liabilities is particularly challenging as neither future technology nor future demands of stakeholder groups are known. Because of these caveats, the full or direct costing-based approaches are only of limited use for eco-control.

Process Costing

Environmental cost accounting, therefore, needs to be extended in two directions. Firstly, it is necessary to include process stages upstream and downstream of the actual production process (which was so far the focus of ECA) into the analysis. Secondly, it is necessary to incorporate those environmental costs, which arise during the use and disposal phases of the product. Extending ECA into such a life-cycle perspective puts the focus of analysis mainly on consumer benefits and competitiveness.

Therefore the logical next steps in the development of ECA would be the development of new methods based on activity-based costing and process costing. One of the main advantages of using activity-based costing or process costing to assess environmental costs is the integration of ECA into the strategic management process and its linking to management objectives and activities. This tool leads managers to review the profitability of “polluting” products, but also to empower their subordinates to get them to review the activities of the organization to prevent these costs.

When the allocation of environmental costs is linked to the compensation system (or other financial incentives), we are taking about eco-control, which is often used as a mechanism to reduce the adverse effects on the environment.

The hierarchical cost analysis of an activity-based costing are simply techniques to allocate more accurately environmental costs (e.g., by identifying cost drivers) and temporal costs (level 0: usual costs; level 1: hidden costs; level 2: environmental liabilities; level 3: less tangible costs), depending on the political and regulatory environment of the organization Cho et al. (2103)

Also, conventional approaches, such as direct costing, are less decision oriented than activity-based costing and process costing, because it concentrates on calculating the costs of specific business activities using volume as a cost driver, rather than the richer set of cost drivers used in activity-based costing.

Several important decisions may be made from activity-based management (ABM) for environmental sustainability Malone (2015). First, decreasing production of any of products will not necessarily result in the reduction of short-term costs or emissions. Over time, redesign of products and processes may be informed by the relative resource intensity of these products; however, no short-term gains are likely to result from shifts in product mix, as allocations would simply shift among products, not be eliminated. Second, in the long term, where resource shifts can be accomplished and environmental costs –both financial and physical – may be avoided, one must take into account the marginal product of the environmental resources being consumed. Finally, by examining the resource intensity for indirect physical environmental costs, a firm can more effectively plan resource allocations, plan product mixes, and make design changes with a better understanding of the implications for changes in physical environmental resource consumption. Applying this methodology in the context of environmental sustainability provides the firm better information with which to plan strategic initiatives and responses to environmental demands (e.g., regulatory pressures).

Environmental quality costs and activity-based costs

Another important pathway for analysis of environmental cost is linked with the “quality approach” Russell Skalak and Miller (1994); Roth and Keller (1997). This method aims to measure in financial terms, the benefits of high quality management. It relies on the idea that financial measures increase the pressure and stimulate motivation to reduce costs of quality failure. The same framework of quality costing can easily be applied to the environmental costs. When developing this framework to measure environmental costs the goal is the overall control and reduction of these costs.

To carry out this analysis, an activity-based costing method can be useful. In fact, environmental costs should be traced to the activity that causes them. For example, the costs of handling and treating toxic waste brought about by the production of say, product X should directly and exclusively be allocated to product X.

So, following the environmental quality-costing scheme and applying the ABC method, three main types of activity are defined:

- **Prevention activities** are designed to solve environmental problems before they occur, or even to turns problems into competitive advantage;
- **Assessment activities** (or monitoring activities) to observe the level of environmental impacts and control measure damage, assess internal processes and products services supplied, and audit of environmental performance of supply chain partners;
- **Failure activities** that can be split into two sub-categories: control activities to correct environmental breakdowns discovered during the production and in the products. In other words, activities facing internal failure; and external failure activities to put right and remedy external company impacts.

In this environmental analysis, costs include several that are intangible and/or changing from different location and times. With this categorization the focus is mainly on the costs of preparing the product/service, and the costs during production and after distribution for customer car activities (under legal and voluntary warranties). Considering these activities, the environmental quality costs can be:

- **Prevention costs**, coming from prevention activities, which can be considered an investment that can provide a long-term cost/technical/ reputation advantage over direct competitors;
- **Appraisal costs,** coming from assessment activities which are costs that measure depreciation of equipment, resources used in monitoring, external certification and audit, and personnel department;
- **Internal failure costs**, (coming from control activities);
- **External failure costs**, (coming from failure activities).

Material and energy flow cost accounting

Another recent approach is defined by the term “cleaner production approaches” that is in line with eco-efficiency strategies and ecological approaches. The most valuable tool, which deals with eco-efficiency issues, is material and energy flows cost accounting. The clear trend in cost management towards accounting for the costs of material and energy flows causing environmental problems requires a tight link between material flow information and cost information to manage environmental performance cost-effectively.

Effective sustainability management demands a more refined measurement, tracking, and accounting of the flow of physical materials, wastes, and energy, both within and outside the organizational boundaries. Material balance and energy balance accounts enable accurate identification of wastes or non-product outputs. These non-product outputs not only represent wasted resources but also are directly related to many of the adverse environmental impacts. Material and energy inputs also proxy for ecological and social impacts from an extraction of resources Marelli (2013). The physical accounting information collected is, therefore, the key to the identification of many environment-related costs. For a complete and integrated picture of materials use, the details of materials flow must be traced through all the different organizational materials management steps, such as materials procurement, delivery, inventory, internal distribution, use and product shipping, as well as a waste collection, recycling, treatment, and disposal. Materials tracked include raw and auxiliary materials, packing materials, merchandise, operating materials, water, fuels, product output, byproducts, and non-product outputs. Once the physical flow data have been collected, they can be used to support the cost management system. The physical accounting side of material and energy flows cost accounting provides the needed information on the amounts of flows of energy, water, equipment and wastes to assess these costs. The goal is to track material costs of product outputs, materials costs of non-product outputs, waste and emission control costs, prevention and other environmental management costs, research and development costs, and other less tangible costs Joshi and Krishnan (2010). The related capital and personal cost to produce waste and emissions may be added, thus calculating production costs of waste.

Target costing for environmental sustainability

Environmental issues insert themselves into the traditional target cost model (TC) due to regulatory issues, consumer demand, and shareholder/stakeholder demand that many products face. Those issues present themselves in many ways, most often specific to the nature of a firm's products and production process.

A firm may, however, decide to be proactive in becoming more environmentally friendly or sustainable. Financially, the target process is the same. A firm simply adopts internally imposed standards that would have otherwise been imposed externally (e.g., either the regulatory requirement or competitive expectations as described previously). Still, TC is a very efficient tool in assisting a firm in meeting those goals.

The life cycle perspective and cross-functional nature of TC implies a vibrant process of product/process transformation with the aim of achieving a derived target cost. Indeed, a firm must plan carefully as far in advance as possible due to the nature of committed costs, both financial and environmental. The further into the life cycle of a product a firm progress, the higher the cost of adjusting costs (again, both financial and environmental) in response to changing environmental conditions (e.g., regulatory) Malone (2015). Rather than focusing solely on financial improvements; in TC environmental sustainability the targets can be set in physical terms used to achieve these targets.

3-2 Sustainability Investment Decisions

Corporate management understands that innovative environmentally friendly products which contribute to reducing Green House Gas (GHG) are indispensable for the conservation of the global environment but also require an enormous amount of capital investment and face huge uncertainties – not only technical but business uncertainties. Management of GHG is usually therefore accompanied by a deterioration of cash flow in the short-term due to the huge investment and not guaranteed a return even in the medium- and long-term.

(Reverte 2016) Demonstrates that creating a business case for sustainability requires a good understanding of links between non-monetary social and environmental activities on the one hand, and business or economic success on the other. The core question, and the basis for any business case for sustainability is how profit resulting from increased social and environmental activities can be identified and managed. So, management needs to assess appropriately the economic value created by innovative environmentally friendly projects.

Some papers in the literature suggested many appraisal and assessment methods. To assess the economic value created through environmental investments, (the Japanese Ministry of Economy, Trade and Industry 2002) has established a method for capital investment in environmentally friendly facilities. They recommend using a table to compare alternatives and which incorporates not only the economic assessment, such as NPV but also the environmentally harmful substance reduction benefits such as GHG reduction. Management then has to make a decision based on both the financial value and physical value.

By contrast, the United States EPA (1992) has recommended the total cost assessment (TCA) method. It is designed to assist in the cost comparison of one or more pollution prevention alternatives to a current industrial practice, and sets up a hierarchy of costs as follows:

Tier 0: Usual Costs

Tier 1: Hidden Costs

Tier 2: Liability Costs

Tier 3: Less Tangible Costs

The hierarchy progresses from the most conventional and certain costs in Tier 1 through to the most difficult to estimate and least certain costs in Tier 3. The user first analyses all costs associated with the current and alternative projects and then calculates key financial indicators of the economic viability of the alternative projects. Financial calculations are added to each tier in sequence until the result concludes that some alternative meets the investment criteria of the corporation, or until all tiers have been completed. (Kokubu 2000) Argues that the advantage of this method is to evaluate the value of the environmental investment at a high level and to expand the acceptable scope of the environmental investment. However, these methods cover only the internal costs that have a direct impact on a company's profit and do not bring into consideration the effect of corporate environmental behavior on competitive position, – revenue enhancement and the prospects of appealing to green consumers and investors or the value of flexibility (Minato 2011).

Minato (2011) has proposed a decision-making method for capital investment in environmentally friendly projects, which enables management decisions to be made appropriately under highly volatile conditions while promoting good corporate environmental behavior. On the assumption that the market is prepared to incorporate the effect of environmental elements and managerial flexibility in share prices, an investment appraisal model, which incorporates these factors, is developed.

To utilize the investment appraisal model, there are two challenges in establishing a decision-making method for environmentally friendly projects. The first is corporate value creation from environmental impact reduction by which the social, environmental value, which is created by environmental investment, i.e., the reduction in environmental impacts, can be converted into internal corporate value creation. It is assessed by using the life-cycle impact assessment method based on endpoint modeling (LIME). The second is to incorporate management decision flexibility into the appraisal of environmental investment, which is undertaken using real options theory.

The total economic value of environmentally friendly projects includes the standard NPV, the environmental impact reduction value, and the managerial flexibility value. The formula is shown in Eq.1.

Total economic value = Standard NPV + Environmental impact reduction value + Managerial flexibility value (1)

The first challenge is corporate value creation from environmental impact reduction. The implication of the literature on existing research into corporations' motives for investing in environmentally friendly projects is that value from environmental investments can be created by attracting green consumers who are willing to pay a product price premium and by attracting green investors who are prepared to pay a share price premium. Green stakeholders, such as green consumers and green investors, accept the price premium equivalent to the economic value of environmental impact reduction. This aspect can then be brought into the investment appraisal calculation. LIMA assesses the economical value of the environmental impact reduction. It is a life-cycle impact assessment method developed as part of a Japanese national project from 1988 through 2003. The assessment of social, economic impact due to environmentally harmful substances assessment can, therefore, be done without specialist knowledge. The formula of LIME is shown in Eq. 2.

$$SI = \sum_{Is} \sum_{S} IF_{S.Is} \times INV_S \qquad (2)$$

Where:

SI – Social, economic impact due to environmentally harmful substances

IF – Social, economic impact per amount of weight for each impact category and each harmful substance

INV – Amount of weight of harmful substance

IS – Each impact category such as GHG, acid rain and so on

S – Each harmful substance such as carbon dioxide (CO_2), nitrogen oxide (NO_x) and so on

The second challenge is to incorporate decision flexibility into the appraisal of environmental investment. The NPV method treats NPV as a fixed value at the time of decision-making, and uncertainties, after decisions have been made, are treated as business risks. (Smit and Trigeorgis 2006) Indicate that the management has flexibility to proceed with, abandon, enhance, or shrink, its plan compared to the original plan and has a right to acquire an asset for a specified price at some later date. Techniques derived from option pricing can help in quantifying management's ability to adapt plans to capitalize on favorable investment opportunities or to respond to undesirable developments in a dynamic environment by cutting losses.

Total economic value is an indicator that is used in decision-making for capital investments in environmentally friendly projects, even if a project's standard NPV is negative, if the total economic value is positive then a capital investment decision for the green friendly projects can still be made.

3-3 Sustainability Supply Chain Management

Supply chain management is closely connected to the issue of globalization which is driven by reduced trade barriers, new logistic systems and lower transportation costs, as well as by new information technologies and the fast growth of newly developing and emerging markets.

(Seuring and Muller 2008) summarize six *external* incentives for including sustainability in supply chain management based on available literature between 1994 and 2007:

- Legal requirements and command-and-control regulations are the most frequently cited triggers for action, making regulators a primary stakeholder in sustainable supply chain management.
- Customer demands on the focal company are the second most highly ranked pressure.
- Responding to stakeholders comes a close third.
- Competitive advantage is necessary, and placed well ahead of pressure from social and environmental groups and reputation loss.
- Besides, internal risk management and the need for minimization are seen to be important triggers for sustainable supply chain management. Seuring and

Muller (2008) suggest that risks can derive from potentially poor environmental or social performance, as well as from potential disruptions of supply.

- Increased outsourcing, particularly to overseas suppliers, multiplies the number of companies in different contexts in the typical supply chain and thereby encourages the focal company to push their suppliers for an increase in take-up of and compliance with standards and codes of environmental management and social responsibility so that performance can be improved.

Given the growth in demand for sustainable supply chain management, what are the information challenges facing those companies which are keen to implement appropriate sustainable cost management systems (SCMS)? How should sustainability cost management be designed to provide the foundation for the supply chain and the sustainability information management challenges for internal management decision-making, as well as for internal and external reporting? Five central challenges are mentioned in the literature: confidentiality and business secrets; movement from cost management to eco-efficiency; distance; complexity; societal observation and going global.

To respond to these challenges, companies need new information systems about environmental and social impacts along the supply chain. Hence, data collection by very different companies in different cultural settings presents a problem for securing reliability to decisions, as factors relating to the credibility of information are less controllable once the supplier is located in a different legal organization, country, or cultural context. Other challenges of supply chain information management include the coordination of actors so that they provide and pass on information, auditing and assurance, trust building, and an understanding of why social and environmental issues are important to the focal company Burritt et al. (2011).

Seuring and Muller (2008) emphasize the pressures that a focal company in a supply chain can bring to bear on its suppliers concerning the provision of reliable data about environmental and social issues. The focal company can dominate the suppliers, or it can work to build up a trusting relationship. It has the power to make suppliers provide credible data or else lose their supply contracts, although the presence of power does not necessarily mean that it has to be used. Given a singular lack of government involvement in sustainable supply chain relationships in practice, a focal company can dictate that its suppliers must use a specific method of measurement and reporting, and then by their suppliers further upstream. Suppliers can be required to provide information on their sustainability, which is subject to direct oversight, and audit (or assurance) as it is obtained by employees of the focal company. For such a purpose, the requirements could be those pre-specified by the focal company, based on its own standards; or based on well-accepted voluntary standards such as ISO 14001 for environmental management issues or SA 8000 and ISO 26000 for social matters; or standards based on global best practice as a benchmark for information quality. At the other extreme is the development of trust, leading suppliers to be intrinsically motivated to do what it is right to do and to provide accurate, reliable and useful information, and thereby to reduce the cost of strategic management control. The critical dimension in the sustainable supply chain: how eco-efficiency, eco-effectiveness, and eco-equity are to be measured.

3-4 Life-Cycle Based Sustainability Assessments of Products

According to the well-known interpretation of the original definition given in the Brundtland Report, sustainability comprises three components: environment, economy, and social aspects. These components or ‘pillars’ of sustainability have to be properly assessed and balanced if a new product is to be designed or an existing one be improved.

For the environmental part, there is already an internationally standardized tool: Life-Cycle Assessment (LCA). Life-Cycle Costing (LCC) is the logical counter part of LCA for the economic assessment. LCC surpasses the purely economic accounting and cost calculation by taking into account the use- and end-of-life phases and hidden costs. For this component, a guideline is being developed by (The Society of Environmental Toxicology and Chemistry (SETAC) 1993). It is an essential point that different life cycle based methods (including Social Life-Cycle Assessment ‘SLCA’) for sustainability assessment use consistent system boundaries (Klopffer and Renner 2008).

SLCA has been neglected in the past, mainly due to great methodological difficulties, but is now beginning to be developed. The central problems seem to be how to relate the social indicators (social impact assessment) quantitatively to the functional unit of the product-system, and how to restrict to a manageable number the many social indicators proposed. Furthermore, a better regional resolution of the Life-Cycle Inventory, compared to conventional LCA, has to be achieved since the social conditions vary geographically much more than the core element of LCA industrial production. We will display the status of development for each method.

Life-Cycle Assessment; a logical extension of material and energy flow cost accounting is to go beyond the boundaries of the firm to encompass the entire supply chain, including customer use and product disposal. Life-cycle assessment (LCA) facilitates such a system view in environmental evaluation of products, materials, and processes.
LCAs can also help identify potential supply chain disruption risks due to environmental burdens of suppliers and future regulations. Estimates of use phase and end-of-life environmental burdens faced by customers can also help in designing better products. ISO 14040 describes the principles and framework for LCA including the definition of the goal and scope of the LCA, the life cycle impact assessment (LCIA) phase, the life-cycle interpretation phase, reporting and a critical review of LCA and its limitations.

In the introduction of ISO 14040 (ISO 2006a), 'LCA addresses the environmental aspects and potential impacts (e.g., resource use and environmental consequences of releases) throughout a product life cycle from material acquisition through production, use, and disposal (cradle-to-grave). This standard (ISO 1997); ISO (2006a) defines LCA as the 'compilation and evaluation of the inputs, outputs and the potential impacts of a product system throughout its life cycle.'

LCA is the only internationally standardized environmental assessment method (ISO (1997); 1998, 2000a, b). The historical development of LCA since the proto-LCAs of the 1970s and 1980s has recently been summarized with particular emphasis on the role of SETAC in this process (Klöpffer 2006). The international standards have been slightly revised and updated (ISO (2006a), 2006b; Finkbeiner et al. 2006); the revised standards superseded the old series used prior to October 2006.
The basic principles of LCA which distinguish this method from other environmental assessment methods are:

- The analysis is conducted from cradle-to-grave.
- All mass and energy flows, resource and land-use, and the potential impacts connected with these interventions are set in relation to a functional unit as a quantitative measure of the benefit of the system(s).

- LCA is essentially a comparative method (comparing the present state of the system to a future state).

In short, two, or more systems are compared to each other on the basis of a common benefit in a holistic way. The advantage (at least theoretical) of completeness is partly offset by the uncertainty about where and when processes, emissions, etc., occur, which ecosystems or how many humans may be harmed. Whether or not thresholds of effects are actually surpassed due to the emissions, or other effects, which can be attributed to the system(s) studied. Furthermore, the magnitude of the functional unit is usually fixed arbitrarily in wide margins.

Life-Cycle Costing; the economic counterpart of LCA is known under several names, as Life-Cycle Costing (LCC), Full-Cost Accounting (FCA), Total-Cost Assessment (TCA) (White et al. 1996; Norris 2001; Shapiro 2001).

Conventional cost accounting of products also includes life-cycle aspects, since the costs of raw and intermediate materials enter into the calculation of the final product. However, costs involved in the use of products and in waste removal or recycling generally do not show up in cost accounting (with the exception that in exceptional cases the producer may have to take back the product or pay for the waste collection, as in the case of the German Green Dot system of packaging recycling). Other main differences between conventional cost accounting and LCC consist in accounting for hidden or less tangible costs in LCC, including costs for environmental protection White et al. (1996); Shapiro (2001). These costs are captured in conventional cost accounting, mostly in the form of overheads, but they are not attributed directly to a product. As in LCA, this clear attribution to a product system is necessary for assessment to estimate the true costs (LCC) or true environmental interventions (LCA) of the product (system) to be compared with another, which fulfills the same function or has the same benefit. The basis of comparison in LCC is the same as in LCA, the functional unit.

White et al. (1996) define Total-Cost Assessment as the “long-term, comprehensive analysis of the full range of internal costs and savings resulting from pollution prevention projects and other environmental projects undertaken by a firm.” In this method, the economic benefits of pollution control measures are included whereas in conventional accounting only the costs of pollution prevention would be taken into account. This inclusion of positive trade-offs indicates life-cycle thinking. The term life- cycle, however, is often defined in another way in the economic sciences, namely as the sequence of product development—production—marketing/sale—end of economic product lives. As noted by Norris (2001), this economic life cycle may be even shorter in some products than the environmental life-cycle (cradle-to-grave) used in LCA.

In a further step, external costs due to environmental damages connected with the products may be included White et al. (1996); Shapiro (2001). Rather society or even future generations do not incur these costs to the company. The quantification of these costs is difficult since it is often not clear what damages are—or will be—connected to the interventions caused by a product system. Short-term damages in a well-defined area might, at least, at first sight, be calculated if a clear cause-effect chain can be established.

LCC is older than LCA, but it is not yet standardized. It has great potential for extending the scope of LCA in the direction of sustainability assessment (Klöpffer 2003); Norris (2001); (Rebitzer 2002). This LCA-type LCC is based on the environmental life-cycle used in LCA and avoids the miniaturization of externalities since this would mean a double-counting: environmental impacts are quantified in the Life-Cycle Impact Assessment (LCIA) component of LCA in physical units ISO (2000a), ISO (2006b).

It should be noted that LCC includes the use- and end-of-life phases (cradle-to-grave as LCA) so that the result cannot be approximated by the price of a product (cradle-to-factory gate or cradle-to-point of sale). LCC is an assessment method, not an economic cost-accounting method. It does not mean that the two research communities cannot learn from each other.

Societal Life-Cycle Assessment; the Societal Life-Cycle Assessment (SLCA) is considered to be still in its infancy, although the idea is not new (O'Brian et al. 1996).
Similar to the case of (environmental) LCA, it will not be possible to quantify all social impacts related to a production system. In LCA, the important impact category 'biodiversity' can hardly be quantified with a suitable indicator. The same is (still) true for invasive species, which are probably a greater threat to the ecosystems than the chemical emissions. Finally, indicators will be chosen to assess a quantitative correlation with the functional unit. Indicators related to the

workplace (including agricultural and other ‘open-air’ places) will be preferred over indicators related to general political issues of a region or country.

One Life-Cycle Assessment or Three? There are two options to include the social aspects into a life cycle based sustainability assessment. The first option corresponds to Equation 1 and relies on three separate life-cycle assessments with consistent, ideally, even identical system boundaries Klöpffer (2003).

SustAss = LCA+LCC+SLCA (1)

Where:
LCA is the environmental LCA
LCC is a LCAtype life cycle costing
SLCA stands for societal LCA

A formal weighting between the three pillars, although possible, should not be performed. The main advantage of this approach is it’s transparency—no meaningless sustainability points. The attribution of pros and cons in comparative assessments is clear in this variant. There is no compensation between the three pillars. As a consequence, a favorable (economic) LCC result for a given product cannot outweigh less favorable or even bad results in (environmental) LCA and SLCA. Such an overweighting of the economic part would perpetuate the largely unsustainable status quo.

The second option can be written as Equation 2:

SustAss = LCA (new) (including elements of LCC and SLCA as additional impacts in LCIA) (2)

Option 2 means that one LCI is followed by up to three impact assessments covering potential environmental, economic, and social impacts per functional unit of the product system studied. The advantage of option two would be that the same LCI has to be used for all three-impact assessments, solving the system boundary problem. Such a solution seems preferred by (Weidema 2006). Disregarding, for the moment, the danger of mixing up the three dimensions there remains the question whether or not option 2 is compatible with the ISO.

According to the revised framework ISO 14040, ‘LCA addresses the environmental aspects and potential impacts ... [and] LCA typically does not deal with the economic or social aspects of a product, but the life-cycle approach and

methodologies described in this International Standard may be applied to these other aspects ISO (2006a).' These statements prefer, in our view, option one and future separate standardizations of LCC and SLCA would be a logical consequence. On the other hand, ISO 14040 and 14044 could be revised in the future and possibly accommodate economic and societal impact assessments within LCIA. Since this revision will certainly not start soon, we should use the time for discussing the best way to formalize sustainability assessment.
Concerning SLCA, more experience with the new indicators will be needed especially the best method to link them unambiguously to the functional unit of a product system. Selection and quantification of the most appropriate indicators per functional unit will be the main scientific problem regardless whether option 1 or 2 will be followed.

3-5 Sustainability Performance Management System

Effective contributions to corporate sustainability require that sustainability performance measurement system be embedded in a structured sustainability approach to performance management. With this in mind, sustainability performance management could be structured in two fundamentally different ways Schaltegger and Wagner (2006):

- Strategy and accounting-driven sustainability reporting (the "inside-out perspective")
- Reporting-driven sustainability accounting (the "outside-in perspective")

From a performance management perspective, with strategy and accounting-driven sustainability reporting, strategy defines the performance measurements and indicators, which in turn define the accounting methods and the contents of sustainability reporting. While from reporting-driven sustainability accounting perspective, external guidelines, rating, and assessment schemes define information requirements and indicators which in turn define the accounting methods and information management systems. Although both the "inside-out" and "outside-in" perspectives have their strengths and weaknesses, combining them may be most fruitful.
Though not excluding the possibility of other weakness, the following problems can be formulated as three "research gaps" in the SPMS literature as follows:

Research gap 1: Current performance measurement systems focus on the financial and environmental performance but pay less attention to integrated "Sustainable

Development" objectives that encompass social, economic, and ecological performance in a balanced manner. The balanced scorecard methodology appears a promising approach to integrate ecological and social management with the general administration of the firm. There are three possibilities to integrate ecological and social aspects in the BSC. First, ecological and social aspects can be integrated into the existing four standard perspectives. Second, an additional perspective can be added to take environmental and social aspects into account. Third, a specific environmental and social scorecard can be formulated Epstein and Wisner (2001); Figge et al. (2002).

Research gap 2: Current literature concerning the relationship between the environmental and social performance of the firm and its economic performance mainly based on empirical studies that refer to the correlation but not to the causality between ecological and social measures and the economic success of the firm. Developing sustainability strategy maps is an essential first step in visualizing and clarifying the causal links as to how external natural and social capital resources together with an organizations' internal resources and processes help drive organizational value creation and performance. These exercises will also contribute to communicate how various decisions and organizational processes can affect the flow of these ecosystem and social services and thereby impact long-term performance of the firm. S-BSC can also help develop strategic sustainability performance indicators Joshi and Krishnan (2010).

Research gap 3: Instead of allowing a natural evolution beginning with a top-down external reporting focus, firms may be at an advantage by taking a bottom-up, strategic, decision-focused design of SPMS. Underlying this approach is the belief that incorporating sustainability consideration in decision-making can help improve competitiveness and create long-term shareholder value. The overarching goal of SPMS is to help the firm continually create value by incorporating sustainability considerations into every day decisions making Joshi and Krishnan (2010).

To bridge the gaps, it is necessary to propose a new system to measure and manage the sustainability performance. In the figure (4), an integrated model for "Sustainability Performance Management System" (SPMS) is outlined, aiming at the three "research gaps" of the current performance measurement system in the literature, in which some components of SPMS are designed based on the gap analysis. However, an organic system to integrate all in compact components closely is still not yet settled. To refine this new regime, the Balanced Scorecard (BSC) and its new model "Sustainability Balanced Scorecard"(SBSC) are adopted to formulate the mission and strategy towards sustainable development into tangible objectives and measures in a balanced way. Furthermore, the identified key factors and measures will be used as benchmarks to control the sustainability performance. SCM tools will aim to collect and provide all decision-relevant information both internal and external and track opportunity costs and shadow costs. Ideally, SCMS will become an integral part of the SPMS and provide timely and accurate data for making superior decisions. On the other side, incorporating of environmental and social costs routinely into decisions can play a major role in avoiding sub-optimal decisions regarding regulatory compliance, cost-reduction, and efficiency improvement, product mix and pricing decision, risk management and product design, and help the firm to obtain product market differentiation. Therefore, based on the methodology of the SBSC with the support of SCM tools, a new model SPMS can be developed to encompass multi-aspects such as social, economic, and environmental issues.

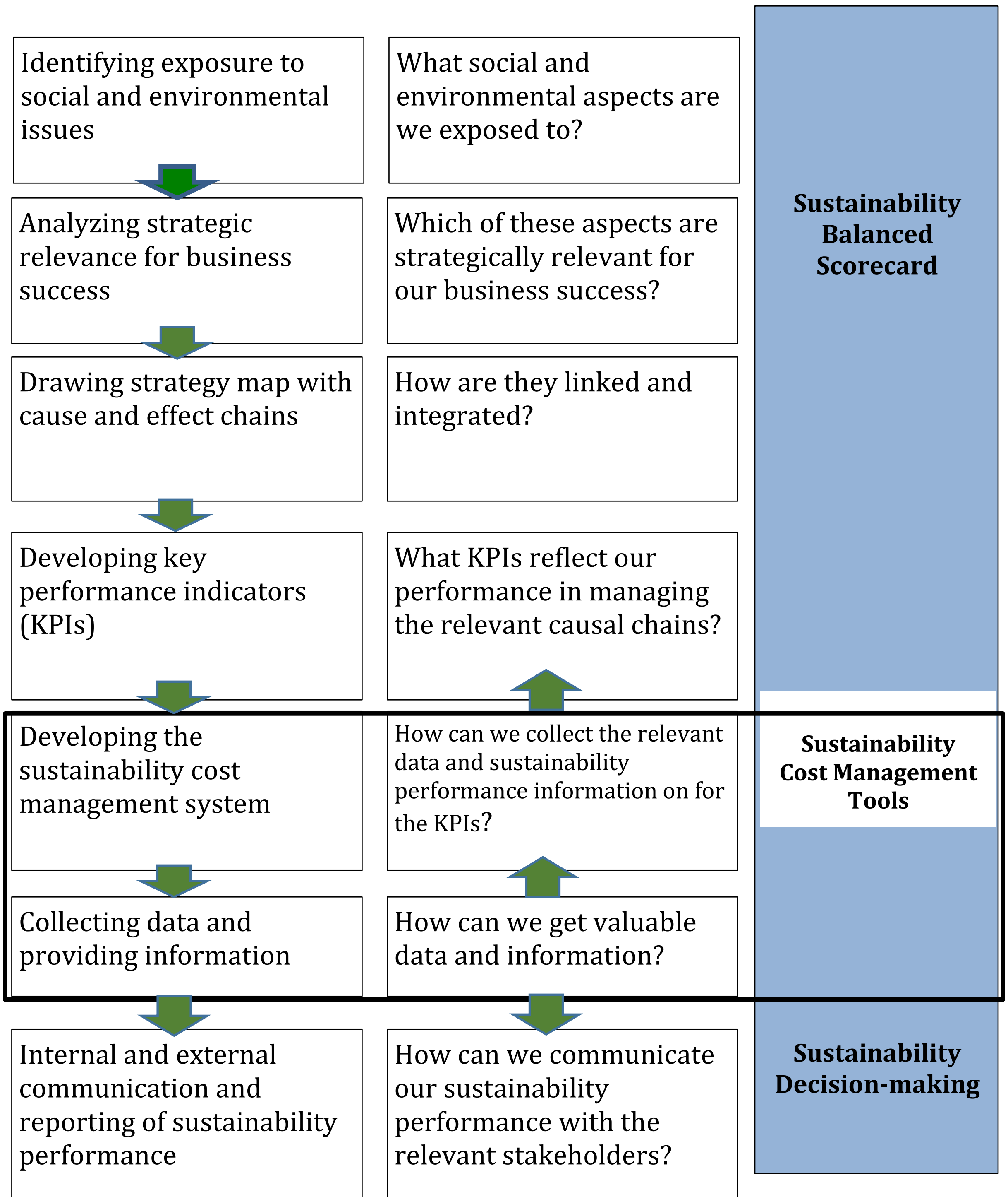

Figure (4): An integrated model for sustainability performance measurement and management linking the SBSC, SCM tools, and sustainable decisions making

4. Summary and Conclusions

For the last decade, corporate sustainability accounting has gained increased importance in practice, of which sustainable cost management receives the most attention. This paper suggests a typology of SCM tools that facilitate the integration of sustainability issues into management decision-making. The diversity of these tools is a response to the wide variety of motivations regarding types of sustainable decisions and goals of SCM that may lead a company to get interested in sustainability issues. As such, some tools allow the company to comply with laws and regulations, others to evaluate the improvement of its competitiveness and risk management, while others lead to the reduction of adverse impacts of its activities on the environment and society (social benefits/costs analysis). At the same time, each one of these three types of tools parallels support one these three goals of sustainable cost management (eco-efficiency, socio-efficiency, and eco-justice).

The following four issues may constitute some limitations for the use of sustainable cost management tools presented in this paper. First, the heterogeneity of these tools' components (e.g., physical units and monetary units, products and process, but also externalities) presents significant assessment issues. Second, in addition to presenting assessment issues; externalities are not subject to generally accepted values. Third, the definition of environmental costs is problematic because several definitions exist based on the interests of stakeholders, and it is sometimes difficult to distinguish the current operating costs. Fourth, the multidisciplinary nature of the sustainability require the leaders to collaborate with experts in natural sciences, sociology, law, engineering, environmental economics, etc.

However this paper neglect the fact that SCM tools are complementary and rely on each other. Thus, two interesting issues that future studies could suggest a consistent system of sustainable cost management to improve competitiveness and creating long-term firm value. Second, do an empirical study of the significant influence of sustainability cost management system on the motives of managers to incorporate sustainable issues in decision making and to align processes in firms with sustainability goals than does conventional financial and cost accounting system.

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