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Product-Oriented Environmental Management Systems (POEMS)

Improving Sustainability and Competitiveness in the Agri-Food Chain with Innovative Environmental Management Tools

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Foreword

Agri-food is one of the most important sectors for the environment, both in a positive (e.g., landscape safeguard and protection) and in a negative sense; therefore, a book addressing how to manage and improve the environmental aspects of agri-food processes and products in a systematic way, using Product-Oriented Environmental Management Systems (POEMS), is certainly welcome.

Presently in Europe agriculture has a gross added value of € 138 billion, with 13 million workers, while 40 % of the European land area is farmed (EUROSTAT 2010). The famous EIPRO study (Tukker et al. 2006) by the European Commission estimates that food alone is responsible for 17 % of overall emissions of greenhouse gases and uses 28 % of natural resources. Moreover, food wastage in Europe is estimated to be 90 million tonnes per year, corresponding to 180 kg per person per year (Barilla Centre for Food & Nutrition 2012). Taking into account the expected growth of food, fodder, and fibre demand (70 % by 2050), there is an apparent need for an increase by a factor of 4–10 in overall sector efficiency, compared to the present, if we want to achieve absolute decoupling of environmental impacts (WBCSD 2010). Indeed, the recent European Road Map for Resource Efficiency (European Commission 2011) is setting very ambitious targets for agriculture by 2020: 50 % reduction of waste and wastage; conservation of natural capital, biodiversity and ecosystem services; reduction of land use and improvement of soil quality; independence from fossil fuels. These targets require a sector capable of involving, besides the primary producers (often the weakest ring in the value chain), other stakeholders such as customers and consumers, investors, public decision makers, the processing industry, and retailers.

Sustainability issues, with complex problems involving multidisciplinary issues, regulatory aspects, and empirical knowledge, demand the active participation of all the above-mentioned actors. Therefore, sustainability decision-making should be supported and informed by scientifically sound quantitative information in order to discern values from facts, and to help a fair attribution of responsibility along the supply chain. In that sense, it is now widely recognised that life cycle thinking is the only way to support sustainability assessment, while avoiding the risk of problems shifting among impacts, environmental compartments, and life cycle stages. Life Cycle Assessment (LCA), as a standardised method (ISO 2006 a, b), is well known and widely applied in the food sector for the environmental assessment of a large variety of products (Notarnicola et al. 2012). Companies will have to face the required increase in efficiency by applying LCA, communication tools like environmental labelling and management tools to guide the organisation and its internal and external stakeholders throughout the whole dynamic process. This book is a perfect introduction to all these concepts and contains extensive literature research, which can be used to further investigate the matter.

A number of international initiatives are presently in progress for the purposes of reaching a broad consensus on a harmonised protocol for LCA studies in the food sector and for the communication of their results. Particularly important is the European Food Sustainable Consumption and Production Round Table,[1] jointly chaired by the European Commission and trade associations. Its goal is the identification of scientific, reliable, and harmonised methods for the environmental assessment of food and drinks in their life cycles, named the Envifood protocol. Presently (September 2012), the final draft of the Envifood protocol is almost ready for wide public consultation and a testing period.

Certainly, once systems have been evaluated and improved, communication of environmental excellence is a means of gaining value from this effort. Integrated Product Policy (European Commission 2003) and, more lately, Sustainable Consumption and Production Policy (European Commission 2008) include environmental labelling as a means both for communication and for promoting customer behavioural change. The up-to-date Chap. 8 is a perfect text for introducing companies to this topic. Moreover, the guidelines contained in Chap. 9 and the practical implementation of the guidelines in an Italian company operating in the pasta supply chain, described in Chap. 10, make these texts extremely useful. We can read how the companies involved see the optimised procedures developed during the project as easy to implement and useful to their business needs.

One critical characteristic of the agri-food sector is the widespread presence of small- and medium-sized enterprises (SMEs). In Italy, for example, the average size of the 1,620,884 farms is as small as 7.9 hectares, employing on average only 2.4 employees (ISTAT 2012). Micro and small enterprises require very specific environmental assessment and management tools, able to address efficiently and effectively the trade-off between sound scientific basis and simplicity of implementation and use. Moreover, a large proportion of food sector enterprises lack professional knowledge of environmental issues. This fact, together with the very high number and fast changing nature of products on the shelves of the distributing companies, make a simplified approach to LCA a fundamental need, which is effectively addressed in this book. The approach presented in Chap. 6 on defining the user's needs and on quantitatively evaluating how different simplified LCA tools are adapted to those needs is especially interesting. Product-Oriented Environmental Management Systems (POEMS) are a promising way of solving this

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[1] http://www.food-scp.eu/

trade-off, as experienced in the recent past also in other sectors. POEMS, in a similar way to the traditional environmental management system, has an approach aimed at continuous improvement. Therefore, it does not require the achievement of a high degree of precision and accuracy in the environmental assessment of the product. What is important is that the product assessment be able to capture the presence of possible trade-offs and to identify the key environmental aspects on which to focus improvement measures.

The reader will find a thorough explanation of POEMS both in an extensive and fairly complete introduction, as well as in Part V of the book, which is based on the integration of other tools (Integrated Management System, Life Cycle Assessment, Product Environmental Labelling) thoroughly described in the text.

We very sincerely congratulate the authors for this important work and see this book as essential in helping the implementation of an environmental management tool, POEMS. Both of us highly appreciate the effort made to adapt the conceptual findings to SMEs, because a great part of our own research work, even performed together, has been focused on this type of organisation. The book is a clear step forward in the literature aimed at helping environmental management operability, as a result of the impressive network of researchers set up for the EMAF project, which will certainly mean continual improvement of POEMS conceptual framework.

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Preface

This book is the result of the coordinated work of a research group from four different Italian University Departments which carried out the Eco-Management for Food (EMAF) Project; this research project was conducted during 2010–2012 with co-funding from the Italian Ministry of Education, Universities and Research (PRIN 2008 *Improving sustainability and competitiveness of the Italian agri-food chain with innovative environmental management tools* No. 2008TXFBY).

The overall objective of the EMAF project was to develop, test, and consequently, spread a model of Product-Oriented Environmental Management System (POEMS), specifically tailored to companies operating in the Italian agri-food sector, aimed at supporting these firms (mainly SMEs) in the introduction of organisational innovations that allow them to manage and continuously improve the sustainability and competitiveness of their products/processes. Indeed, the EMAF project was based on increasing awareness of the environmental relevance of agri-food products and of the related need for companies to meet stakeholders' requirements regarding life-cycle product performance.

The main distinctive characteristic of the proposed POEMS model is its modular structure, as it is composed of a collection of management tools that can be applied, individually (Integrated Management System, Life Cycle Assessment, product environmental labelling guidelines) or as an integration of two or more elements, on the basis of organisations' specific requirements and of the objectives they aim to reach.

The research work conducted on these tools (combining theoretical and methodological phases with practical and applied steps) is presented in this book and the pathway and reasoning followed for carrying out the analysis on each tool can be summarised as follows:

- Integrated Management System—an Integrated Management System (IMS) is based on the combination of separate Management Systems (MSs) with the aim of planning, realising, controlling, auditing, and systematically improving a range of company performances to enhance efficiency and competitiveness. Although an IMS is a highly relevant management approach—capable of generating significant benefits, including less bureaucracy and paperwork, combined audits, fewer costs and more efficient management, and use of resources—to date there is no international formalised standard for the integration process. Within the EMAF project a priority was to design a methodology for IMS implementation—the backbone of POEMS—encompassing the Quality Management System (QMS) and Environmental Management System (EMS), addressed to the agri-food sector. A preliminary step in this context was a literature review of theoretical and empirical studies, focused on different perspectives, strategies, methodologies, and degree of integration. A model of IMS, specific to the agri-food sector, was defined: compatibility, similar terminology, procedures and documentation, but above all, the common structure of MSs based on the Plan-Do-Check-Act (PDCA) cycle, represented the methodological pillars of the proposed integrated approach. Finally, the application of the model was tested in a pilot company, operating in the tomato processing industry.

- Simplified-Life Cycle Assessment—dissemination and awareness of Life Cycle Thinking approaches and related methods, such as Life Cycle Assessment (LCA), is crucial among SMEs. LCA requires a large amount of validated general and sector-specific data. Since their availability and costs can be insuperable barriers for SMEs, preprocessed data and meta-data, use of standards and low cost solutions, such as simplified tools, are required.
  In order to identify a simplified LCA tool, tailored to the needs of SMEs in the agri-food sector, a four-fold approach was adopted. First, a meta-review of LCA case studies was carried out. Then, another review was performed in order for simplified LCA tools to be identified, both at a general and at a sector-specific level (agri-food sector). Third, a set of criteria was identified, based on which, the most suitable simplified tool for this case was selected. Finally, the simplified tool identified was implemented along with a full LCA, in order for its robustness to be evaluated.

- Product Environmental Labelling Guidelines—over the past few decades environmental labels and declarations have received greater attention on the international scene; this has led to the implementation of a policy which, starting from the concept that awareness of environmental problems leads interested subjects to a behavioural change, encourages producers to improve the environmental performance of their products, and stimulates consumers to get out of their habit of making purchases.
  In order to identify the general principles on which environmental labels and declarations are based, first a critical review was carried out of the most significant literature on labels and declarations in all fields of production; then the review was focused only on those labels and declarations usable in the agri-food field, trying to discover the influence they have had on the behaviour of consumers and preelaborated data producers. Starting from this accurate review, it was possible to identify the guidelines which represent an innovative instrument which, through the evaluation of the characteristics and the environmental impacts of a product/service, could be a suitable tool for assisting firms in their

choice of the most suitable environmental label for their own products. In the end, in order to verify their applicability and functionality, these guidelines were tested on a pilot firm in the pasta production chain.

- Product-Oriented Environmental Management System (POEMS) can be seen as a great opportunity for increased knowledge and competitive advantage for SMEs, but considering that there is still no standard reference, few studies are available in literature on POEMS and that SMEs need special guidance adapted to their size and sector activities, the definition of a POEMS model specifically tailored to SMEs operating in the agri-food sector was the main goal of the EMAF project.
  Pursuing this goal, a literature review of previous methodological and applicative studies of POEMS was performed, in order to identify the most appropriate methodological solutions for the agri-food industry; the information gathered allowed the definition of key issues, which were then translated into requirements for a POEMS model tailored to the needs of SMEs operating in the agri-food sector. Finally, in order to verify the effective functioning of this model, its implementation potentiality was tested in pilot companies, operating in two different agri-food supply chains.

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Part I
Background and Concepts

Chapter 1
Innovative Environmental Management Tools for the Agri-Food Chain

Roberta Salomone, Daniela Rupo and Giuseppe Saija

1.1 Introduction: Management of the Environmental Variable in the Agri-Food Sector

In recent years, management of the environmental variable in the agri-food sector has been continuously expanding, mainly as a result of a few drivers raising companies' awareness, such as the following:

- the growing interest of the market in eco-sustainable agri-food products also connected to the awareness that the environmental impacts associated with the production and consumption of food and agricultural products are relevant; for example, the Environmental Impact of Products—EIPRO study (Tukker et al. 2006) conducted by the European Commission showed that among the products consumed in Europe, those which have the greatest environmental impacts, from a life cycle perspective, are foods and beverages, along with the private transport and the housing sector (buildings, furnishings, equipment, energy for residential use, etc.);
- the need to increase the competitiveness of the food industry through the introduction of appropriate eco-innovations—indeed, even though the European food industry structure is particularly complex and articulated, with very

Sections 1.1, 1.2, 1.4, and 1.5 were written by Roberta Salomone and Giuseppe Saija, while Sect. 1.3 was written by Daniela Rupo.

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different supply chains,[1] one element that connects all the different agri-food firms is the significant presence of SMEs, variously placed along the entire production chain, often competing in a globalised international market, heavily dominated by multinationals. For this reason, one of the target actions of the European Commission is to stimulate innovation (including eco-innovation) in SMEs, precisely in order to increase, in such a situation, the competitiveness of European enterprises. Additionally, in traditional sectors, such as the agri-food industry, margins of innovation may be more limited, and working on issues of environmental sustainability, including for example the introduction of organisational innovations, may be of strategic relevance;

- the need to face this growing environmental awareness pushes agri-food companies to adequately manage all environmental impacts related to the processes and products included in the whole agri-food chain—consequently, these companies are called upon to govern the processes that extend beyond the limits of their own production sites, considering *Life Cycle Thinking* and *Life Cycle Management* approaches.

In this context, management of the environmental variable in the agri-food sector is mainly carried out through the use of *voluntary standards*. The high number of variables to be considered in the management of a firm in the agri-food sector certainly requires the adoption of an integrated management approach, encompassing system, product and process quality. In fact, agri-food firms, as enterprises in any other sector, have a series of tools at their disposition, based on international standards, which may be useful for the purposes of environmental management (Salomone et al. 2012a).

The standards considered to be most significant for single or integrated use for the management and assessment of environmental issues can be classified as "system standards" (such as ISO 14001 for Environmental Management Systems) and "product standards" (such as the ISO 14040 series for Life Cycle Assessment and ISO 14020 series for Environmental product labels and declaration). In fact, system standards, in general, are the most widely used, as they can be adapted to the real situation of each business, especially regarding management of contractual and mandatory aspects, as well as continual improvement processes; however, they have the significant disadvantage of being poorly perceived by final consumers. This is partly due to the low visibility of the relative acronyms, which can only be used on packaging with considerable limitations, so as not to create confusion among consumers regarding what is being certified (the organisation's management system and not the product), whereas regulated certification logos (quality marks and organic products) can properly be given greater prominence. A more suitable approach to environmental quality management in the agricultural and agri-food sectors is probably one based on using direct means of ensuring the

[1] In this book the terms "supply chain" and "product chain" are indiscriminately used to refer to all actors (parties or organisations) involved in the creation of a product or a service, from the extraction of raw materials to production, consumption and end-of-life.

environmental performance of products; capable of guaranteeing and facilitating social acceptability on the one hand and, on the other hand, greater appeal in more environmentally aware markets, which are expanding.

In addition to these considerations, nowadays businesses are held responsible for the impacts of their activities (so-called *extended producer responsibility*) in every phase of the life cycle of the products they make; therefore, companies have to manage processes that extend beyond their factory gates. This push towards moving the emphasis from the environmental impacts of individual production sites to those associated with products can be seen from numerous aspects including, for example: in the EU Green Paper on Integrated Product Policy (IPP), in the EMAS III Regulation, in the revision of the ISO 14001 standard and in the indications emerging from businesses with experience of a possible integration of the previously separate system (Environmental Management Systems) and product (Life Cycle Assessment, Eco-design, ecological labelling) fields, with the development of positive synergies. Therefore, the boundaries between an organisation pursuing its competitive strategies and other actors in the economic system, as well as those between process management and product/service management, have proved to be permeable whenever businesses decide to make a concrete commitment to improving their environmental performance (Andriola et al. 2003), so new approaches centred on the *product-orientation of environmental management* have emerged.

1.2 Product-Oriented Environmental Management: Moving Outside the Boundaries of Traditional Environmental Management

Product-Oriented Environmental Management (POEM) can be defined as "an approach for organising and operating a firm in such a way that improving the environmental performance of its products becomes an integrated part of operations and strategy" (de Bakker 2002).

A brief history of product-oriented environmental management is presented in van Berkel et al. (1999): its birth could be dated to 1989 when the Netherlands Environmental Policy Plan (NEPP) defined an environmental policy not merely focused on production processes, but also on products, by taking a life cycle approach. In 1995 the Dutch government changed its environmental product policy (with the PMZ programme)[2] pushing producers into making environmentally responsible decisions so that companies started to work on products, pursuing the continual improvement of their environmental performances. A European policy based on life cycle thinking and with a product focus was created only in 2001 with the Green Paper on Integrated Product Policy (European Commission 2001a),

[2] See Sect. 11.2.1.1.

which proposed a new strategy to strengthen and refocus product-related environmental policies and develop the market for greener products.

Afterwards, many companies increasingly realised that environmental benefits can be achieved by assessing products and organising, together with partners, measures and activities for the reduction of environmental impacts of products (PricewaterhouseCoopers 1999). With a product-oriented environmental approach the focus shifts from the individual organisation to the entire product chain with a focus on the life cycle stages which imply the most important environmental impacts in the supply chain; indeed, these impacts often appear in parts of the chain other than in the organisation in question (Jørgensen 2008). Considering that environmental improvements of products can be gained in each part of the product life cycle phases, several companies in the product chain should look jointly at how environmental effects can be reduced and how this can be translated into commercial benefits (Klinkers et al. 1999). Thus, dialog throughout the product chain should be considered as a precondition of success (Schmidt et al. 2001). When a company decides to put this approach into practice the environmental condition of the products, business opportunities, strategic targets and stakeholders' expectations should be evaluated (Schmidt et al. 2001). Indeed, by implementing a product-oriented approach, companies gain different benefits, such as (Brezet and Rocha 2001; Danish EPA 2002; Schmidt et al. 2001):

- greater knowledge of products (including their financial aspects and price calculation);
- closer coordination within the company and a better synergy between the environmental function and the firm's other functions;
- closer cooperation among firms thanks to better dialog and exchange of information with customers and suppliers;
- improvement of the company's strategic position in green markets;
- reduction of environmental impacts.

In literature more than one term is used to indicate environmental management approaches, activities, procedures and/or structures that go beyond firms' boundaries with a life cycle and/or a supply chain approach, often creating terminology that can be confused with the above mentioned definition of POEM. The most widely used terms cited in international literature[3] are:

- *Product-oriented Environmental Care* (PEC) is intended as an extension of environmental management aimed at allowing firms to control the environmental impact of their products anywhere in the chain and "product-oriented environmental management system could be regarded as a very promising solution to incorporating responsibility at the right places within the industry" (Klinkers et al. 1999). It can be specifically defined as "a systematically set up management system through which all efforts and activities within a company

[3] For each definition just one reference is cited, which does not necessarily represent the most widely quoted definition in international literature.

are structured in such a way that environmental effects of products or services within their product chain, under given preconditions (economically sound) are controlled, reduced and, where possible, prevented, in a continuous process" (PricewaterhouseCoopers 1999);

- *Inter-Organisational Environmental Management* (IOEM) is an environmental management approach that "involves learning about the environmental impacts throughout the supply chain and the life cycle of products, and interacting with other firms or organisations in the supply-chain to reduce these impacts" (Sinding 2000);
- *Life-Cycle Oriented Environmental Management* (LCOEM) is a form of environmental management that requires firms to examine environmental impacts throughout the life cycle of their products and that "can only be achieved through coordinated efforts of all parts of the organisation, its suppliers and its customers" (Sharfman et al. 1997);
- *Environmental Supply-Chain Management* (ESCM) is a form of supply chain management that involves introducing and integrating environmental practises aimed at auditing and assessing suppliers on environmental performance metrics; at the same time, suppliers should undertake measures that ensure the environmental quality of their products (Darnall et al. 2008);
- *Green Supply Chain Management* (GSCM)—for Srivastava, implementing GSCM means "integrating environment thinking into supply chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers, and end-of-life management of the product after its useful life" (Srivastava 2007);
- *Product-Oriented Environmental Management* (POEM) is a management tool "in which by taking a systematic approach all processes and activities in a company can be organised such that the environmental impact along the product chain can be constantly controlled, minimised and avoided wherever possible" (Brezet et al. 2000);
- *Product-Oriented Environmental Management Systems* (POEMS or P-EMS) or *Product-Based Environmental Management Systems* (PBEMS) are all synonyms that indicate an extension of traditional process-oriented Environmental Management Systems (or a stand-alone tool including EMS) in order to facilitate the integration of environmental product considerations into the process of continual improvement (Brezet and Rocha 2001; Donnelly et al. 2004; van Berkel et al. 1999).

Although this list may not be exhaustive, it refers only to cases directly or indirectly linked to environmental management practises, activities and tools that imply co-operation between a firm and suppliers and/or customers aimed at evaluating, controlling and managing environmental issues connected to a product. The above mentioned terms (which always embrace life cycle and/or supply chain approaches) are often synonyms, but in other cases their meaning may have a different scope. For example, POEM, IOEM and LCOEM are more general, indeed they are umbrella terms that may include ESCM, Life Cycle Assessment, Industrial Ecology, and other tools and practises that involve an inter-organisational efforts and a lifecycle perspective. On the contrary, POEMS, P-EMS and PBEMS specifically refer to Environmental Management Systems (EMSs) and always include this type of management structure in their framework. Therefore we can conclude that POEMS, P-EMS and PBEMS are systems that can be certainly included in the wider category of "inter-organisational environmental management" (IOEM) and of "life-cycle oriented environmental management" (LOESM) and are strongly related to *Life Cycle Management* (LCM) and *Supply-Chain Management* (SCM) approaches.

Without a doubt the growing interest shown by society in the environmental consequences associated with the whole product life cycle is a key pressure towards the diffusion of product-oriented environmental management approaches in firms; however, for their successful implementation systematic procedures need to be developed and inserted into a routine organisational activity, such as an EMS. Indeed, investigating the various above mentioned concepts, some authors (e.g., Ammenberg and Sundin 2005a; Donnelly et al. 2006; van Berkel et al. 1999; etc.) highlighted the important role that standardised EMSs may have in the pursuit of product-related environmental goals and in the implementation of product-oriented environmental management approaches; this role is explored here below, presenting a brief overview of the reasons for which standardised management structures should be used as a basis for product-oriented environmental practises.

1.2.1 Products in Environmental Management Systems

In the wide and diversified range of environmental management tools that firms can use in pursuit of sustainability goals, EMSs are certainly the most widespread in every different productive sector; indeed, at January 2007, more than 134,400 companies in the world had an EMS in compliance with ISO 14001 and/or EMAS Regulation (Corporate Risk Management Company 2012; Eurostat 2011).

The success of this environmental management tool is demonstrated by the fact that the number of certifications/registrations has grown steadily over time, however, considering the above mentioned product-related issues, its major limitation is the fact that EMS only cover the organisation itself, without considering the environmental aspect of the life cycle, thus limiting the organisation's environmental improvement actions and the consequent market opportunities to be potentially exploited (De Lima Ottoni 2010; Kim 2008). Indeed, in industrial experiences, EMSs have a primarily internal orientation, usually being directed at site level (Klinkers et al. 1999) because companies mainly implement site-specific procedures aimed at reducing emissions through process improvements. In these cases, EMSs often lack a life-cycle perspective on products, so companies have a limited perception of the environmental impacts of their products (Ammenberg and Sundin 2005a, b), with the result that concentration on internal performance may be less effective since environmental impacts may go beyond firm boundaries (Sinding 2000).

Therefore "if managers wish to minimise their company's impact on the natural environment, logic dictates that they look at all the effects, not just those specific to a single production or service process" (Sharfman et al. 1997), and to do so they need to move outside the boundaries of a traditional environmental management system, changing the focus from site-specific processes to the whole product-chain, implementing product-oriented approaches.

Indeed, despite this criticism of EMS, there are several aspects which indicate that products can be properly managed in the structures of the standardised EMS and that traditional EMSs are a useful starting point for product-orientation work with a life cycle and/or a supply chain approach:

- *several product-related issues are integrated into the EMS standards*—the EMS standards require that companies pay attention not only to environmental issues regarding the production process, but also to their products and services, and product-related references are quite often cited in both the EMS reference documents—i.e., ISO 14001 (International Organization for Standardization 2004a) and EMAS Regulation (European Commission 2009) - with potential significant consequences in terms of management of product environmental issues, even if "it is uncertain to what extent normal EMSs encompass and influence the environmental load of products" (Ammenberg and Sundin 2005a);
- *the EMS framework is a useful support for the implementation of product-related strategies*—indeed, some authors (e.g. Brezet and Rocha 2001; Ammenberg and Sundin 2005a) suggest that an EMS provides an adequate structure for helping a firm acknowledge its own product environmental problems, implementing product environmental improvement strategies, providing consistency through the allocation of resources, assignment of responsibilities and ongoing evaluation of practises, procedures and processes. Even though EMSs are not a guarantee of continual improvement of product environmental performances—which depends on effective strategic choices by companies (Brezet and Rocha 2001)—it is indubitable that EMS structure may be a significant starting point, albeit insufficient, for addressing and implementing product environmental improvement strategies. The fundamental aspect is to integrate the requisites and the additional activities "into strategic management and the daily operation of companies in a dynamic process of continuous environmental performance improvement" (Brezet and Rocha 2001) and this aspect can be ensured by the organisational structure of an EMS;
- *significant synergies exist between EMS and life cycle tools*—life cycle management tools such as Life Cycle Assessment (LCA) can be used in EMS in order to evaluate environmental performance and to identify significant environmental aspects of an organisation's products and services (Lewandowska 2011). ISO 14001 and EMAS do not specify the tools that should be used for the identification and assessment of environmental aspects, but ISO 14004 states that "there is no single approach for identifying environmental aspects and

environmental impacts …" (International Organization for Standardization 2004b). Furthermore, EMS standards contain requirements that should be adapted to the real situation of the company applying them and third-party certification will check if the company satisfies the requirements, but the method used to meet them is optional. This means that LCA can be considered as a suitable tool in this context. Remaining on this subject, a survey conducted by Zobel et al. (2002) revealed that the identification and assessment of environmental aspects in an EMS context can differ considerably among different organisations and may be influenced by personal value judgements, with the result that the environmental managers interviewed felt that the most common improvements should be the use of more objective and similar methods among the different units of a company and LCA is suggested as the scientific method that can satisfy these requirements. Indeed, although an LCA study only allows the potential environmental impacts associated with a product to be identified, while EMS needs detailed impact modeling, LCA certainly enables a broadening of the review of environmental aspects with indirect aspects related to the whole supply chain, using a well-established impact assessment methodology, generating results scientifically relevant and reproducible (Lewandowska et al. 2011);

- *significant synergies exist between EMS and Green Supply Chain Management (GSCM)*—GSCM is highly coherent with EMS, indeed, for organisations, GSCM involves measures oriented to requiring suppliers to undertake actions that ensure the environmental quality of their products; it also sometimes includes measures intended to inform buyers on how to reduce the environmental impact when they are using the product, so that practically organising management activities embracing the chain from suppliers to consumers. GSCM and EMS practises are strongly complementary: their measures and actions aim to reduce direct and indirect impacts of an organisation; they both rely on the Deming Cycle continual improvement model; EMS offers a management structure to support supply chain management decisions that affect the environment, etc.; but the great difference is, once again, the different perspective (the organisation in EMS and the whole chain in GSCM), so for an organisation, GSCM activities involve greater external contacts than EMSs and this may require additional skills outside the EMS framework (Darnall et al. 2008).

The similarities and potential synergies between EMS and other product-oriented tools and approaches (e.g. eco-design, eco-labelling, etc.) could be analysed in greater depth, but it is already clear that there are strong incentives to integrate product management into EMS, because the product life cycle perspective could enrich and broaden the scope of EMS (Ammenberg and Sundin 2005a) bringing benefits in terms of resolution of environmental pollution problems, better relations with the other actors involved in the supply chain, and market orientation of the environmental activities performed. So, even though traditional EMSs do not practically encompass products into their procedures, there is a growing need to incorporate life cycle perspective into the more general environmental management of an organisation and also to be able to manage the indirect aspects associated with product and services, within a structured framework, with a scientific method and with a supply chain focus. It is for all the above mentioned reasons that a growing number of organisations that pay great attention to environmental issues are therefore experiencing the need to integrate system standards (e.g. ISO 14001) with product standards (e.g. ISO/TR 14062 on Eco-Design, ISO 14040 series on Life Cycle Assessment, and ISO 14020 series on environmental labelling on products), progressively shifting attention from system/process to product/service.

In line with this orientation, during the 3rd Integrated Product Policy Expert Workshop on IPP (European Commission 2001b), some of the participants identified three types of EMS with a broader focus (Product-Oriented Environmental Management Systems—POEMS—which focus on products; Organisation-Oriented Environmental Management Systems—OOEMS—which focus on the site or organisation; Integrated Environmental Management Systems—IEMS—which integrate ISO 14001 and EMAS) and finally *Product-Oriented Environmental Management System* (POEMS) was indicated as the standardised management system useful for the integration of products into firms' strategies and this work certainly influenced the ISO 14001 and EMAS revisions (Kim 2008). The importance of POEMS was then newly confirmed in the communication of the European Commission to the Council and European Parliament, with particular reference to its role in the development of the concept of product life cycle (European Commission 2003).

1.2.2 Product-Oriented Environmental Management System

POEMS is a new framework designed to bring together traditional environmental management systems and tools oriented towards improvement of the environmental performances of products. The abovementioned considerations highlight the increasing need for integration between system standards and product standards and, as a result of this, alongside management "tools" that are already widely used (ISO 14001 and EMAS), companies have started to appreciate other "tools" that are oriented more towards the management of environmental performances of products (Life Cycle Assessment, Eco-Design, ecological labelling).

One of the most widely used definitions of POEMS to be found in the limited literature available is the one provided by Rocha and Brezet: "an environmental management system with a special focus on the continuous improvement of a product's eco-efficiency (ecological and economic) along the life cycle, through the systematic integration of eco-design in the company's strategies and practises" (Rocha and Brezet 1999). Another definition, which is more appropriate for the agri-food sector as it is not unequivocally tied to eco-design and is, thus, also applicable to companies that do not deal with product design, is the one coined by de Bakker (referred to the more general POEM): "a systematic approach to organising a firm in such a way that improving the environmental performance of its products across their product life cycles becomes an integrated part of operations and strategy" (de Bakker et al. 2002).

Currently, there are no prescriptive standards for POEMS and the only elements that can offer methodological references are the Spanish UNE 150.301 standard and the ISO 14006; the Spanish standard was used as a basic reference point for the ISO one and both relate to the insertion of eco-design into environmental management systems. Despite there still being no standard reference and few studies available in literature—mainly in manufacturing industries and only early attempts in the food processing industry (van Berkel et al. 1999) and in the agri-food sector (Ardente et al. 2006)—a growing number of organisations are experiencing the need to integrate environmental management system standards with those addressed to the environmental evaluation of products, shifting attention from system/process to product/service (Salomone et al. 2011).

Thus, within a context in which organisations are showing increasing interest in ways of integrating system standards and product standards, there is certainly great interest in being able to create a POEMS model that reflects the real needs of companies and their stakeholders, also considering the lack of a uniform and widely accepted methodology, exploring its benefits both in the environmental and in the economic dimensions. In particular, the role of economic benefits (e.g., cost savings through eco-efficiency, reduced risk, improvement of the firm's/product's image and market position, etc.), should be investigated in detail, because very little is written on how POEMS affects firm's performances, and the drivers that may push companies to implement POEMS should be clearly identified, as they can vary depending on the sector of production and the specific organisational and strategic conditions in which a firm operates.

1.3 The Role of POEMS in the Improvement of Economic and Competitive Performance

The existence of a mutual benefit between environmental and economic performance is usually considered as a basic assumption of sustainable development. As mentioned in the previous section, the framework of POEMS itself is designed in order to support an environmental system focused on the continual improvement of both ecological and economic product eco-efficiency along the life cycle (Rocha and Brezet 1999).

This section is intended to focus attention on some relevant issues of the relationship between environmental and economic performance, regarding the implementation of POEMS in the agri-food sector:

- the relevance of economic issues in the adoption of environmental management systems by firms;

- the pros and cons of accounting for the environment, with regards to the integration of the economic variable into the accounting system in the Life-cycle approach;
- the benefits of POEMS in the improvement of economic and competitive performance, at firm level and at supply chain level.

1.3.1 The Relevance of Economic Issues in the Adoption of Environmental Management Systems

Achieving sustainable development often represents a strategic business decision, which plays a key role for the competitive advantage of a firm. The reasons why firms are embracing sustainable development at a strategic level are both ethical and economic.

The size of the firm can probably explain the predominance of ethical or economic reasons underlying the choice to go green. There is evidence, in this regard, that economic benefits are not a relevant issue for SMEs, whose interest in environmental management systems more likely springs from the will to improve: organisational and managerial efficiency; continuous monitoring of compliance; corporate reputation (Biondi et al. 2000). Though there is general acceptance of the virtuous cycle embedding the three dimensions of sustainable development—economic, environmental and social results –, into the ongoing debate over the value relevance of environmental management systems, evidence points to different results in different contexts. Whether or not the choice to invest in environmental management systems is associated with the aim of pursuing economic benefit, and independently of the awareness of the economic implications of such decision making, significant economic benefits are always associated when optimising resource use. The lack of awareness of economic benefit is often the necessary consequence of the lack of information in financial and in management accounting. Green (or environmental) accounting is suggested to overcome this "information gap", encompassing environmental benefits and costs into decision-making.

1.3.2 Accounting for the Environment: The Pros and Cons in the Life-Cycle Approach

1.3.2.1 The General Aspects of Environmental Accounting

The widely accepted view that financial and non-financial data are traceable to the same framework of knowledge, being complementary in supporting decision making, highlights the existence of an “overlapping area” between the two types of information.

With regard to environmental issues, assuming that the environmental accounting domain is independent of the accounting information system leads management to underestimate the economic and competitive implications of environmental choices. Based on the assumption that “if you can’t measure it, then you can’t manage it”, management accounting is the prominent area of interest of environmental accounting, aiming to measure (in monetary terms) the consumption of factors of production (costs) and the results associated with the incurrence of such costs. While the latter are characterised by a greater degree of uncertainty, since it is very difficult to correlate the value created for only one of its potential determinants, the former is affected by the typical arbitrariness and uncertainty of cost accounting (Rupo 2001). Nevertheless, companies who follow the path of eco-management, sooner or later, have to adapt their cost accounting systems for the identification and proper allocation of environmental costs to their activities, processes and products. Information systems in use often allow the recognition of only a few types of costs among those related to the environment. Traditional accounting systems usually include these costs among general expenses (overheads), and this makes it harder to identify what causes the cost to be incurred (cost-driver). This could be justified only if environmental costs are supposed to be low, with the result that environmental accounting proves to be relatively expensive. Otherwise, the increasing importance of environmental costs, and the need to balance ethical and economic objectives, encourages companies to change their cost accounting systems, in order to have reliable information for decision making in the environmental field.

The integration of the environmental variable into the accounting system is direct detection of the so-called “green bottom line”, by which we mean the impact on business outcomes resulting from the adoption of environmentally friendly policies. Authoritative doctrine in this field has focused on the main objectives of environmental-related management accounting, which can be summarised as follows: (a) demonstrating the impact on economic and financial performance associated with environmental management; (b) identifying opportunities for cost reduction and other improvement opportunities; (c) defining environmental priorities; (d) product-pricing and definition of product mix; (e) enhancing customer value; (f) supporting investment appraisal and other long-term decisions; (g) supporting sustainable business (Bennet and James 1998). In short, environmental accounting provides insight into the evaluation of environmental impacts and of the associated financial effect, hence being a suitable tool for strategic planning and management control (Burnett et al. 2007). Together with various standardised procedures, such as 14001 for EMS, ISO 14040 series for LCA and ISO 14020 series for environmental product labels and declaration, environmental accounting can assist companies in managing, measuring and improving the environmental effects of their products/services and processes.

1.3.2.2 The Multi-Dimensional Notion of Environmental Cost and the Boundaries of the Accounting System

The scope of the environmental accounting system is related to the type of costs included in the system. Environmental costs have a wide range of meanings, corresponding to different theoretical approaches and practical purposes. Therefore, it is necessary to mark off the boundaries of the accounting system, distinguishing between *internal* (private) environmental costs, and *external* (societal) environmental costs. The former are costs incurred by the company, at its discretion or in accordance with legal rules, the latter represent the cost burden on society as a result of the business and which can be expressed by the depletion of resources and the consequent decrease in welfare and quality of life. It is well-known that the boundaries between internal costs and external costs are becoming more and more blurred, as a consequence of the growing pressure deriving from regulatory measures—enactment of laws, standard setting, threshold-parameters –, aimed at building the progressive internalisation of environmental costs, through the imposition of penalties for contraveners.

Another useful criterion in the definition of environmental costs is the reference to *time*. It must be clarified whether it is worth considering, in addition to costs already incurred, those costs which the company (or society) may incur in the future due to current or past choices. Despite the difficulties inherent in estimating future costs, companies should be aware of them, in order to set plans and programs on a rational basis.

Finally, but no less important, is the distinction between the costs incurred by actions to *prevent*, reduce or eliminate, the environmental impact, and the costs that the company is obliged to pay in order to *repair* environmental damage caused, in the form of fines, penalties or compensation for damage caused by past actions (environmental losses). It is quite evident that while the former are expected to produce future benefits, being the expression of the company's commitment to the environment, the latter represent, at most, the reparation due for conduct contrary to the environment. Accepting the narrow meaning, which is coherent with the European approach to Financial Accounting, it is possible to uncover the environmental costs incurred by the company for activities intended to prevent, reduce or eliminate the environmental impact of products and processes, and the costs incurred to preserve environmental resources.

1.3.2.3 The Integration of the Economic Variable in the Life-Cycle Approach

LCA supports the evaluation of the potential environmental impacts associated with a product, process or service, allowing the identification of solutions for the environmental improvement of the system under study. Due to its nature, LCA handles only physical data and does not enable the identification of the most cost-effective means of making environmental improvements. On the contrary, Life

Cycle Costing (LCC) is designed to compare the cost-effectiveness of alternative investments, enhancing consideration of the economic aspects of environmentally related decisions (Norris 2001). In its broader original meaning, LCC is designed to identify all the environmental costs—internal and external—associated with a product, process, or activity throughout all stages of its life (Epstein 1996). The objectives pursued are, as a matter of principle, to optimise the use of resources and reduce overall costs along the life cycle. LCC goes beyond the gate of the single firm, extending the analysis to the whole supply chain, and including the phase of consumption until end of life of the product. This configuration corresponds to the wider definition of environmental costs, embracing current and future costs, private and societal costs, associated with a product or process covered by the calculation, with the objective of evaluating the full life-cycle, encompassing each phase from raw material extraction to the end-of life phase of the product or process (from cradle to grave). In this perspective, the cost analysis integrates the LCA procedure, being focused on the economic impact (cost) rather than on the determination of physical inventory.

Therefore, the potential of LCA methodology to improve environmental performance of products/services can be emphasised through integration with accounting tools. The life-cycle assessment, as a domain of the accounting system, entails coupling a quantitative value (in monetary terms) to environmental impacts associated with a project or a product by assessing the potential environmental and social impact associated with identified inputs and releases, so as to support decision making.

It's worth considering that, both in literature and in practice, the boundaries of LCC are defined in different ways, according to the approach adopted for the estimation of external and future costs. The subjectivity underlying the evaluation of such costs probably represents the most important limitations of LCC, emphasising the arbitrariness of any cost-accounting method. In fact, only the *societal LCC* includes societal costs and extends the time horizon to the long term. The more recent SETAC position, for example, is to encompass in the LCC all the costs incurred by firms operating in the supply chain, extending the analysis only to those external costs which are expected to be internalised in the decision relevant future. Given the difficulties incurred in the evaluation of all relevant costs for LCC, many firms prefer the adoption of partial LCC, especially in the pilot phase.

Realising the importance of monitoring economic effects of environmental management systems, an LCA procedure represents a necessary input for costs assessment, providing LCC with data for the cost inventory and subsequent allocation to cost types.

It is possible to argue that the greater the accuracy and reliability of LCA, the greater the reliability of cost accounting (and LCC) and the trustworthiness of information for decision making. Thus, the first step is to set up a suitable methodology for LCA, in order to properly assess environmental impacts; it is then worth encompassing economic implications in the decision making process, implementing adequate environmental cost accounting methods (such as LCC and Total Cost Accounting), as part of the same integrated information system.

1.3.3 The Benefits of POEMS in the Improvement of Economic Performance at Firm Level and at Supply Chain Level

A POEMS can assist uniform and widely accepted methodology in the improvement of environmental, economic and competitive performance, thanks to its following features:

- a structure compatible with the flexibility of the accounting information system and/or with gradual implementation of economic/financial measures related to environmental performances;
- the source of data gathered when implementing the product management system, which enables evaluation of the firm's strategy, on the assumption that improving product environmental performance across product life cycles is bound to become a key factor in operations and strategy;
- the potential benefits at the supply chain level, considering that adoption of EMS has impacts on the three pillars of the triple bottom line.

Once POEMS is implemented in firms, it is expected that variables to be included in the measurement of environmental performance will be developed, and then integrated within the accounting information system, in order to support a more comprehensive evaluation of firms' performance. The availability of data from LCA, suitable to be processed for management decision making and for external reporting, provides a framework for testing the coherence of financial, social/environmental and competitive relapses of strategic planning and of voluntary and mandatory reporting.

Given the perspective adopted in a POEMS, its implementation will offer a good "test bed" for assessing the impact of sustainable operations on the triple bottom line both: *at the firm level*, in order to verify the profitability of alternative choices, given a certain priority in the environmental perspective, and *at the supply chain level*, in order to verify whether the adoption of collaborative practises with supply chain partners could have positive impacts on economic and social performance.

A recent empirical survey (Gimenez et al. 2012) shows that the implementation of internal environmental programmes produces positive effects on the components of the triple bottom line (social, environmental, economic). Environmental initiatives lead to lower manufacturing costs, through the optimisation of resource use and the reduction of reparation costs; at the same time, sustainable operations improve brand image and stakeholder relations. On the other hand, the results of the empirical study point out that supply chain collaboration has a significant impact on the triple bottom line, suggesting that the partnership approach should be preferable, since collaboration with suppliers and customers pays off in terms of improvement of environmental and social performance.

These results highlight that a firm engaged in POEMS implementation is expected to produce positive impacts on the various dimensions of its success (competitive, economic, social) other than it being desirable for environmental purposes. Finally, the adoption of collaborative schemes with suppliers and customers is considered the best way for implementing a sustainable initiative, while the exclusion of suppliers that fail to meet standard requirements could be unsuccessful.

1.4 A POEMS Framework for the Agri-Food Industry

Starting from the emerging interest in ways of integrating system standards and product standards described in the previous sections, the research project Eco-Management for Food (PRIN No.2008TXFBYT), co-funded by the Italian Ministry of Education, Universities and Research—MIUR (EMAF 2012), was designed in order to propose, test and, consequently, spread a model of POEMS, specifically tailored to companies operating in the Italian agribusiness sector, aimed at supporting these firms (mainly SMEs) in the introduction of organisational innovations that allow them to manage and continually improve the sustainability and competitiveness of their products/processes.

In the belief that the most appropriate definition of a POEMS model should be structured following a *Life Cycle Management* (LCM) approach, the main findings of the United Nations Environmental Programme (Remmen et al. 2007) were used as a starting point for the identification of the key elements of the POEMS. In particular, the POEMS model should be:

- a product management system with a life cycle perspective and a chain vision—indeed "LCM is a product management system aiming to minimise environmental and socio-economic burdens associated with an organisation's product or product portfolio during its entire life cycle and value chain…"(Remmen et al. 2007);
- based on the continual improvement of product performances—indeed "LCM is making life cycle thinking and product sustainability operational for businesses through the continuous improvements of product systems…" (Remmen et al. 2007);
- structured as a set of tools ensuring the most appropriate management of the main priorities of the firms that implement it—indeed "LCM is not a single tool or methodology but a management system collecting, structuring and disseminating product-related information from the various programmes, concepts and tools incorporating environmental, economic, and social aspects of products, across their life cycle…" (Remmen et al. 2007).

In order to specify which tools should be embedded in the POEMS model and to successfully apply this framework in agri-food firms, the first step was to identify the main sector-specific barriers to LCM implementation; then, the identified barriers were used as starting points for setting the success factors, the solutions to overcome barriers and achieve the success factors and, finally, the POEMS model tools that permit the identified solutions to be reached.

This path allowed the EMAF project partners to identify the tools that constitute the final framework of the POEMS model:

- *Integrated Quality and Environmental Management System* (ISO 9001 and ISO 14001 or EMAS Regulation)—one of the most frequent obstacles encountered in the implementation of LCM approaches is the resistance to change that many organisations show when employees are asked to change their old ways of working. This barrier is mainly due to a lack of internal environmental awareness, so it should be dealt with by spreading an environmental cultural change and involvement through proper environmental training and dissemination activities, which are fundamental processes of Environmental Management Systems (EMS). Another specific barrier to LCM implementation is the dispersion of environment-related information, which should be dealt with through a structural and organised vision of the environmental aspects that the firm has to face. The structural organisation of EMS certainly offers a solution to this problem, but little attention is paid to product performances in EMS, while LCM strategies need to be targeted on products. The internalisation of product requisites within the environmental management structure can be ensured by the integration of EMS with a Quality Management System. All these considerations lead to the choice of an Integrated Management System as the most suitable tool for facing this group of barriers;
- *Simplified Life Cycle Assessment*—a very common feature in agri-food firms (but also widespread in other production sectors) is the main focus on short-term problems and the lack of chain management responsibility. In order to contrast these aspects, the internalisation of a chain management vision and long-term value creation should be assured by implementing LCM and Life Cycle Thinking (LCT) approaches. These approaches require detailed knowledge of the environmental issues connected with the whole life cycle of the product. However, a lack of awareness of product life cycle environmental impacts usually affects firms in this field. Organisations that aim to identify their product life cycle environmental impacts may use the Life Cycle Assessment (LCA) methodology, but poor access to the large amount of life cycle data, the lack of in-house expertise and the costs associated with its implementation, make it highly necessary to define *Simplified LCA approaches*, in order to allow SMEs to perform environmental assessment by themselves using an easily understandable tool;
- *Guidelines for the Environmental Product Communication*—although environmental awareness is constantly increasing in many businesses, environmental commitment is still not perceived as an opportunity, so the success strategy is

represented by the ability to transform the environmental measures taken into commercial advantages, for example through accurate environmental product communication. The problem is that single firms encounter many difficulties in whole chain involvement, whereas product communication requires a life cycle perspective and a chain vision. The only solution is represented by spreading an external environmental cultural change and involvement throughout the supply chain with environmental training and external dissemination. In addition, the choice of the most suitable form of environmental message may be a complex and uncertain one for firms to make, so guidelines targeted at helping them in the identification of the proper environmental label declaration are absolutely necessary (*Environmental Product Labelling and Declaration guidelines—EPLD*).

The above described path to the definition of a POEMS framework is summarised in Fig. 1.1; the path efficiency is enhanced by the fact that each tool can provide multiple solutions for overcoming several barriers.

This book presents the individual environmental management tools of which the POEMS model is made up, with a description of their methodological structure and the main results of their implementation in different pilot agri-food companies, in order to verify their effective functioning and to highlight the strong and weak points of the POEMS model and of its individual fundamental elements.

Indeed, the innovative character of the POEMS model presented in the EMAF project has a double dimension connected to the fact that:

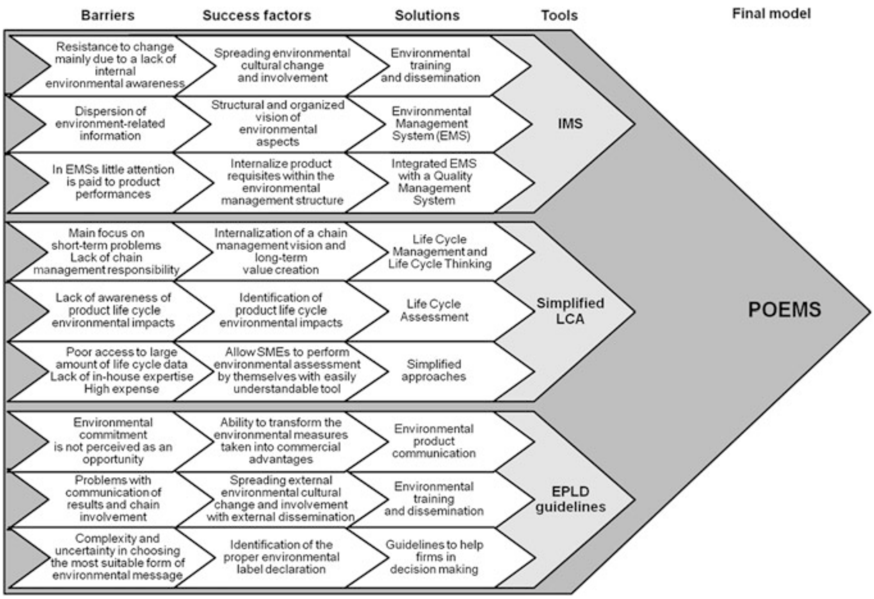

Fig. 1.1 The path towards the final POEMS model (Salomone et al. 2012b)

- each environmental management tool included in the POEMS framework is individually developed in its methodological structure and then applied in pilot firms;
- each environmental management tool can be observed both with a single and an integrated approach, offering agri-food organisations a "modular" format that refers to each tool separately and to the POEMS in general. In this way, whatever the starting point of the firms and whatever their targets, they will find an answer and a strategy via which they may formulate their own route to eco-compatibility.

This double dimension is also translated into a coherent structure of the book as described in Fig. 1.2.

Each single part of this book can be read independently from the others. Each part (except Part I—Background and concepts) is structured on three different levels of analysis (literature review, methodological structure and case studies in pilot firms) corresponding to three different chapters for each part:

- part I describes background and concepts useful for understanding the field and the main topics covered in the other chapters;
- part II describes the state-of-the-art of Integrated Management System, the methodological structure of a framework for agri-food SMEs and its application experience in a pilot firm of the tomato processing sector;
- part III describes the state-of-the-art of Simplified Life Cycle Assessment approaches and tools, the methodological structure of a framework consistent with the needs of agri-food SMEs and its application experience in a pilot firm of the wine industry;

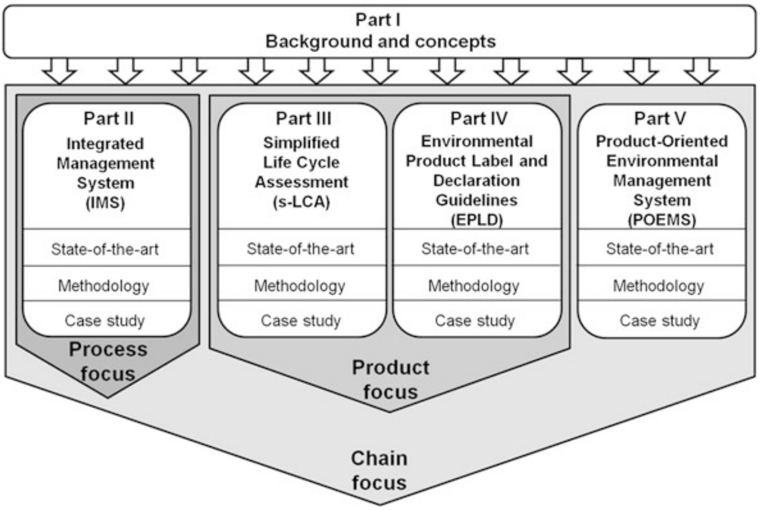

Fig. 1.2 How to read the book

- part IV describes the state-of-the-art of environmental labelling practises in the agri-food sector, the structure of Environmental Product Label and Declarations Guidelines tailored to the characteristics of agri-food SMEs and their application experience in a pilot firm in the pasta production sector;
- part V describes the state-of-the-art of product-oriented environmental management systems, the methodological structure of a POEMS framework for agri-food SMEs, resulting from an integration of the previously described tools, and its application experience, with different levels of integration, in pilot firms in the olive oil production sector and in the roasted coffee production sector.

Moving from part II to part V, the environmental management standpoint gradually widens, progressively focusing on a process, product or supply chain perspective.

1.5 Conclusions

Ways of managing the environmental variable have changed a great deal since problems associated with pollution produced by human activities were first faced. Indeed, following the evolution of environmental policies, businesses have moved from a command-and-control approach towards a proactive approach and, consequently, a set of new tools for environmental management have been developed.

Nowadays, the majority of the EMSs implemented in firms are based on standards (e.g. ISO 14001) that allow improvements of the environmental performances of production processes in a flexible way; therefore, they are mainly oriented towards the internal operations of a company. However, growing interest in the environmental impacts of products along their life cycle opens the way to new scenarios. Indeed, the availability of product environmental tools and the development of IMS models enable the implementation of management systems that incorporate processes realised, partially or entirely, beyond the boundaries of a company, according to a supply chain logic. In such situation, a POEMS can play an important role, because it allows a company to manage both economic and environmental performances. The above considerations are valid for companies in any sectors, but they take on a special significance in the agri-food sector where the expectations of stakeholders are related to factors of food product quality (e.g. food safety), and of a cultural (e.g. tradition) and ethical-social nature (e.g. environmentally responsible behaviour). In conclusion, the development of a dedicated model can be an important aid for guiding agri-food SMEs in the implementation of a POEMS, in order to allow compliance with mandatory rules and specific customer requests, while improving economic and environmental performance and maintaining competitiveness.

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Part II
Integrated Management Systems (IMS)

Chapter 2
The Integration of Quality Management and Environmental Management Systems

Maria Proto, Ornella Malandrino and Stefania Supino

2.1 Introduction

From the beginning, Quality Management in business organisations has encountered many difficulties, often in conflict with the different perspectives acquired during the course of time. From the quality of product perspective, there has been a shift in approach towards the process or system, ending with the incorporating of factors related to environmental protection, health and safety in the workplace and social responsibility.

Currently, various Management Systems (MSs) have been put in place by a great number of organisations in order to improve their global performance and the most recent challenge is the implementation of an integrated Management System (IMS).

The main aim of this chapter is to analyse the opportunities and constraints arising from such a process of integration, at the same time, highlighting the evolving dynamics of the quality concept over time.

The evolution of the conceptual framework of quality in economic systems has resulted in a certain momentum in the development of the methods and operational tools adopted to keep pace with these evolutionary dynamics (Proto 1999).

In the age of handicraft production, the concept of quality was closely related to the quality of the design and the quality of the finished product, in relation to which particular importance was given to compliance with predetermined specifications of the raw materials used and the rigorous acceptance tests to which they

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were submitted. Quality was related solely to the product and was identified with its perfect realisation (Salomone and Franco 2006).

With the emergence of mass production, from 1900 to 1920, the aspects of quality, far from being considered factors of competitiveness for firms, were in fact reduced to mere checks and a final testing of the product at the end of the production process (Chiacchierini 2003). Evaluation was based on inspections carried out by department heads or foremen who had the task of detecting any defects in the products when inspecting for more or less standardised characteristics.

That period, in fact, saw the diffusion of the first procedures of standardisation using previously established quantitatively measurable properties that were maintained over time. Moreover, with the intensification of international trade it was found necessary to standardise the criteria for assessing quality characteristics of the major commodities—raw materials, energy sources, semi-finished products, byproducts, etc.—using quantitative parameters of comparison. This approach has consequently, resulted in a standardisation process in use also for the methodology of assessment of product quality.

From the 1920s—and until the early 1950s—quality was considered synonymous with previously established technical specifications. During that period an early evolution of the concept of quality, based primarily on the assessment of the match between the programmed quality and the quality effectively achieved was traced. In this context, firms carried out operations aimed at controlling and testing to verify product compliance with predetermined design parameters.

These operations were performed on each product by specific departments independently managing methods and procedures and very often resulted in disadvantages associated with high costs, excessively long duration, particularly for large-scale production, and poor reliability of the outputs.

The above drawbacks were overcome, over the course of time, by adopting testing procedures on samples and not on the whole field, testing only a percentage of units taken from batches consisting in homogeneous quantities of product. In this way, statistical sampling techniques and statistical tools, still in use today, were defined.

Attention to these issues initially appeared during the 1920s in the U.S.A., where business organisations were identifying the most appropriate means for achieving management policies designed to expand and/or acquire market share. These means lay primarily in lowering prices but also in the standardisation of products and the improvement of quality.

The application of statistical control to products and production processes (Shewart 1931) represented a significant turning point, both on a conceptual and on a practical-operational level. At the conceptual level it established the principle that the output of the production process could be governed through the control, performed in real time, of some dominant variables in order to counteract the risk of deviation from conformity. At practical level a process of slow but steady change started with the affirmation of statistical principles applied to quality (Conti and De Risi 2002).

Furthermore, that until the end of World War II, the statistical techniques for quality control did not find widespread application in manufacturing but were adopted extensively in the defense industry, especially in the U.S.A.

In 1946 the American Society for Quality Control (ASQC) was established with the adhesion of the largest U.S.A. companies and Quality Control (QC) was officially recognised as a technique aimed at improving the quality of the production process. In later years other associations were set up, such as in 1956, the European Organisation for Quality Control, now the European Organisation for Quality (EOQ).

Operators paid great attention in those years to "Statistical Quality Control", performed initially on the products and subsequently on the processes for cost reduction and assessment of conformity to design parameters.

So up to the fifties, the term quality was primarily intended as a "degree of conformity" to the technical specifications of products and, therefore, determined by the detection of any defects in production.

The Sixties, however, characterised by a demand for consumer goods that outstripped supply, were also characterised by a lack of attention to the quality of products marketed by business organisations, which were more committed to maximising productivity and reducing costs.

Only large companies in particular sectors (nuclear, armaments, etc.) continued to refine the tools and statistical techniques needed to improve their performance

The period saw the establishment of the new concept of Quality Assurance (QA), which ensured that organisations adopted programmatic and systematic actions to guarantee compliance with the quality requirements of products or services.

In the Seventies, the concept of quality was further expanded, going beyond the boundaries of mere compliance and arriving at "reliability", seen as the capacity of a product to perform certain services, under suitable conditions, and for a fixed period of time (Mattana 1991).

Quality requirements spread outside the factory demanding the conformity of products throughout the entire period of their "useful life", so that reliability was considered as quality over time and space.

The expansion of the quality boundaries also changed the relative assessment activities, no longer conducted as simple control and testing operations at the end of the production cycle, but performed through more complicated programs. The aim was not only to predict and guarantee the performance of products over time, but also above all to promote continuous improvement.

This was a fundamental moment on the road to quality, because the activities of planning, management and control of product quality were devised from a systematic viewpoint based on an approach linked to the product life cycle, that is, from design to development, production, marketing and service, right up to final disposal.

The next step in the reliability process of the products was favored by other determining factors, including the internationalisation of markets and the intense rhythm of technological innovations, which needed the involvement of top management and typical managerial functions: setting goals and planning, coordination of human resources, scheduling of tasks and their implementation, analysis and control of the results.

So quality control now progressed from a statistical control of the product—at the end of the production phase or over its entire life cycle—to the control and management of the quality of the organisation. Improving the quality of performance of an organisation, whether profit or no profit, public or private, was seen as a system finalised to the involvement of all the key aspects of management and supported by clear cut commitment.

This new vision was matched by new terminology: Total Quality Control (TQC), to better highlight the extension of the techniques of quality control to all internal business processes. Quality was no longer to be understood only as a function of the design and application of the technology, the analysis and the control of products and processes. Rather, it was the result of motivation and participation of all the stakeholders of the organisation through the implementation of programmes aimed at "quality improvement" of the global performance.

Much attention, in fact, was given to the analysis of managerial problems related to Quality Control (QC). Issues ranging from the establishment of the standard requirements to which the output must comply, to the assessment of the deviations of the same, to the development of programmes to prevent inefficiencies and, above all, to the implementation of actions necessary to coordinate all the activities of management and control in order to achieve set targets.

The phase of Total Quality (TQ), originating at different times and with different characteristics in the United States and Japan, established itself in the organisational realities of the world during the late 1980s. It unfolded along two major axes: the Total Quality Control (TQC) in the Western world, based on leadership and orientation to results, and in Japan with the Company Wide Quality Control (CWQC), based on a continuous improvement, in small steps, of the circles of Quality and attention to internal and external customers. Quality no longer focused on achieving partial and short-term goals but was perceived as continuous improvement of the efficiency of all business performance to be achieved and consolidated in the medium and long term.

This new culture of Quality, the fields of application of which expanded to involve the organisational system as a whole, was then denominated Total Quality Management (TQM). The approach was adopted, also in Japan, only in the late Nineties. In the same period, great attention was addressed to the role of human resources in TQM and its relative motivational aspects (Proto et al. 2004).

2.2 Quality and Environmental Management Systems: The Pillars for Integration

At the end of the Eighties, the history of the evolution of Quality reached a particularly important landmark with the publication—by the International Organisation for Standardisation (ISO)—of a series of voluntary standards for organisations, based on a structured and coherent model, the "Quality System" (QS), giving them the fundamental requirements for application. These standards were supported by others aimed at establishing the requirements for certification—that is the formal process of verification of system conformity carried out by third parties—and for accreditation from certifying bodies.

The first series QS standards, ISO 9000, was published in 1987, with the specific objective of unifying the pre-existing standards, forming the common denominator for business quality on an international level.

The release of ISO 9000 standards was followed with the issue of the environmental standard series, ISO 14000 (Environmental Management Systems—EMS) in 1996, for organisations wishing to operate in an environmentally sustainable manner. Since then the number of organisations certified of ISO 14001 have increased, even if in a measure proportionally lower to ISO 9001. Both ISO 9001 and ISO 14001, in their various revisions, have since become the most extensively registered management system standards in the world; at the end of 2010, ISO 9001 accounted for 1,109,905 registered companies in more than 170 countries and ISO 14001 for 259,972 in about 150 countries (ISO 2011). Although other standardised management systems have been implemented in organisations, quality and environmental management systems represent the fundamental pillars of the integration process for combining management systems in order to implement a single Integrated Management System (IMS).

2.2.1 Quality Management Systems

The first edition of the ISO 9000 series was emended in 1994, with the first strategic revision of the standards, aimed not only at eliminating some of the weaknesses which had emerged during their use, but also to introduce innovative elements. These elements could be traced to their greater adaptability to the different needs of the company but above all to the emphasis placed on centredness customer and on continuous improvement.

In both versions of the standards (1987 and 1994) great importance was given to documentation as a demonstrative issue of compliance with the chosen standard, becoming in practice, the key element for certification. However, these standards did not produce a satisfactory level of "quality culture", due not only to the lack of a normative structure but also and above all to the interpretation of its market operators that often led to a merely formal application of the standards.

The need to bring organisations into contact with the principles of TQM, driving them beyond conformity towards management models orientated to excellence, produced the new ISO 9000 series of standards, edition 2000, also known as Vision 2000.

This revision represented a challenge for Quality Management Systems (QMS) to make the badly needed transition to a new paradigm, no longer based on the conformity to models and procedures, but on efficacy, the measurement of actions and the adequacy of results.

The new standards (i.e., ISO 9001:2000—"Quality Management Systems. Requirements" and ISO 9004:2000—"Quality Management Systems. Guidelines for performance improvements") marked the passage from the model of Quality Assurance (QA) to the model of Quality Management (QM), through a substantial change not only in the structures and contents of the standards but, above all, in their cultural setting.

The former in particular states the requirements for a QMS that enables the organisation to satisfy customer needs; it is the only reference standard for assessing and certifying the conformity of MS for Business Quality, whereas the latter ISO 9004 becomes the reference point for an organisation's continuous improvement in performance.

The two standards were similarly structured, five sections with the same title, though the contents of each follow specific objectives. The object of such a structured coherence was to highlight the complementarities and contiguities of application for organisations that, having respected the minimum requirements and given customer satisfaction, wanted to improve both system performance and financial and managerial efficiency (Proto et al. 2004).

Other important standards which made up Vision 2000 were ISO 9000:2000—"Quality Management Systems—Fundamentals and Vocabulary", which substituted the previous ISO 8402, and which was in its turn revised in 2005, and the standard ISO 19011:2002—"Guidelines for quality and/or environmental management systems auditing". The latter was amended in 2011 with the revised title "Guidelines for auditing management systems". Providing guidance on auditing management systems it is applicable to all organisations that need to conduct internal or external audits of management systems or manage an audit programme.

Vision 2000 proposed a management model founded on eight main principles that all organisations should apply in order to improve performance and obtain long lasting competitive advantages. They are (ISO 2012):

1. Customer focus—"Organisations depend on their customers and therefore should understand current and future customer needs, should meet customer requirements and strive to exceed customer expectations".
   Every organisation should fully understand its customers and, above all, their needs, both explicit and implicit, which should be analysed and transferred to the general management and policies of the organisation, so as to offer products/services capable not only of always fulfilling their expectations but also of anticipating their needs. This kind of customer orientation needs a customer strategy that places the customer at the centre of the organisation's activities and a constant assessment of their satisfaction as a fundamental instrument of control and prevention. Improving customer satisfaction creates among other things the conditions for customer fidelity and contributes to improve the organisation's image.

2. Leadership—“Leaders establish unity of purpose and direction of the organisation. They should create and maintain the internal environment in which people can become fully involved in achieving the organisation’s objectives”. Leadership should not be seen as an exercise of power but as a responsibility. The leader is the one who shows a marked ability to guide and orientate activities and people towards strategic objectives; they are not only ambitious, but above all, common, widespread, and shared. The leader’s commitment and the improvement of information channels and internal communication constitute non-negotiable condition in managing human resources, alongside high motivation and participation and the creation of the maximum coherence between the different activities.
3. Involvement of people—“People at all levels are the essence of an organisation and their full involvement enables their abilities to be used for the organisation’s benefit”.
   In an example of excellence, an organisation identifies itself with its members because the quality of the product, and any possible improvement in processes depends on the skills, experience and attitudes of the employees. The ISO 9000 standard assigns a strategic role to human resources, to their training, to the recognition of their contribution and to the necessity of constantly examining needs and satisfaction. In this way they not only participate in the vision of the business but they also share objectives and policies for quality with top management.
4. Process approach—“A desired result is achieved more efficiently when activities and related resources are managed as a process”.
   organisations must identify and manage numerous correlated and interacting processes. Often, an output element can constitute an input element in the subsequent process. The identification and the systematic management of the processes adopted by an organisation and, in particular, the interactions between these processes, can be synthesised in the expression “process approach” for the realisation of which it is necessary to:

- identify the relevant processes for quality management;
- determine the sequences and interactions;
- identify criteria and methods to ensure efficient functioning and control;
- guarantee the availability of resources and information for management and monitoring;
- effect the necessary measurements and relative analyses;
- implement the actions necessary to ensure continuous improvement.
  Responsibilities, measurable objectives and performance indicators need to be defined for each process. This approach focuses attention on processes that will improve overall organisation performance and therefore maximise the creation of value for all the parties involved.

5. Systemic approach to management—“Identifying, understanding and managing interrelated processes as a system contributes to the organisation’s effectiveness and efficiency in achieving its objectives”.

As is well known, a business constitutes a system that, independently of its size or nature, is made up of a coordinated set of multiple elements. The systemic vision of a business, and its capacity to integrate processes, objectives, strategies and actors on the planning and implementation level, is a fundamental requirement not only for the development of an effective QMS, but also for creating competitive advantage.

6. Continual improvement—"Continual improvement of the organisation's overall performance should be a permanent objective of the organisation".
   The constant search for performance improvement becomes a permanent and crosscutting objective for the organisation oriented to the satisfaction of changing customer and stakeholder needs. Actions for improvement, as stated by the ISO 9000 standard, consist in:

 – analysis and assessment of the existing conditions to identify areas for improvement;
 – definition of objectives;
 – search for possible solutions to achieve objectives;
 – assessment, selection and implementation of solutions;
 – measurement, confirmation, analysis and assessment of results in order to ascertain achievement of the objectives;
 – formalisation of the changes to be enacted;
 – the constant assessment of results and objectives and the analysis of the customer and stakeholder feedback identify further opportunities for improvement.

7. Factual approach to decision making—"Effective decisions are based on the analysis of data and information".
   Data and information, both from internal and external sources, of a quantitative and qualitative nature, constitute the fundamental linking element between strategic and operative activities, in that they allow the organisation to undertake suitable control on their management and to implement eventual corrective actions.
8. Mutually beneficial supplier relationships—"An organisation and its suppliers are interdependent and a mutually beneficial relationship enhances the ability of both to create value".
   The capacity of the organisation to produce innovative quality products is considerably influenced by the way it selects its suppliers. The organisation identifies and chooses them not only for their ability to supply goods that conform to requirements but also for common economic objectives where joint actions can be defined to improve performance.

The publication of a new edition of ISO 9001:2008 "Quality Management Systems Requirements" which "offers an organisation the possibility to align or integrate its quality management system with the corresponding requirements of the management system in use" (ISO 2012) has not introduced new requirements, or modified the existing ones. The standard has attempted to satisfy both the need for clarification of some applicative aspects, and the desire to improve its compatibility with the "homologous" ISO 14001 relative to Environmental Management Systems (EMS), which will be dealt with in the following paragraph.

Currently, ISO 9001:2008 constitutes the principal reference for organisations wanting to improve customer satisfaction and to create value using a horizontal and inter-functional approach.

The eight management principles have been confirmed in the ISO 9001:2008 and should be considered by any organisation wishing to comply fully with the intent of the standard.

The revised ISO 9000 standard is supported by the above mentioned ISO 9000:2005 "Quality Management Systems—Fundamentals and vocabulary", which substituted the previous 2000 edition without modifying the descriptions of the basic QMS principles. The ISO 9000:2005 was devised to supply a univocal meaning to the relevant keywords, to enrich the lexicon with new definitions, to update and, in some cases, supplement the explicative notes, in line with more recent ISO 9000 series documents.

Substantial modifications were also introduced with the ISO 9004:2009, "Managing for the sustained success of an organisation—a quality management approach", which substituted and revised the previous ISO 9004:2000. The standard sets out various aims, above all as regards "promotion of self-assessment as an important tool for reviewing the level of maturity of an organisation, including its leadership, strategy, management system, resources and processes, to identify areas of strength and weakness and opportunities for improvement and/or innovation" (ISO 2009).

The ISO 9004:2009, moreover, while firmly anchored to the eight QM principles, provides guidance for the continual improvement of an organisation's overall performance, efficiency and effectiveness through the process-based approach, emphasises in particular:

1. ethical-social perspectives;
2. organisational mission and vision;
3. adaptability and flexibility—capacity of organisations to change itself, its products and processes, when necessary—to comply with changing conditions of risk/opportunity;
4. knowledge management;
5. risk management;
6. alignment and link up with other management systems adopted by the organisation;
7. capacity to transform strategies into concrete actions, correlating results to objectives.

Although ISO 9004:2009 complements ISO 9001:2008—which first defined the general and documentary requirements that an organisation must respect if it wants to implement, document and manage a QMS efficiently—it provides a broader perspective of QM in that it promotes self-assessment in order to devise value creating activities that enable the organisation to satisfy all market requirements.

A QMS is set up by means of documented procedures according to the type of organisation, the complexity of process interaction, technology, staff, etc.

The mandatory documentation of a QMS is an organised and updated collection of documents, characterised by various levels of detail and diffusion. Substantially they constitute the Quality Manual, documented procedures and diverse documents and records.

The Quality Manual, a core QS document, defines: quality policy; organisational structures and principal responsibilities; essential operative steps in the Quality System. The Manual, which describes the process interrelations, is drawn up and continually updated by the Quality Manager who disseminates it to the staff.

The procedures are documents which describe how activities should be performed, for the purpose of controlling the processes systematically, in coherence with the Quality Manual and in respect of the standard's requirements.

The QMS documentation must include not only the documents which the organisation deem necessary and/or useful for efficient planning, functioning and control of its processes, but also the records required by the standard (e.g., the results of the internal and external audits, the results of corrective actions, etc.).

Great emphasis is placed on the process based approach. The analysis of business processes should be the key element specifying objectives and responsibilities linked to each process and expected results.

The organisation is no longer seen as a set of activities (even though they may be integrated in a systemic vision), but rather as an effective system that carries out its strategic-operative mission through interconnected elements (the processes) and finalised in the supply of products/services to satisfying customer requirements on a long term basis.

The planning and implementation of a QMS depend on the identifying and monitoring of the processes characterising the organisational structure, with specific reference to those that have a direct impact on the quality of the product/ service. Responsibilities and the availability of adequate resources for achieving the objectives defined by top management also have to be clearly identified.

Furthermore, it is fundamental that the QMS be adequately documented using procedures that are appropriate to the nature and complexity of the processes to be managed. To this end, the organisation can define, in function of specific needs, further integrative documentation, establishing its extension, content and form to support operative and managerial activities. However, all documents have to be adequately checked and controlled, correctly drawn up, periodically reviewed, updated and archived, to guarantee traceability, verification and conservation.

A QMS has to be built on four key macro-processes, as indicated in the ISO 9001 standard: *management responsibility; resource management; product realisation; measurement, analysis and improvement*. These represent the basic requirements of the system and are linked to each other in accordance with the Plan-Do-Check-Act (PDCA) scheme. The cycle created by these macro-processes—the principal characteristic of which are indicated below—overlaps and integrates the "customer cycle".

1. *Management responsibility*—In the process based approach, the commitment of top management to the continual improvement of QMS is key. This requires the definition of quality policies and related general and specific objectives; management reviews; assurance of resource availability to implement, maintain and improve the QMS, defining roles, responsibilities and competences. The responsibilities of top management are defined in great detail, with particular emphasis on QMS priority requirements. The policy for Quality, concrete, feasible and comprehensible, must be published and known, understood and applied by every member of the organisation. Top management planning objectives, have to be realistic, measurable, continually monitored and assessed, in order to identify the necessary activities and resources. Objectives should be specific to the overall system and/or to various levels and functions of the organisation, and management need to consider information resulting from data analysis, tests carried out on products and services, customer satisfaction and management review. The latter consists in a systemic assessment of the QMS, carried out regularly and aimed at verifying system adequacy, efficiency, efficacy and performance improvement, making the necessary changes where needed and, eventually, redefining objectives and responsibilities. The management review takes into account all QS data input: the results of the audits, customer feedback and process performance as well as the outputs of preventive and corrective actions. This guarantees appropriate decision making and interventions to optimise both the system and relative processes, in order to improve overall organisational performance.
2. *Resource management*—Having defined objectives and planned the necessary actions, top management must allocate the resources needed for QMS implementation, updating and improvement of the QMS. Human resources, infrastructure and the workplace have to be allocated on the basis of the organisation's effective needs, financial capacity and investment policies. Furthermore, the organisation periodically needs to review resource allocation in a perspective of optimisation. The centrality of human resources is reaffirmed in the revised ISO 9001. The latter emphasises the need to increase staff competence through specific continual training, relative to activities that affect product/service quality. The working environment affects motivation, staff satisfaction and performance and, consequently, organisational performance. Furthermore, in the field of resource management, the ISO 9004:2009 highlights other factors that should be appropriately managed by the organisation: financial resources, which must be allocated and used efficiently; suppliers and partners, with whom it is essential to set up collaborative relationships in order to increase mutual value creation capacities; knowledge, information and technology, essential resources for improving organisational performance and finally, the optimisation of the use of natural resources, that represent one of the most important factors influencing lasting success.
3. *Product realisation*—This macro-area represents the operative part of the QMS in terms of defining requirements relative to all processes linked to the realisation of the product/service. The product or service realisation process consists

in a series of phases or sub-processes. These phases implicate the planning of activities from design to delivery, with particular reference to those regarding the product, and include the identification of customer needs, translated into specific requirements, identification of resources, manufacturing techniques, monitoring and control tools, guaranteeing compliance with requirements. In particular, to ensure that the sequence of processes is conducted in a controlled manner, it is necessary to define: quality objectives for the product/service; processes and documentation, and to provide resources and facilities specific to the product/service; verification and validation activities, and criteria for acceptability; the records that are necessary to evidence conformity of the processes and resulting product/service to specified requirements. Moreover, critical aspects and predictable problems along the supply chain must be taken into account to improve product realisation. At the same time, core elements to be monitored, along with the sequences and interrelations with the other business processes have to be identified.

4. *Measurement, analysis and improvement*—The fourth macro-area, which completes the cycle for continuous improvement based on the PDCA approach, consists in defining, planning and implementing the measurement and monitoring activities needed to assure conformity and achieve continual improvement. The organisation has to select adequate Key Performance Indicators (KPIs) and efficient control methodologies, including statistical methods, to assess its needs and operative conditions, and to set up fixed objectives for monitoring and improvement. The aim is to acquire qualitative and quantitative data that are accurate, reliable and useful in the implementation of eventual preventive and corrective actions to improve process efficiency and efficacy. Methods used to collect such data—as expounded in detail in the ISO 9004:2009 standard—range from risk evaluation and control to interviews, questionnaires and surveys on customer and stakeholder satisfaction, to benchmarking and performance reviews—including those of suppliers and partners—and the monitoring of process variables and characteristics of the realised product or the service supplied. Also the results of the internal audits, carried out to assess QMS efficacy, suitably documented, have a strategic role, allowing the reduction, elimination and prevention of eventual causes of non-conformity with proposal for the improvement of business processes. Through process measuring and analysing the organisation can evaluate the overall degree of improvement of its performance over time, using, in particular, self-assessment and benchmarking methodologies for long-lasting success. QMS is a potent tool for dealing with the challenges deriving a from socio-economic context that is complex and continually changing.

2.2.2 Environmental Management Systems

Growing scientific and technological knowledge concerning the causes and effects of environmental impact has called for change, especially as concerns economic activities, considered an essential part of the environmental problem.

Over the course of time a complex range of eco-management tools, many of which are voluntary, or receive spontaneous support from the business community have gradually been devised and put in place. They are based on the principle of shared responsibility and the participation of various social actors, who, from mere recipients, are asked to assume a leading role during the phases of both definition and implementation of these environmental policies.

The worlds of production and consumption are, therefore, called upon to contribute to greater sustainability, such goals exceeding those characterising previous decades. The sustainability hoped for today contemplates that businesses assume precise moral responsibilities based on socially shared ethical principles, and that consumers take on responsible lifestyles.

Measurement and evaluation tools are now fairly common as are the tools for environmental and socio-environmental management (e.g., Life Cycle Assessment, Environmental Performance Evaluation, environmental reports, sustainability reports, environmental and energy labels, etc.) the common elements of which are voluntary adhesion and a proactive attitude on the part of economic actors. They express the overcoming of the logic of command and control, typical of the environmental policy of past years, and are characterised by the use of the law as a tool for command and control, testifying a new relationship of cooperation and transparency between institutions, businesses and communities.

During 1996, the year in which the EC Regulation, Eco-Management and Audit Scheme (EMAS) was in its starting version (i.e., Council Regulation no. 1836/93 of 29 June 1993), the ISO issued the 14000 series—a set of standards for environmental management. The ISO 14000 "family" covers a broad range of standards not only related to the Environmental Management System (EMS), but also to: environmental performance indicators (Key Performance Indicators—KPI), lifecycle analysis (Life Cycle Assessment—LCA), environmental labelling and greenhouse gases.

The main purpose of these standards is to provide:

1. a practical guide for the implementation and improvement of an EMS;
2. assessment tools in line with the specific aspects of environmental management;
3. the basic principles and practical guidance to provide information on environmental aspects of products and services.

Among the eco-tools for organisations, the most important is ISO 14001 which states the "requirements" that an EMS must satisfy in order to formulate an environmental policy and establish consistent objectives coherent with the laws. It also includes information regarding significant environmental impacts.

The EMS implemented in accordance with ISO 14001, therefore, while it may be used for contractual purposes, is not oriented to customer needs—as is the case of Quality Management Systems—but takes into account the needs of a wide range of stakeholders and the growing needs of society for the protection of the environment.

Adherence to this standard, structured on a process-based approach similar to ISO 9001, is voluntary and determined by competitive and social pressures perceived by the enterprise, rather than by binding regulatory requirements (Proto 1994; Proto and Supino 1999).

The first issue of the ISO 14001 was in 1996, "Environmental management systems—Requirements with guidance for use", and had the primary purpose of providing a guideline for all organisations—regardless of the type of service or product provided—interested in establishing, implementing, maintaining and improving an EMS (Proto and Supino 2000).

In 2004, a new edition of ISO 14001:2004 was issued which did not introduce new requirements or change existing ones, but attempted to respond to the need for clarification of some aspects of application of the standard and enhanced compatibility with the ISO 9001.

In this current version the standard has made a clearer distinction between the "environmental aspects, which the organisation can control" and "those that it can influence", relative to both goods and services used by the organisation and to the products and services it provides.

This standard concerns all those—contractors, suppliers and, in general, all the persons to whom the organisation entrusts certain activity—which in fact lose direct control of the environmental aspects, but retain, more or less significantly, an influence on their behaviour. It follows a "philosophy" that permeates the whole standard whereby all the stakeholders are directly involved.

These results in the environmental analysis of all the processes related to the organisation's operational sites, the implementation of which permits the definition, among all the defined aspects, of the truly important aspects that have, or could have, significant impacts on the environment.

The environmental analysis represents the preliminary stage on which the subsequent stages of planning, implementation and verification of the EMS are based.

However, the main difference to the previous edition of the standard can be found in the possibility of proving compliance not only through self-declaration or certification, but also using indirect conformity assessments (in the relationships between customers and suppliers) and through confirmation of its self-assessment by external parties. This represents an emblematic different forms of conformity assessment that the organisation can choose according to its specific needs.

Currently, ISO 14001 provides operational guidance to achieve "sustainable development" through the minimisation of environmental impacts generated by the activities of business processes. It represents a cornerstone for the whole ISO 14000 system of standards, and is articulated under five main headings that identify a logical sequence based on the Deming cycle for continuous improvement (Proto and Supino 2000).

This standard specifies requirements for an EMS, or part of the management system which includes the organisational structure, planning activities, responsibilities, practices, procedures, processes and resources for the development, implementation, achievement, reviewing and maintenance of an environmental policy whose basic elements are attributable to:

- beliefs, values and principles of the organisation;
- specific commitments (e.g., compliance with legislation, continuous improvement, prevention of pollution, minimisation of impacts and resource consumption, development of controls, etc.);
- requests from stakeholders and coordination with other policies of the organisation (e.g., quality, health and safety at work).

The steps for the implementation of an EMS, in accordance with ISO 14001, are summarised as follows:

1. Definition of the environmental policy and its dissemination inside and outside the organisation. It establishes the general principles and objectives in the environmental field and is expressed by the statement of the principles underlying the action taken by an organisation for the environment;
2. Planning to establish objectives and targets consistent with the environmental policy and the programmes necessary to achieve them. This means not only the indication of the responsibilities and times required, but also a suitable system for the assessment of environmental performance, based on specific Key Performance Indicators (KPI);
3. Implementation and functioning through the definition of the operational structure, the formalisation of roles and responsibilities, documentation—paper based or electronic—of the EMS, and the planning of tests and responses to potential accidents and emergency situations;
4. Tests and corrective actions to monitor regularly the characteristics of the activities carried out by means of a structured and systematic audit of the EMS, in order to verify its proper implementation and maintenance;
5. Management review that in light of the results of the audit system and its commitment to continuous improvement, evaluates its adequacy and effectiveness, considering any possible need for policy changes, objectives or any other elements of the implemented system.

The current version of ISO 14001 evidences how the goals should be consistent not only with environmental policy and commitment to pollution prevention but also with a commitment to legal compliance as a base from which to develop concrete goals, progressively more ambitious and oriented to continuous improvement.

The real innovation of a voluntary EMS lies, firstly, in being able to harmonise the adoption of environmental control techniques with the modern management practices of organisations and, secondly, in the very principles from which it finds inspiration: the correlations and sharing of responsibility in managing environmental issues; the integrated control of polluting activities and the use of environmental excellence as a source of competitive advantage.

It should be emphasised that in this standard too, just as in the ISO 9001, the level of detail and complexity of the EMS, the amount of documentation and the resources involved are dependent on several factors, including the scope of the system, the size of the organisation, the nature of its activities and the characteristics of its output. This is to encourage the adoption of the standard, particularly in small and medium enterprises.

Another standard of the ISO 14000 family, equally important though less well known, is the ISO 14050, "Environmental management—Vocabulary", which, by defining the terms reported in all the other standards of the series, is an indispensable tool for their correct implementation.

The ISO 14004, "Environmental management systems—General guidelines on principles, systems and support techniques", is the most practical way to implement an EMS as it provides guidelines for the application of ISO 14001. Furthermore, it is worth mentioning the ISO 19011 standard because it provides guidelines on principles, on programme management and on the conduct of the audits for QMS and EMS and on the responsibilities of auditors, constituting the first example of a standard that has integrated "quality" and "environment".

As previously mentioned, the implementation of an EMS can also follow the route suggested by EU Regulations.

Responsibility, active commitment and transparency are the essential common features of the legislator's commitment to prevention and control of the environmental impact of production activities—an attitude very different to the usual prescriptive legislation.

The preference given to prevention rather than correction, has led to developing instruments to promote a proactive approach to dialogue and cooperation between stakeholders in the pursuit of a common purpose such as the protection of our planet's natural resources (Proto and Supino 2009).

The current environmental policy of the European Union would like to replace the old conflicting and repressive relationship between the state and entrepreneurs with the voluntary participation of organisations in the project for improvement of the environment, for cooperation with the government, for reciprocal support and transparency of behaviour towards all stakeholders.

The main instrument for promoting dialogue and cooperation among stakeholders, defined in the Fifth Action Programme for the Environment in 1992, is the Eco Management and Audit Scheme (EMAS), introduced by the EU Regulation 1836/1993 for "voluntary participation of companies from the industrial sector in a community system of eco-management and audit", amended in 2001 by the Regulation no. 761, thus called EMAS II. Among the main changes introduced by this Regulation are extension of both the scope of the Scheme to non-industrial sectors, and the concept of premises, replaced by the broader concept of organisation.

The objective of improving the applicability of EMAS was also pursued through a direct call for wider dissemination of the key points of the Rule:

"legal compliance", "improvement of environmental performance", "external communication" and, finally, "staff involvement".

This latter aspect constitutes one of the key factors for achieving the objectives of the Scheme, realisable only through staff motivation and involvement and by improving the models of external communication.

Recently, the new EMAS Regulation no. 1221/2009 (EMAS III) has been issued, introducing some significant improvements while remaining compliant with the initial scheme in order to underline substance and credibility. In particular, it reaffirms the principles of excellence of this instrument of environmental policy and aims to facilitate the membership of different organisations through forms of funding and incentives. Its aim is to remove the critical issues that have hindered its full statement in the past, especially among SMEs, which, as is well known, represent the most significant economic reality of the European Union.

The logic of the EMAS Regulation aims to encourage improvement of environmental performance according to criteria, timing and modalities that are appropriate and proportionate to the peculiarities of different organisations. They identify the environmental commitment to be undertaken, on the basis of their characteristics and the tangible environmental problems, by establishing appropriate improvement objectives to be achieved through the gradual implementation process of an effective EMS.

In view of proof of a real commitment to improving its environmental performance and on receipt of verification of the proper functioning of the implemented EMS, the Regulation guarantees public recognition through the "registration" of any organisation that meets the EMAS requirements. The results are publicised in a special list drawn up by the European Union under the heading of a special logo.

To better understand the purpose of the Scheme it is above all necessary to analyse the structure in detail, identifying its characteristic aspects and elements.

The regulations provide some basic steps for those wishing to acquire membership to the Scheme, set out in a logical sequence and summarised as follows:

- implementation of an initial environmental analysis;
- formulation of environmental policy;
- preparation of an Environmental Improvement Programme;
- implementation of an Environmental Management System (EMS);
- preparation of an Environmental Statement (ES) to be submitted to the validation of an EMAS verifier accredited by the competent body.

The environmental analysis stems from the examination and evaluation of the environmental effects that may result from all the organisation's activities (past, present and predicted), as regards normal operating conditions, exceptional activities and any unforeseen accidents. Issues to consider range from air emissions to water effluents, from the production of waste to soil contamination, thermal pollution and noise and the visual impact to the use of natural resources.

The main purpose of the analysis is to provide all the elements that define the environmental objectives consistent with the peculiarities of the organisation and to put in place the improvement programme by structuring the EMS in accordance with the principles defined by the Environmental Policy. This, in fact, unequivocally states the commitment and the strategies to be adopted in favor of environmental protection by setting out the general principles that have inspired this commitment.

Using the previous analysis so as to act on significant environmental aspects, the organisation must then define and implement an environmental programme, specifying times and financial and human resources. To this end, the environmental programme is generally articulated in:

- instructions defining the activities affecting or likely to affect the environment;
- procedures relating to purchasing and procurement to ensure that suppliers, and those acting on behalf of the organisation, conform to the organisation's environmental policy;
- approval systems of processes and calibration of equipment;
- criteria for improving efficiency;
- mechanisms for the monitoring of each activity or sector, specifying the procedures to be adopted and systems for the relative documentation;
- mechanisms of inquiry, in the case of non-compliance with environmental legislation and consequent corrective action.

To achieve the objectives set out in the Environmental Programme, the organisation must implement an Environmental Management System (EMS) that requires the identification of an organisational structure, responsible for the management of the system, a management representative with the task of ensuring implementation and maintenance of the system with appropriate responsibilities and environmental skills assigned to the management, execution and monitoring of the activities to be realised.

The EMS must be subjected to an internal audit programme to periodically verify the environmental performance and must be performed by the organisation's internal auditors or by external experts.

As soon as the EMS becomes operational, the organisation must elaborate an Environmental Statement (ES) declaring its commitments. This contains, in sufficient detail, all the information about the activities of the site and its relative impacts on the environment, the results obtained in the pursuit of improved environmental performance, objectives and future plans.

The main change introduced by the new revision of the Regulation (EMAS III) concerns the need to describe within the ES the organisation's performance through a number of "core indicators" specified in Annex IV of the Regulation. These are defined uniformly for all possible areas of activity, to the extent that they are relevant to the issues identified as significant by the organisation and concern mainly the following key environmental issues: energy efficiency, efficient use of materials and water, waste management, reduction emissions and safeguarding biodiversity.

These core indicators have been introduced by the European Commission with the dual purpose of providing clear support to organisations in the calculation of the indicators and obliging them to publicly report the results of their environmental management, so as to show the trends over time and to allow a direct comparison between organisations belonging to the same sector of activity or located in the same territorial context.

For the purpose of validation, in order to guarantee the reliability of data and information, the ES is subject to examination by an external, independent and qualified expert, or an environmental verifier accredited by the Ecolabel and Ecoaudit Commitee. The aim of validation is to verify: the Environmental Policy and the fulfillment of the requirements dictated by the Regulation, the operation of the Programme and the EMS, compliance of the environmental analysis and the audit to tangible needs, the reliability, adequacy and consistency of data and information contained in the ES.

Verification is carried out not only by means of the analysis of the documentation provided by the organisation, but also through site visits and meetings with staff to evaluate the effectiveness of the EMS, consistent with the requirements of EMAS.

After validation on the part of the environmental verifier, the ES is made public and sent to the Competent Body. This initiates the procedure for obtaining environmental "registration", after which the organisation is inserted in the Community Register (published in the Official Journal of the European Union and on the EMAS website of the European Commission) and can use the EMAS logo as a tool for environmental communication.

The accreditation body of environmental verifiers also plays a significant role in defining criteria for access and controlling the work done.

However, the preparation of the ES in accordance with the requirements of the Regulation, the verification and validation of the data they contain and its subsequent publication should not be considered as routine red tape, but rather as a tangible manifestation of commitment.

The ES must represent, therefore, a real communication tool with a strategic value, that its specific requirements and a call for the use of pertinent indicators of environmental performance have been defined in a special attachment.

The increased emphasis that the Regulation gives to data and indicators as aspects of communication also emerges from the specific need to ensure that public information is accurate and not misleading, substantiated and verifiable, relevant and used in appropriate contexts, representative of the organisation's overall environmental performance and significant with respect to the overall environmental impact. The aim is to provide an accurate assessment of organisational performance, to convey effective, comprehensible information, to allow a comparison with compulsory requirements and a comparison of the trends of performance over time for the various sectors through benchmarking activities, on a national or regional level.

The Regulation, in affirming the role of the ES as a tool for meeting the requirements of a registered organisation's interlocutors, shows how these registered organisations become a national patrimony to treasure and emulate as an example of excellence, capable of substantially and directly contributing to environmental quality and economic and social sustainability.

Particular attention has been given to the diffusion of the EMAS Scheme to SMEs, currently held back by their size and by the lack of technical, financial and managerial resources, with particular interest for those belonging to the more important industrial districts.

In this regard, in the light of the numerous EMAS experiences implemented in districts and homogeneous production contexts both in Italy and other member States, the recent Regulation, EMAS III has decided to take up on users' suggestions for a more widespread diffusion of this tool. Modifications range from the simplification of procedures and greater flexibility to easier access to information, technical assistance and financial support and to increasing integration with other management and environmental communication systems.

It is interesting to note the analogies between an EMS that follows the ISO standard and the one that follows the EMAS Scheme. The significant differences are due primarily to the nature of the systems themselves in that the EMAS Scheme is promoted by the European Commission and managed by national bodies specifically concerned with environmental policies, whereas the ISO 14001 is an international system, equally voluntary but privately run and certification is recognised by a private body. Furthermore, the European system has a formal requirement for an initial environmental analysis which, however, is common procedure when implementing ISO 14001 (Proto et al. 2010).

2.3 Literature Review: Critical Analysis and State-of-the-Art of IMS

The integration of standardised Management Systems (MSs) has been attracting growing attention since the early 1990s, even if integration and/or coordination were already key elements of the classical approach to Organisation Theory (Galbraith 1977; Mintzberg 1983).

In the quality management approach, an Integrated Management System (IMS) is based on the combination of separate MSs in order to plan, realise, control, audit and systematically improve a wide array of company performance, related principally to quality, environment, health and safety. Generally, it derives from the merger of the related pillars: ISO 9001 standard for Quality Management System (QMS), ISO 14001 standard for Environmental Management System (EMS) and the standard 18001 for Occupational and Health and Safety Management System (OHSAS). The adoption of an IMS is favored by the same basic principles and the similar common structure of these three standards (Block and Marash 2002; Fresner and Engelhardt 2004; Matias and Coelho 2002). In order to assist organisations in IMS implementation, ISO has published a handbook "The integrated use of management system standards" which provides operative methodology (ISO 2008). Besides, some guidelines for integration have been developed in different countries, such as PAS 99:2006 (BSI 2006).

A field of studies recently considered for the integration of management systems is that of social responsibility, as demonstrated by research that has also addressed management systems related to corporate social responsibility (Jonker and Karapetrovic 2004; Rocha et al. 2007; Proto 2008).

Furthermore the many issues deriving from the integration process have been discussed during the last few decades, in a number of theoretical and empirical studies.

As regards definition and content, Garvin (1991) maintains that integration requires the total harmony and alignment of policy and purpose throughout the organisation. Other studies point out that an IMS is a composite process operating harmoniously, sharing the same pool of human, material, and financial resources, aiming towards the achievement of a set of goals (Karapetrovic and Willborn 1998; Karapetrovic and Jonker 2003). In other terms, an IMS is characterised by the loss of the different identities of each system, because integration means their amalgamation covering different organisational functions (Karapetrovic 2002). Beckmerhagen et al. (2003) define integration as a process capable of joining "together different function-specific management systems into a single and more effective IMS". Its implementation process could be seen as a flow of activities focused on the fulfilment of a target, in order "to form one composite and holistic management system" (Asif et al. 2009).

Other studies in the IMS literature are focused on different perspectives and address potential strategies, methodologies and degrees of the integration pathway (Bernardo et al. 2009). Strategies refer to the selection and implementation sequence of sub-systems, while methodologies cover the implementation phases and steps; degree concerns the level of integration that the organisation intends to achieve.

Integration can be achieved using MSs strategies, in order to realise a simple alignment of processes, objectives, and resources or the full integration of all different systems (Jorgensen et al. 2006; Wilkinson and Dale 1999; Karapetrovic and Willborn 1998). Nevertheless, much research highlights that the need for integration derives from the decision to implement new MSs, beside the first management system adopted that is generally a Quality Management System (QMS).

Labodova identifies two possible sequences of integration that may be attained through the introduction of individual systems, followed by their successive integration or development and the implementation of an IMS, integrated from the very beginning (Labodova 2004). Zeng et al. (2007) suggested a "synergic model for implementing an IMS", while Karapetrovic proposes a two pronged approach: the first involves the creation of a generic management system standard to support integration; the second prong refers to the auditing of the IMS (Karapetrovic 2002). Other researchers highlight the benefits regarding the integration of IMS audits, both internal and external (Bernardo et al. 2009).

As regards the results of IMS implementation, empirical studies conducted in different countries have identified motivations and benefits for organisations operating in various activity fields (Renzi and Cappelli 2000; Zutshi and Sohal 2005; Salomone 2008; Asif et al. 2009). The capacity of the IMS to develop many synergic effects in the organisation is underlined by many authors (Karapetrovic 2003; Jorgensen et al. 2006; Bernardo et al. 2010).

Besides the above mentioned aspects related to the features and goals of the integration process, other issues have been analysed relative to the difficulties associated with the implementation and maintenance of an IMS, involving aspects such as the lack of human resources, lack of government support and resistance to change on the part of the people involved (Karapetrovic and Willborn 1998; Wassenaar and Grocott 1999; Matias and Coelho 2002; Karapetrovic 2003; Jørgensen et al. 2006; Zeng et al. 2007; Simon et al. 2012).

All these topics are still under review and investigation, also on the basis of the experiences that are being carried out and evaluated.

The need for integration has also arisen in specific manufacturing activities, where sector standards are diffused, such as those related to the agri-food sector.

The increased awareness of consumers and their pressure on regulators about food safety and traceability have caused the proliferation of certifiable standards and the relative need for a framework designing integrated approaches for the holistic governance of food safety management.

However, in the face of greater attention addressed to the various dimensions of quality and its certification in the contemporary food business community, scientific studies published in literature are very few, and not focused on IMS in agri-food organisations (Weyandt et al. 2011; Mensah and Julien 2011).

Although the concerns related to IMS theoretically and empirically explored definitions and contents, strategies and processes, motivations and synergies, drivers and levels, constraints and opportunities can be adapted in the agri-food sector, it presents some peculiarities that require the need for a tailored system approach to integration.

The roadmap towards the integration of MSs, particularly in the agri-food sector, has to be seen as a complex and evolving path, able to embody innovative future management systems and tools, deriving from the call to satisfy emerging socio-economic requests as well as from the needs on the part of organisations engaged in continuous improving of their global performance in quality, environment, health and safety and social responsibility.

2.4 Conclusions

Organisations have become more aware of the importance of product and process quality and of the need for organisational and managerial innovation for continual improvement in global performance, in order to meet the requirements of their stakeholders.

Business and market remits are leading companies towards certified quality management systems in conformity with international standards. Recent trends show a marked inclination towards a common vision of the different dimensions of quality organisations, assessed by third party audits and assured not only by compliance with Quality Management Systems but also by integrating other Management Systems, such as Environmental Management Systems (ISO 14001), Occupational Health and Safety Management Systems (OHSAS 18001) and Social Accountability (SA 8000). Companies operating in the food industry have in addition, "tailored" Management Systems for food safety and traceability voluntary certifications (ISO 22000, ISO 22005) to harmonise and integrate mandatory and voluntary elements of food quality. The use of the above mentioned standardised tools in organisations has determined the need to integrate the different approaches, highlighting similarities and synergies wherever possible avoiding unnecessary duplication and fragmentation. Nevertheless, as is well known, there are no international standardised references for integrating the requirements of various management systems and procedures.

The Integration of Management Systems is a highly relevant management approach, capable of generating significant benefits, less bureaucracy and paperwork, combined audits, fewer costs and more efficient management and use of resources (Bernardo et al. 2010). However, there are many challenges that must be overcome to obtain such benefits and to avoid the failures related to the integration process.

At present, different models for the integration of standardised MSs have been developed both at theoretical, geographical, and empirical levels.

The multitude of theoretical approaches found in the literature on the integration of MSs, lead to the conclusion that there is no a "one size fits all" methodology on which to build an integrated structure (Karapetrovic 2003; Beckmerhagen et al. 2003; Pojasek 2006; Jørgensen et al. 2006). Every integration process depends on the specific characteristics of the organisations involved, particularly in reference to dimension, number of pre-existent MSs, and sector features.

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Chapter 3
A Model of Integrated Management System for Agri-Food Small and Medium Enterprises (SMEs)

Maria Proto, Ornella Malandrino and Stefania Supino

3.1 Introduction

The modern day challenge of market globalisation, increasingly characterised by complexity and turbulence, cannot be resolved up exclusively with quality, but rather through the adoption of a wide variety of tools suited to satisfying the express and implicit needs of all the parties involved in an organisation's activities. Organisations, that are under pressure to meet the requirements of their stakeholders, need a new approach to the concept of quality, which is now viewed in a wider and multidimensional way, as it tends to incorporate dimensions linked to environmental protection, workers' health and safety, as well as the many-sided aspects connected to social responsibility (Proto et al. 2010).

A fundamental contribution comes from the adoption of Integrated Management Systems (IMS) different approaches to quality for continuous improvement of the effectiveness and efficiency of the numerous processes involved, both internal and external (Salomone 2006). This with an eye to satisfying the requests that come from the complex network of stakeholders with which the organisation systematically interacts. To this end, the voluntary adoption of the various Management Systems (MSs) and their integration (Quality ISO 9001:2008, Environment ISO 14001:2004, Health and Safety OHSAS 18001:2007, Social Responsibility SA 8000:2008) is of highly strategic value for organisations. The characteristics of these systems—all based on the Deming Cycle—allow for synergic integration, which strengthens their operativeness, thus amplifying the

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results. While this sort of approach is valid for all types of organisations, it is even more so for enterprises operating in the agri-food sector characterised by specifics and complexities. In fact, the past few decades have seen the trend towards quality and safety standards tailored for the food sector: private safety control systems, standards and certification programmes have been developed. Among these, an important role is played by the British Retail Consortium's global food safety standard (BRC) and by the International Food Standard (IFS). The BRC standard was developed to assist retailers in their fulfilment of legal obligations and to safeguard consumers. Although this standard has been developed in the UK, it has been adopted by food manufacturers throughout the world. The IFS is a global food safety system designed by German and French retailer and wholesaler associations, in order to create an evaluation system for all companies supplying retailer branded food products.

Moreover, the agri-food organisations can take advantage of another MS focusing on food safety aspects (ISO 22000:2005), which is able to reconcile the mandatory and voluntary aspects of agri-food processes, but which is also highly consistent with the most widely used international standards.

The ISO 22000:2005, *Systems management for food security. Requirements for any organisation in the food chain,* includes the mandatory application of the Hazard Analysis and Critical Control Point (HACCP) system and integrates the methodology by identification of Critical Control Points (CCP) but also the definition and implementation of Prerequisite Programmes (PRP). It is applicable to all product safety business areas and the management of the risk assessment process. Moreover, the ISO 22000 integrates the Quality Management System (QMS) provided by ISO 9000.

The standard answers to the requirements expressed by the agri-food sector, to define internationally recognised, common and certified standards of food safety. It sets out the principles and rules underpinning a Management System for Food Security (FSMS) which—being part of an organisation involved, directly or indirectly, in any segment of the food chain—has to undergo third party audits for the purpose of issuing a certificate of conformity. A company that has voluntarily implemented a FSMS certified as compliant with ISO 22000 by an independent third party proves its ability to identify and control all the dangers inherent to the exercise of its activities and to food safety. In essence, a FSMS ensures that the organisation has taken all the precautions and actions necessary to ensure health and safety up to the phase of food consumption.

Agri-food organisations have become more sensitive to the global performance of their products and processes in the awareness of the need to meet stakeholder expectations along the food supply chain.

The voluntary adoption of MSs—Quality ISO 9001:2008, Environment ISO 14001: 2004, Health and Safety OHSAS 18001:2007, Food Safety ISO 22000:2005, as well as the British Retail Consortium (BRC) and International Food Standard (IFS)—is a highly strategic option for organisations operating in the agri-food sector.

The respective characteristics of these systems provide the opportunity of synergic integration, enhancing operations and amplifying results.

The integration of management systems, in fact, is not a requirement that an organisation must necessarily adopt in case it decides to use two or more management systems, but represents a tool for improving efficacy and efficiency in terms of resources and experience, as suggested by the regulations themselves.

3.2 A Model of Integrated Management System for Agri-Food SMEs

The following model suggests a path for integration of standardised MSs, tailored for organisations operating in the agri-food sector, in order to achieve improved management efficiency and to fulfil the needs of the stakeholders involved. In fact, it also aims to identify the environmental burdens associated with manufactured products by quantifying the environmental effects of input factors (raw materials, energy resources, water, etc.) and output factors (waste, air emissions and water, noise, etc.) following the 'from the cradle to grave' approach, in line with the ISO 14044 standard.

The model proposes an integration process that involves not only MSs but also the quality of food products from an environmental perspective (Salomone et al. 2011).

To this end, the various references to environmental quality of products referred to ISO 14044—to better distinguish them from those related to management systems—are highlighted by placing them in a appropriate box.

Adopting an Integrated Management System (IMS) represents a preliminary decision making policy on the part of an organisation's top management in pursuing competitiveness and sustainability (Proto et al. 2010). It represents, in fact, an essential starting point for the adoption of other environmental tools that can be used by companies of the agri-food sector. The model may be considered the backbone necessary to encourage the diffusion and the progressive growth of innovative environmental tools.

The IMS model—establishing the requirements for integration—has been developed in accordance with the following standards:

- ISO 9001:2008 "Quality Management Systems—Requirements";
- ISO 14001:2004 "Environmental Management Systems. Requirements with guidance for use";
- ISO 14044:2006 "Environmental Management—Life cycle assessment—Requirements and Guidelines";
- ISO 22000:2005 "Management Systems for Food Safety—Requirements for any organisation in the food chain";
- BS OHSAS 18001:2007 "Systems Management of Health and Safety at work";
- British Retail Consortium "Technical Standard and Protocol for companies supplying food retailer Branded Food Product" Issue no. 5 to 2008;
- International Food Standard Issue no. 5 to 2007;

- BS PAS 99 "Specification of common management system requirements as a framework for integration".

The Table 3.1 shows the correspondence between the elements provided for MSs and agri-food product standards, considered above.

Consequently, regardless of the type of management of an organisation, numerous elements of integration can be identified. These include the development of an integrated policy and the setting out of strategic objectives under which resources can be organised, responsibilities are defined, documented and processed, analysis and assessment of the efficiency of business management are planned and, finally, intervention is organised, monitored and assessed to achieve the desired goals for a continuous improvement.

The level of detail and complexity of the IMS and the amount of documentation and resources devoted to it depend on the scope of the system, the size of the organisation and the nature of the activities, products and services provided.

This document, therefore, aligns and integrates the specific requirements of MSs and is the axis for the diffusion and progressive growth of additional tools for the improvement of competitiveness and sustainability of the agri-food sector.

The methodological criteria adopted follows the Plan, Do, Check, Act Cycle (PDCA) (Fig. 3.1).

3.2.1 Purpose and Scope

The model covers the common aspects of the MSs implemented (generally Quality, Environment, Health and Safety and Food Safety) and specifies the requirements of an Integrated Management System for an organisation that intends to:

- plan, implement, update operations and improve an IMS for Quality, Environmental, Health and Safety and Food Safety, by continuous improvement;
- develop and implement an integrated policy and procedure to monitor issues related to Quality, Environment, Health and Safety and Food Safety;
- demonstrate to all interested parties its ability to manage the processes in accordance with legislative requirements and regulations for the safety of food and facilities, occupational health, to the satisfaction of the requirements expressed or implied by customers as well as for the management of environmental aspects of both processes and products;
- identify, among the possible alternatives for the realisation of products, the most appropriate methods for reducing environmental burdens;
- pursue certification relative to the management systems under consideration, and on the basis of which the IMS was adopted.

The requirements outlined in this document are general in nature and designed to be applicable to all organisations of the agri-food sector, regardless of type, size and location and the product realised.

Table 3.1 Correspondence between standard elements

Correspondence	ISO 9001	ISO 14001	BRC	IFS	ISO 22000	OHSAS 18001	ISO 14044
1 Purpose and scope	1	1			1	1	1
2 Normative references	2	2			2	2	2
3 Terms and definitions	3	3			3	3	3
4 Integrated Management System							
4.1 General requirements	4.1	4.1	2.1, 1.10, 1.11	1.2	4.1	4.1	4.1
4.2 Documentation requirements	4.2	4.4.4, 4.4.5, 4.5.4	3.7.1, 1.8, 2.12, 3.2, 3.7	2.2, 2.3	4.2, 7.7	4.4.4, 4.4.5, 4.5.4	
5 Policy of IMS							
5.1 Planning	5.1, 5.3, 5.4	4.2, 4.3.3	1.3, 1.4, 2.2, 2.3, 2.4, 3.1, 3.9	1.1, 2.1.1, 4.1, 4.7, 4.16, 4.17	5.1,5.2, 5.3, 7.9	4.2, 4.3.3	4.2, 4.4.1, 4.4.5; 6.1
5.2 Identification and evaluation of aspects, impacts and risks	5.2, 7.2.1, 7.2.2	4.3.1	2.6, 2.7, 2.8, 3.4, 3.7.2, 4.8, 4.11, 5.2, 7.4 7.5	1.3, 2.1.3, 4.2, 4.9, 4.10, 4.18, 5.6	7.1, 7.2, 7.3, 7.4	4.3.1	4.5
5.3 Identification of legal and other requirements	5.2, 7.2.1	4.3.2	2.2.2, 4.10.2, 4.10.3, 7.3	3.2, 4.8.1, 4.18.1, 5.5.1	7.2.3	4.3.2	
5.4 Preparation and response to emergencies	8.3	4.4.7	3.10, 3.11	5.8, 5.9, 5.10	5.7, 7.10.4	4.4.7	
5.5 Roles, responsibilities and authorities	5.5	4.4.1	1.1, 1.5, 1.12, 2.1, 3.3	1.2, 2.1.2	5.4, 5.5	4.4.1	
5.6 Communication	5.5.3, 7.2.3	4.4.3	1.2		5.6	4.4.3	5
6 Resource management							
6.1 Management of human resources, infrastructure and work place	6	4.4.1	1.1, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 5.3, 6.3, 7.2	3.1, 3.4, 4.6, 4.13, 4.14, 5.4, 5.5.3	6	4.4.1	

(continued)

Table 3.1 (continued)

Correspondence	ISO 9001	ISO 14001	BRC	IFS	ISO 22000	OHSAS 18001	ISO 14044
6.2 Training, induction and awareness	6.2.1, 6.2.2	4.4.2	7.1	3.3	6.2.2	4.4.2	
7 Implementation and functioning							
7.1 General	7.1	4.4		4	7.1	4.4	4.3.1
7.2 Operational control	7.3, 7.4, 7.5	4.4.6	3.6, 3.9, 4.9, 4.10, 4.12, 5.1, 5.4, 6.1, 6.2	4.1, 4.3, 4.4, 4.5, 4.8, 4.11, 4.12	7.5, 7.6	4.4.6	4.3.2, 4.3.3, 4.3.4
8 Monitoring and measurement							
8.1 General	7.6, 8.1, 8.2.1, 8.4	4.5.1	2.5, 2.13, 3.4		8.1, 8.3, 8.4.3	4.5.1	4.4.2, 4.4.3,4.4.4
8.2 Assessment of compliance	8.2.3, 8.2.4	4.5.2	2.9, 2.11, 5.5, 5.7	4.15, 5.3.1, 5.5.2, 5.7	8.4.2, 7.6.4	4.5.2	
8.3 Internal audit	8.2.2	4.5.5	3.5	5.1, 5.2	7.8, 8.4.1	4.5.5	
8.4 Management of non-compliance	8.3	4.5.3	1.13, 5.6	5.3.2, 5.9, 5.10	7.6.5, 7.10	4.5.3.2	
9 Improvement							
9.1 Corrective, preventive actions and improvement	8.5	4.5.3	2.10, 3.8	5.11	8.5, 7.10.2	4.5.3.2	
9.2 Management review	5.6	4.6	1.6, 1.7, 1.9	1.4	5.8, 8.5.2	4.6	4.3.3.4, 4.5.1.2, 4.5.4, 6

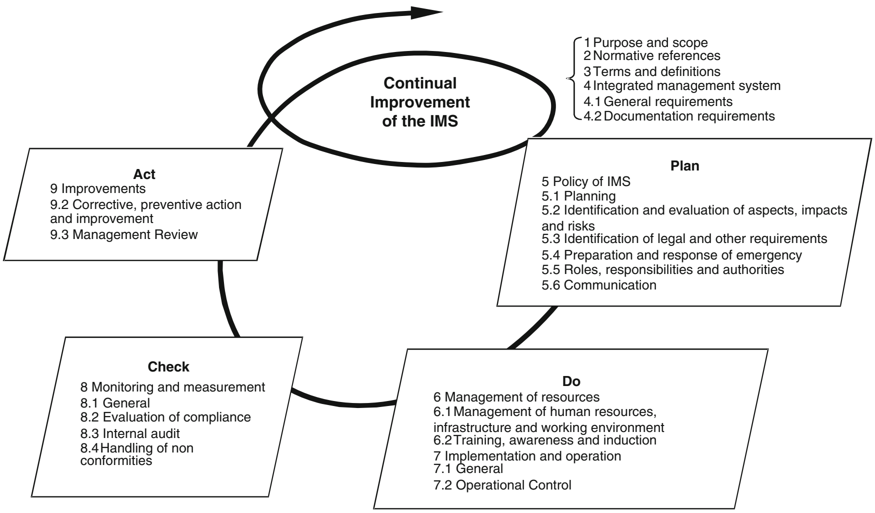

Fig. 3.1 The pathway for integration of MSs

3.2.2 Normative References

The voluntary normative references of an IMS on Quality, Environment, Health and Safety and Food Safety include the standards, guidelines and laws set out below:

- ISO 9000:2005 “Quality Management Systems—Fundamentals and vocabulary”;
- ISO 9001:2008 “Quality Management Systems—Requirements”;
- ISO 9004:2009 “Managing organisation for sustainable success—the approach to quality management”;
- ISO 14001:2004 “Environmental management systems. Requirements with guidance for use”;
- ISO 14004:2010 “Environmental management systems—General guidelines on principles, systems and technical support”;
- ISO 14040:2006 “Environmental management—Life cycle assessment—Principles and framework”;
- ISO 14044:2006 “Environmental management—Life cycle assessment—Requirements and Guidelines”;
- ISO 22000:2005 “Management Systems for Food Safety—Requirements for any organisation in the food chain”;
- OHSAS 18001:2007 “Systems management of safety and health at work”;
- British Retail Consortium “Technical standard and protocol for companies supplying retailer Branded Food product” Issue no. 5 to 2008;
- International Food Standard Issue no. 5 to 2007;

- BS PAS 99 "Specification of common management system requirements as a framework for integration".

3.2.3 Terms and Definitions

The IMS is defined as the set of activities, resources, responsibilities, procedures used by the company to achieve and maintain the objectives defined in terms of improving food and plant safety, occupational health protection, business and environmental efficiency.

For the purposes of this document, the following terms and definitions apply in accordance with the relevant standards (ISO 9000:2005, ISO 14001:2004 and ISO 14044:2006, ISO 22000:2005, OHSAS 18001:2007, BRC Issue no. 5 to 2008, IFS Issue no. 5 to 2007).

3.2.4 Integrated Management System

3.2.4.1 General Requirements

Management shall establish, document, implement, maintain and continually improve an effective IMS and update it whenever necessary.

The design and implementation of an IMS depend on the identification, assessment and monitoring of the processes that characterise structure of the organisation's structure, the clear determination of responsibilities and provision of adequate resources in order to pursue and achieve the goals set by top management.

Therefore management has to define and document first the purpose, aim, scope, inventory analysis, impact assessment of the product system and the interpretation of the results of the IMS, identifying the processes needed for its implementation, the sequences and their interactions. It must also establish the criteria and methods for the monitoring, functioning and continuous improvement of the processes, even if the same are outsourced.

3.2.4.2 Documentation Requirements

The IMS has to be properly documented through procedures appropriate to the nature and complexity of the processes to be managed.

The documentation required for an IMS consists in a collection of documents updated and organised, characterised by different levels of detail and dissemination. They constitute the Manual, documented procedures and other documents and records that management consider necessary in order to guarantee the effective planning, operation and control of its processes.

The Manual is the cornerstone document of an IMS in which are formally defined:

- the integrated policy objectives and goals of management;
- the purpose and aim of IMS, including the reasons for any exclusions;
- organisational structures and key responsibilities;
- the operating procedures relating to all essential elements related to IMS;
- the main elements of the integrated system and their interactions;
- a documented analysis process, environmental aspects and evaluation of risks to occupational health and safety;
- documented procedures and records necessary to demonstrate compliance with the requirements of the IMS.

The Manual is prepared and continually updated by the Quality Managers, who also have the task of communicating it to all staff.

Procedures are documents that describe how to perform certain activities, the purpose of which is to maintain a systematic and continuous control over the processes, in line with those indicated in the Manual of IMS and in compliance with regulation requirements.

The procedures, depending on the predefined level of process integration, may be:

- *integrated*, or specific for certain activities, such as management review, management of internal audits, training and involvement of staff and monitoring and measuring devices, or to assess the satisfaction of all parties involved;
- *partially integrated*, if they are common to only some systems, such as emergency management or the assessment of environmental impacts and risks projected for Environmental Systems and Occupational Health and Safety;
- *non-integrated*, if they refer only to a single system, such as quality control for products, waste management, etc.

Finally, even the entries needed to provide evidence of compliance and the functioning of the IMS can be integrated, partially integrated or non-integrated, depending on whether they relate to registrations of processes initially intended for integration or not. An example is the first report of the management review, while non-integrated reporting may be, for example that relating to emissions. These records must however be comprehensible, identifiable and traceable.

Management can define, depending on its needs, a supplementary documentation to the compulsory one, as it can also independently determine the extent, content and format of the documentation necessary to support the operations and management.

However, it is fundamental that all documents are kept properly "under control", or that effective control and management methods have been established, so that they are clearly identified, properly prepared, reviewed and updated periodically and achieved, in a manner ensuring their easy traceability and verification, and recording any changes.

3.2.5 Policy of IMS

3.2.5.1 Planning

Management must plan all the activities necessary to meet the objectives and requirements—quality, environment, safety of workers and food safety—of the product, process and service, defined both in terms of the initial specification and for eventual modifications of those already in existence.

Therefore, management must identify the IMS processes—defining functions, means, resources and roles necessary to implement and maintain the IMS—how to control, monitor and identify all the significant aspects of each activity that could influence the effectiveness and efficiency of the IMS.

In particular, management must define, document and maintain a policy of integrated management system that:

- is appropriate to the aims of management and the role played in the food chain;
- is appropriate to the nature, scale and impact of its activities, products and services;
- includes a commitment to respect and to meet the requirements—legislative, regulatory, mutually agreed with customers—to continually improve the effectiveness of the IMS;
- provides the structural reference framework for the definition and review of objectives and measurable targets;
- is reviewed for continual suitability so that it is pertinent and appropriate to the organisation;
- is communicated and understood within management and available to the public and all interested parties.

> The definition and implementation of a policy of IMS involves the identification of the primary objectives that can be reinforced by the application of the IMS, specifying there is the application of the LCA study, the motivation for the study, the intended recipients, and whether or not the results are intended to be used for comparative publishing. In the latter case the comparison must be conducted among scientifically and technically valid groups, environmentally relevant and internationally accepted.

The primary objectives (which should be identified not only with respect to processes, but also for individual departments) are generally fixed over a certain period, after which results will be assessed and new goals will be set up. This assumes that appropriate records are kept and measurements and controls carried out to verify the achievement of the objectives.

To achieve the IMS objectives and targets, management shall establish, implement and maintain one or more programmes that are regularly updated at scheduled intervals and which shall contain:

- assignment of responsibility for achieving objectives and targets for each function and level of management;
- the means and timing by which they are to be achieved;
- the processes of monitoring and measurement required to validate the control measures and/or combinations of control measures to verify and improve the IMS.

In order to define these programmes, management should consider the following elements:

- space planning, including work areas and those areas assigned to human resources;
- supplies of water, energy and support services, including waste and water disposal;
- suitability of facilities and their accessibility for cleaning, routine maintenance and repairs;
- management of purchases (for example raw materials, ingredients, chemical agents and packaging) and of the finished products (e.g., storage and transport);
- measures for the prevention of cross contamination (cleaning and sanitising, pest control, personal hygiene, microbiological and chemical quality of the water depending on its use).

For the definition of these programmes, management has to resort to the preparation of flow charts for the categories of products or processes covered by the IMS.

Flow diagrams shall indicate the unit processes and their interrelationships and provide a basis for subsequent risk evaluation and therefore, must be clear, accurate and sufficiently detailed to include the following elements:

- sequence and interaction of all the operating steps;
- processes in procurement and manufacturing under contract;
- phases in which energy, raw materials, ingredients and intermediate products enter the stream;
- stages of reprocessing and recycling;
- plan of the structures and layout of the equipment;
- process parameters;
- risks of possible delays in the process;
- segregation between areas of low/high risk and clean/dirty areas;
- phases in which finished products, semi-finished products, by products and waste are released or removed;
- emissions into air, water and soil and other environmental aspects.

Once defined, these flow charts should be carefully checked on site by competent staff and, if necessary, updated and then finally archived.

In defining the scope of the LCA the following points must be considered and described:

- *the system of products under study*, i.e., the set of single processes with the elementary flows and products;
- *functions of the system or systems in the case of comparative studies*, which represent the performance characteristics of the system under study;
- *the functional unit*, consistent with the objective and the field of application, with the main purpose of providing a reference on which to base all data in input and output of the product system. This unit must be clearly defined and measurable. After choosing the functional unit, the reference flow must be defined. Comparisons between systems must be made on the basis of the same function and quantified through the same functional unit in the form of their reference flows;
- *system boundaries* to determine the single processes to be included in LCA and decide which elements (mass and energy flows) will be considered input and output by the system to be analysed. The main criteria for inclusion or exclusion of input and output flows in the system must be identified and justified and must be based on the contributions of "mass", "energy" or "environmental significance". Each system must define the time boundaries, the geographical boundaries and the level of technology employed for the analysis. Exclusion criteria relating to the input and output elements considered in the analysis must also be clearly described;
- *allocation procedures*, that is, how the flows of matter and energy input or output from a process or a system are distributed between the product system under study and one or more other product systems;
- *Life Cycle Impact Assessment* (LCIA) methodology and the types of impacts, determining which categories of impact (intended as the categories that represent the environmental problems of interest to which can be assigned results from the life cycle inventory), category indicators and characterisation models are included in the LCA study. The LCIA phase must be carefully planned to meet the objective and scope of the LCA study and take into account any possible omissions and sources of uncertainty in the Life Cycle Inventory (LCI) study;
- *the interpretation to be used*;
- *data requirements*, the type and sources of data depend on the objective and scope of the study; data may be primary, that is collected directly at the production sites associated with the processes included within the boundaries of the system, or they may be obtained and calculated by other secondary sources;
- *assumptions*;
- *choices of values and optional elements*;
- *limitations*;
- *data quality requirements* should include the following aspects: geographical, chronological and technological accuracy, completeness,

representativeness, consistency, reproducibility, the degree of uncertainty and the sources. It is also necessary to record the methods used to process data and missing or neglected sources of communication;

- *the type of critical review*, describing the type, how you intend to do it and those in charge of running it;
- *the type and format of the report required for the study*.
- The scope of the LCA study must be defined in such a way as to allow comparison of the results.

3.2.5.2 Identification and Evaluation of Aspects, Impacts and Risks

The identification of aspects, impacts and risks associated with activities, products and services and assessing the significance of such impacts on the environment as well as those related to food safety are prerequisites for the definition of objectives and targets consistent with the policy of IMS.

In order to provide a tool to support decision-making at this stage management needs to identify the significant factors arising from the Life Cycle Inventory (LCI) and Life Cycle Impact Assessment (LCIA) phases and examine the results obtained in order to make the necessary choices (Interpretation Analysis).
The interpretation phase of the life cycle includes several elements, which are:

- *identification of significant factors*, conformity with the definition of the objective and scope. Examples of significant factors may be inventory data (energy, emissions, waste, etc.) impact categories (e.g., use of resources, climate change), significant contributions in the early stages of the life cycle (individual single processes or process groups);
- *assessment* conformity with the objective and scope of the study, to define and improve the reliability and credibility of the results of the LCA or LCI including significant factors identified in the previous phase.
- During the assessment the following three techniques must be taken into account:
- completeness verifying, which must ensure the availability and accuracy of all information and data and, if not, a justification must be provided;
- sensitivity check in order to assess the reliability of the final results, estimating the influence of factors—such as uncertainty of data, methods of allocation and calculation of category indicator results—on the conclusions;
- consistency control, aimed at verifying the consistency of the assumptions, methods and data with the objective and scope;

- *conclusions, limitations and recommendations*; this phase is performed interactively with the other elements of the interpretation phase. This is to assess and communicate significant factors, methodology and results for the completeness, sensitivity and consistency checks, to draw preliminary conclusions, checking their consistency with the purpose and scope of the study and, if affirmative, preparing a final report (see Sect. 9.2).

Management shall conduct risk analysis to determine potential hazards to food safety among the workers; degree of control and appropriate combination of all these control measures.

In addition, the methodology used must be described and the results for risk assessment recorded. Finally, the reasons that led to the identification of the levels of acceptability of the finished product must be determined and documented.

The method of hazard identification and risk assessment of the organisation must:

1. be defined in accordance with purpose, nature and timing to ensure that it be preventive rather than reactive;
2. ensure the identification of priorities and preparation of documentation relating to the risks and the setting up of appropriate checks on the prevention of hazards for the safety of the product, processes and work environment. For hazard analysis, management must not neglect the bottom up and top down processes and take into account aspects related to:

   a. raw materials, ingredients and materials in contact with the product, with reference to:

      - biological, chemical and physical properties;
      - composition of the formulation ingredients, including additives and processing aids;
      - origin and method of production;
      - packaging and distribution method;
      - storage conditions and shelf life;
      - preparation and/or handling before use or processing;
      - acceptance criteria, material specifications and ingredients purchased.

   b. characteristics of the finished products, with reference to:

      - product name or similar identification;
      - composition;
      - biological, chemical and physical properties;
      - expected shelf life and storage conditions;
      - packaging;
      - labelling and/or handling instructions;
      - preparation and use;

- method of distribution;
- intended use and handling of the finished product which can be reasonably expected;
- any unintentional mishandling and improper use of the finished product which can be reasonably expected;
- access and movement of staff, visitors and contractors so as not to jeopardise the safety of the product also through provisions for appropriate medical screening.

c. each hazard in need of control measures must be assessed according to:

- the vulnerability of the exposed items;
- the possible severity of adverse effects that may be produced and the likelihood of occurrence;
- survival and multiplication of the micro-organisms concerned;
- the severity of the effects on consumer health;
- the presence or production of toxins, chemicals or foreign bodies;
- contamination of raw materials, finished or semi-finished products;
- any eventual adulteration or deliberate contamination;
- the risk of allergens.

All the information regarding the analysis of hazards must result in a systematic and exhaustive Food Safety Plan based on the Hazard Analysis and Critical Control Point (HACCP) system which management has to implement and maintain. This plan should also refer to the principles of the Codex Alimentarius, to applicable legislation, to codes of practice and to any other guidelines as well as taking into consideration any scientific or technological developments.

The HACCP team must define the specific products and processes that are subject to the HACCP plan. Management shall ensure that the HACCP plan is based on reliable and comprehensive sources of information that are collected, archived, documented and updated.

Management shall establish, implement, document and update appropriate procedures for:

1. timely/continuous identification of the hazards and environmental issues, both direct and indirect, of its activities, products and services for risk assessment and identification of the necessary control measures;
2. determining the aspects that have or may have a significant impact on the environment, updating them in function of changes in activities, products and services.

The procedures for hazard identification and risk assessment must take into account:

- ordinary and extraordinary activities and human behaviour, skills and other human factors;

- the activities of all persons with access to the workplace (including third parties and visitors);
- hazards generated in the vicinity of workplaces due to activities related to those under control of management;
- infrastructure, equipment and material in the workplace, belonging both to management and third parties;
- design of work areas, processes, installations, machinery/equipment, operating procedures and work organisation, including their adaptation to human capabilities;
- changes in the IMS, including temporary changes and their impacts on operations, processes and activities.

Management must also ensure that there are specifications for raw materials, including packaging, semi-finished and finished products (if relevant) and any product or service that might affect the integrity of the finished product.

Specifications should be appropriate and accurate ensuring compliance with the relevant requirements regarding safety and legislative compliance.

Work instructions shall comply with the prescriptions detailed in the specifications agreed with the customer and must be applied.

A complete product description must be developed, including all relevant information on food safety, such as for example:

- composition (raw materials, ingredients, recipe);
- origin of the ingredients;
- chemical and physical properties that affect the safety of the product (pH, free water activities);
- treatment and process (heating, cooling, salting);
- packaging system (modified atmosphere, vacuum);
- conditions of storage and distribution (refrigerated temperature, environment);
- shelf life for which safety is guaranteed under the conditions set out for storage and use;
- instructions for use (storage, preparation);
- considerations of possible inappropriate use (storage, preparation).

Management must also implement a system to ensure that storage, production operations, maintenance or renovation work, the operations of sanitation and handling of packaging materials—both inside and outside the production area—are carried out in accordance with specific criteria to minimise the risk of microbiological, chemical and physical contamination.

3.2.5.3 Identification of Legal and Other Requirements

Management shall establish, implement and maintain a procedure to:

- identify and render available and accessible to the applicable legal requirements, the legislative requirements and regulations and any other requirement that is

applicable to the organisation and the product (international, national or by sector), determining the relevant application requirements which apply to its specific environmental aspects;
- identify the requirements specified by the customer, including those relating to delivery and post-delivery, not the requirements established by the customer but necessary for specified or foreseen use, if known;
- maintain and update all information relevant to legal and regulatory requirements, communicating them to staff and all stakeholders;
- ensure that the applicable legal requirements and any other to which management refers are suitably adopted for establishing, implementing and maintaining its IMS.

3.2.5.4 Preparation and Response to Emergencies

Management shall establish, implement and maintain a procedure to identify potential emergency situations, potential accidents and the associated response mode, in order to prevent or mitigate any eventual negative impacts.

If the packaging constitutes a risk to the product, special procedures must be set up to avoid contamination.

During the planning of emergency response, management must also take into consideration:

- the needs of relevant stakeholders and related notifications (for example, legislative and regulatory authorities, customers and/or consumers);
- methods of control and the related responsibilities and authorities for the management of nonconforming or withdrawn products, as well as the affected products in stock, and the sequence of actions to carry out;
- the need to periodically test such procedures, involving, where possible, the parties concerned;
- reviewing and, where necessary, a review of procedures for preparing and responding to emergencies, particularly after the occurrence of accidents or emergency situations.

3.2.5.5 Roles, Responsibilities and Authorities

Top Management must ensure the availability of resources essential to establish and ensure the effective operation and maintenance of the IMS.

Management, therefore, must define human resources and specialised skills, organisational infrastructure, technology and financial resources.

Roles, responsibilities, authorities, interrelationships and job descriptions of staff whose activities affect product safety, legal compliance, worker health and safety must be defined, documented and communicated, in order to achieve effective integrated management.

Top Management, taking into account the organisation chart, shall designate a member of the management structure who, independently of other tasks, will take responsibility and authority for:

- ensuring that processes needed for the IMS are established, implemented and maintained;
- reporting to top management regarding performance, effectiveness and suitability of the IMS, including recommendations for improvement and immediate use, in order to initiate and record the relative actions;
- ensuring that all staff are aware of the requirements defined in the context of the entire organisation;
- identifying, where necessary, specific skills for key roles (such as HACCP Team Leader, a director for external communications, etc.).

All staff must acquire the responsibility of reporting problems on the IMS to the designated person.

Management must constitute the HACCP team whose members, apart from the managers, must be designated and trained team leaders who can demonstrate competence and experience in the field. External experts may be present in the Team and in all cases records must be kept stating their knowledge and skills.

The team must establish a monitoring system capable of determining the loss of control of each Critical Control Point (CCP) and, where possible provide timely information so that corrective actions are taken and each critical control point (CCP) validated. In addition, the Team must provide documented evidence capable of showing that the control measures selected allow continuous monitoring of the risk to the level specified by the critical limit.

3.2.5.6 Communication

Management must ensure that appropriate communication processes are established at the different levels and functions of management as regards the business aspects and the effectiveness of the IMS.

Management must also determine and implement effective arrangements regarding requests from external interested parties to communicate with:

- suppliers and contractors;
- customers or consumers, in particular in relation to product information, inquiries, contracts or order handling, including amendments and customer feedback information, such as inquiries and complaints;
- legislative and regulatory authorities and other organisations that have an impact on the effectiveness or updating of the IMS or are influenced by them.

The records of communications must be kept and the information obtained through external communication must be included as input for updating the system and reviewed by top management.

Management must submit the results and conclusions of the LCA in a form that is appropriate for the intended recipients, including a discussion on data, methods and hypotheses used and any eventual limitations.
In particular the report should consider the following elements:

- changes and relevant justification to the initial coverage;
- boundary of the system, including the type of elements in the input and output in the form of elementary streams and decision criteria;
- description of the single process including decisions regarding allocation;
- data considering the reasons behind choice, level of detail and quality requirements;
- the choice of impact categories and category indicators;
- any graphical representation of the results of the LCI and LCIA.

If the study is presented to a third party, the final report should include more general aspects and all the characteristic features of the study, e.g.:

- the report presenting the results of LCI;
- a description of data quality;
- the purpose of the categories to be protected;
- impact categories considered;
- models of characterisation used;
- environmental factors and mechanisms;
- profile of the indicator results.

Finally, additional communication requirements are necessary for the purposes of comparative assertions intended for public disclosure, such as the results of uncertainty and sensitivity analyses, assessment of the significance of the differences, an explanation of the technical and scientific validity and of the environmental weight of the category indicators used in the study, etc.

3.2.6 Resource Management

3.2.6.1 Management of Human Resources, Infrastructures and Workplace

Management must determine—in the light of an assessment of business needs, financial capacity and the investment policy—the resources needed for implementation, continuous updating and improvement of the IMS.

These resources include human resources and specialised skills, organisational infrastructures and the work environment.

Management should also periodically review the availability, effective allocation and efficient use of the acknowledged resources, in order to identify any opportunities for improvement in their use.

As regards infrastructure, management must acquire buildings, process equipment (hardware and software), as well as support services such as transport, communication or information, which are adequate, reliable and available for the achievement of organisational goals.

The structures and facilities must be constructed and maintained to control the risk of product contamination and, therefore, for compliance with applicable law. Management must have suitable equipment for the detection of foreign bodies and ensure a timely intervention for the isolation of the contaminated product.

The risk of cross contamination must be minimised with effective measures.

The process flow chart from receiving to shipping must be arranged so as to avoid contamination from raw materials, semi finished and finished products. A "floor plan" must be available which clearly identifies the flow of internal segregation, access points, and paths and staff facilities.

The cleaning of production instruments must be conducted in designated areas or at specific times and separated from the production process. If this is not possible, these operations must be subject to targeted checks, in order to safeguard product safety.

Resource management also includes the work environment or the conditions under which work is performed, affecting staff motivation, satisfaction and performance and, consequently, the overall organisational performance.

Additional factors that need proper management are:

- financial resources, which must be effectively allocated and efficiently utilised in the performance of present and future activities;
- suppliers and partners, with whom it is necessary to establish a working relationship to generate synergies and enhance natural capacity to create value;
- knowledge, information and technology as essential resources to develop and improve organisational performance;
- natural resources, which are factors that can affect the long-term success of an organisation.

On this latter aspect management is required to integrate aspects of environmental protection, in the design and development of its products and processes, so as to minimise the environmental impacts throughout the entire product life cycle.

3.2.6.2 Training and Awareness

The organisation needs to increase the dynamic skills of personnel whose activities affect important aspects of Quality, Environment, Occupational Health and Safety and Food Safety. This is accomplished through targeted actions and ongoing training and education. Records of all these interventions must be kept.

Management should set up courses and the appropriate intervention required to meet the training needs identified in connection with the business and the IMS by preparing a training plan which covers the contents, delivery method, frequency, responsibilities and final learning assessment.

The organisation must acquire qualified employees to periodically check the equipment for the detection of foreign bodies that may contaminate the product.

The organisation must also establish, implement and maintain a procedure to enable people who work in management or on its behalf to be aware of:

- significant aspects related to Quality, Environment, Health and Safety and Food Safety and relevant impacts and risks, real or potential, associated with its activities as well as the benefits achieved through the improvement of individual performance;
- the importance of conformity with defined integrated policies, procedures and requirements of IMS;
- their roles and responsibilities in compliance with requirements of IMS;
- the potential consequences resulting from deviations from the procedures identified.

The training procedures must take into account different levels of responsibility, ability, skills, educational levels and risk.

3.2.7 Implementation and Operation

3.2.7.1 General

The identification and assessment of aspects, impacts and risks associated with activities undertaken by management are essential activities for detecting, identifying and planning operations and control measures to govern the risks of such activities, formalising, through documented procedures and instructions, implementation rules, including the handling of changes (see requirement 5.2).

These activities must include:

- the planning of product realisation consistent with the requirements of other IMS processes;
- the quality objectives and requirements relating to the product and the necessary processes for its realisation;
- the need to establish processes, prepare documents and provide resources specific to the product;
- requests for assessment activities, validation, monitoring, measurement, inspection and tests specific to the product and its acceptance criteria;
- the records necessary to provide evidence that the realisation processes and resulting product meet requirements.

Management shall implement, manage and ensure, in a form appropriate to the way it operates, the effectiveness of planned activities and any changes to such activities.

3.2.7.2 Operational Control

In order to ensure compliance with company policy, objectives and targets, management has to implement and maintain:

A. checks and operational criteria developed within their own IMS, to the extent their applicability to the organisation and its activities, taking due account of the following:

- design and product development and service performed through suitable activities of planning, reviews, verification and validation appropriate to each stage of design and development, also in terms of responsibility and authority. Management, in this sense, must pay particular attention to organoleptic, microbiological and sensorial assessment as well as shelf life tests and the validation of product claims, in order to ensure coherence with risk analysis and the guidelines written on the label;
- production and delivery of services and products under controlled conditions, through adequate validation activities of the processes and the data gathered, of the production/re-elaboration and delivery, identification and traceability of products (including those based on GMOs, containing GMOs or produced from GMOs and containing allergens), the handling of customer property and preservation of the product. This element must take into consideration:

– availability of information to describe the characteristics of the product;
– availability of work instructions, where necessary;
– a system to identify and trace, in good time, all items manufactured from raw materials (including primary packaging and other packaging material and process aids) all through the process phases up to the distribution of the finished product to the consumer;
– availability and use of equipment for monitoring and measuring;
– implementation of release, delivery and post delivery activities of the product;
– transportation, receipt and storage of the finished product, so as to maintain the conformity of products up to delivery and destination.

This element must also take into consideration, too:

- data collection and calculation methods explicitly documented that allow to quantify, on the basis of revenue and expenditure of each single process and in relation to the prefixed boundaries, the material and energy flows throughout of the product system (Life Cycle Inventory—LCI) in order to track the balances of mass and energy. This is an iterative process because as data are collected, the knowledge of the system increases and it may be necessary to identify new requirements or limitations on data, with eventual changes in data collection procedures, in order continually satisfy the purpose of the study

In the inventory phase it is particularly important to consider the "quality" of data, i.e., their validity, reliability, transparency, consistency, etc. Data can be classified in primary, if detected directly, secondary, if derived from scientific literature, from databases, etc., tertiary, if derived from estimates, averages, etc. To make a proper assessment of their real worth the following elements must be made explicit with reasonable accuracy:

- period to which the measurements relate;
- context (territory, process, etc.) and the reference technology;
- type of sampling chosen;
- calculation methodology adopted for obtaining mean values, etc.;
- variance and/or irregularities in measurement;
- control techniques for assessing the quality of data.

To this end a matrix (Data Quality Matrix) could be elaborated to define and evaluate, with an acceptable degree of approximation, the quality of data used. It is dependent on the following indicators: reliability of the source; completeness and representativeness of data; correlation in time between the study and data collection; geographical correlation between the production context and conditions of data reference. The inventory categories may be raw material consumption, water consumption, energy consumption, water emissions, air emissions, waste, risk and safety.
To ensure a coherent and consistent understanding and interpretation of the system under analysis the following guidelines should be considered:

- creation of flowcharts (of the process) that indicate the single processes and their interrelationships;
- detailed description of each process or single process identifying all relevant flows and data;
- development of a list showing all the units of measurement;
- description of the techniques of collection of data and calculation used.

The main categories in which data can be classified, include:

- input elements relating to energy, raw materials, auxiliary materials and other physical entities;
- products, co-products, waste;
- emissions to air, water and soil;
- other environmental aspects.

Within these main categories, the single categories of data must be specified. In the case where the same process gives rise to more products and it is not possible to proceed to a specific allocation of the respective raw materials, energy sources, water, etc. and related impacts, it will be necessary to identify appropriate criteria for classification. In this case reference is made to the principles of allocation, defined as the distribution of flows into or out of a process or a product system between the product system under analysis and one or more external product systems. The more common criteria for allocation are those based on:

- weight systems, which take into account the weight of the various products;
- weight systems, which take into account the economic value of different products;
- allocation, according to the main elements that characterise the various products (e.g., quality, quantity, cost, strategic importance).

Particular attention should be paid to recycled materials, evaluating the energy and environmental related activities carried out when recycling.
The quantitative data of the elements in the input and output of each single process must be calculated in relation to the reference flow. First data are collected then correlated to the functional unit, going on then to evaluate the related quantity of matter and energy in input.

B. Control measures for the management of the hazards identified in the HACCP plan must:

- establish critical limits to ensure that the acceptable level of risk identified in the finished product is not exceeded, documenting the reasons for choice;
- support with instructions or specifications and/or education and training the critical limits based on subjective data (such as visual inspection of the product, process, handling, etc.);
- identify corrective actions when critical limits are exceeded to ensure that the cause of non-compliance is identified, the parameter(s) controlled at the critical control point is/are brought back under control and that recurrence is prevented.

C. Control measures for the purchase of goods, facilities and services and the management of suppliers and visitors in the workplace.

In reference to the latter, if management entrusts transport services and storage to a third party all requirements must be clearly defined in their contract, or the service provider must be certified according to the Global Standard for Storage and Distribution and IFS Logistics.

3.2.8 Monitoring and Measurement

3.2.8.1 General

Management shall plan and implement processes for monitoring, measurement, analysis and improvement required to provide evidence of conformity of products and processes to the requirements defined in the IMS.

The monitoring system is divided into procedures, instructions and relevant records including the following aspects:

- measurements or observations that provide results over an adequate period of time;
- monitoring devices used;
- calibration methods applied;
- monitoring frequency;
- responsibilities and authorities related to monitoring and evaluation of monitoring results;
- both qualitative and quantitative measures to the satisfaction of management;
- monitoring the level of performance and the operational effectiveness of the controls adopted to achieve the defined objectives and targets;
- preventive measures to manage compliance with programme activities, operational criteria and checks;
- reactive measures for the control of occupational diseases, accidents (including injuries, near misses etc.) and other historical evidence which emerges in the organisation;
- a sufficient number of data records and control results and measures to facilitate the analysis of additional corrective and preventive actions.

These procedures shall include the document of information to monitor the development of performance, applicable operational controls and conformity with objectives and targets, including statistical techniques and the extent of their use. The organisation shall determine, collect and analyse appropriate data to demonstrate the adequacy and effectiveness of the IMS, including information resulting from monitoring and measurements deriving from:

- customer satisfaction;
- conformity to product requirements;
- characteristics and trends of processes and products, including opportunities for preventive action;
- suppliers;
- operations that influence product requirements.

This information must also consider the Inventory Analysis.
The latter is the starting point for the LCIA, which consists of mandatory and optional elements. The mandatory elements are:

- selection of impact categories, category indicators and characterisation models;
- classification, i.e., the assignment of LCI results to impact categories;
- characterisation, calculation of category indicator results (using appropriate models), by converting the results of the LCI into common units through characterisation factors and aggregating these results within the same category of impact.

- Optional elements in the LCIA phase include:
- normalisation: calculation of results for each category indicator in relation to reference information, with the aim of comparing the results obtained for each impact category with a reference value;
- grouping: aggregation of multiple impact categories into homogeneous sectors;
- weighting: process of converting indicator results of different impact categories by using numerical factors based on value choices and not on scientific grounds.

Further additional analyses of LCIA data quality useful for the understanding of significance, uncertainty and sensitivity of the results could be:

- gravity analysis: a statistical procedure that identifies data showing the largest contribution to the outcome of the indicator;
- analysis of uncertainty: to determine how the uncertainties and assumptions in data affect the reliability of the results of the LCIA;
- sensitivity analysis: procedure to determine how changes in methodological choices and data affect the results of the LCIA.

Management has to analyse the results of the verification activities, including the results of the internal and the external audits. The analysis must be performed in order to:

- confirm that the overall performance of the system complies with the schedule and requirements of the IMS set by management;
- identify the need to update or improve the IMS;
- identify trends that indicate a higher incidence of potentially unsafe products;
- establish information for the planning of the internal audit programme regarding the status and importance of the areas to be audited;
- provide evidence that all corrective actions are effective.

The results of the analysis and resulting activities must be recorded and reported in an appropriate manner to senior management as input information for the purposes of review. These results can also be used as input information for the updating of IMS.

Management must also provide evidence of the reliability of methods and equipment used for monitoring and measurement and, therefore, must ensure that they are:

- identified and calibrated, adjusted and checked at specified intervals or prior to their use, compared to reference measurements traceable to international or national standards (where such rules do not exist, they must be registered according to the basis used for calibration or verification);

- protected from damage and deterioration and from adjustments that would invalidate the results of the measurements.

Records must be kept of calibration results and verifications.

In addition, management must assess the validity of previous measuring results if it is found that the equipment or processes do not meet the requirements. Records must be kept of the assessment and actions arising from the handling of all equipment and products involved.

3.2.8.2 Assessment of Compliance

Consistent with its commitment to compliance, management shall establish, implement and maintain a procedure for periodically assessing compliance with applicable legal requirements and other requirements to which it subscribes. Management shall keep records of the results of periodic assessments.

Management should systematically assess the individual results of the audits planned. If the test demonstrates compliance with the standing provisions, management must take action to achieve compliance with the request. Such action shall include, without limitation, the review of:

- existing procedures and communication channels;
- the conclusions of the hazard analysis, monitoring plans and prerequisites of the HACCP plan;
- effective management of human resources and training.

Management shall apply suitable methods for monitoring and, where applicable, measure the IMS processes. These methods must demonstrate the ability of processes to obtain results conforming to specified requirements. When planned results are not obtained, corrective actions must be taken.

Management shall monitor and measure the characteristics of the product to verify that product requirements have been met. This should be performed at appropriate stages in the process of production, in accordance with planning. Evidence of compliance with the acceptance criteria must be registered.

Management, based on risk analysis must establish analysis programmes, internal and external—for raw materials, semi finished and finished products as well as equipment and packaging materials and, where necessary, work environments—and planned and documented audits to ensure that specific product requirements are met.

Management may subcontract or perform inspections or tests to confirm that safety; regulatory compliance and product quality are guaranteed, using appropriate procedures, structures and standards to prevent risks to product safety.

Management must also establish a monitoring system for each critical control point (CCP) to show that each critical point (CP) is kept under control.

The methods and frequency of monitoring must allow for timely isolation, prior to its use or consumption, of the product in the case of the critical limits being exceeded, to ensure the proper handling of potentially unsafe products and ensure that they are not released until they have been evaluated.

The records must indicate the person(s) authorised for the release of the product for delivery to the customer.

The product release and service delivery to the customer shall not proceed until the planned arrangements (see Sect. 7.1) have been satisfactorily completed, unless otherwise approved by a relevant authority or where applicable, by the customer.

3.2.8.3 Internal Audit

Management shall conduct internal audits at planned intervals to determine conformity to the plans and the requirements of the international standards of reference and to check effectiveness, implementation and maintenance of the IMS.

An audit programme shall be set up which takes into account the status and importance of the processes and areas to be audited, as well as the results of previous audits. Criteria, scope, frequency and methods of audit must be defined. The choice of auditors and conduct of audits shall ensure objectivity and impartiality of the audit process. There should be no self-auditing.

There must be a documented procedure to define the responsibilities and requirements for planning and conducting audits, to provide the records and for reporting on performance.

Records of audits and their outcomes must be kept.

The management responsible for the area under audit shall ensure that any necessary corrections and corrective actions taken to eliminate detected nonconformities and their causes are carried out promptly.

Further work shall include examining the actions taken and reporting on the results of the examinations.

With regard to food safety, management must ensure that:

- operational programmes and the elements defined in the HACCP plan are implemented and are effective;
- the input information for the analysis of hazards is constantly updated;
- levels are within acceptable levels of identified risk;
- any other procedures required by management are implemented and effective;
- the traceability system is tested annually to ensure that traceability can be maintained from the raw material to finished products and vice versa, including quantitative and mass balance. The results shall be preserved for further investigations.

3.2.8.4 Management of Non-compliance

Management shall establish, implement and maintain a procedure for dealing with actual or potential nonconformities and for taking corrective and preventive action.

The procedure should define requirements for:

1. identification, review and correction of non-compliance, determining the cause and taking actions to mitigate their impacts and prevent their recurrence;
2. treating the products which do not comply as follows:
   - taking action to eliminate detected nonconformity
   - authorising its use, release or acceptance under concession by a relevant authority and, where applicable, the customer
   - taking action to preclude its originally intended use or application
   - taking appropriate action against the effects or potential effects and commensurate with the risks identified in non-compliance when the nonconforming product is detected after delivery or after implementation;
3. assessing the need for action to prevent non-compliance and to undertake appropriate action in order to prevent their recurrence ensuring that the non conforming or potentially unsafe product is identified and monitored to prevent any involuntary use or delivery. When the nonconforming product is corrected it must undergo further checking to demonstrate compliance with the requirement;
4. recording the results of corrective and preventive actions;
5. reviewing the effectiveness of the corrective and preventive actions;
6. management must ensure that any necessary changes resulting from corrective or preventive actions shall be detailed in the IMS documentation.

To ensure the safety of food produced, corrections and planned corrective actions to be undertaken when the critical limits have been exceeded must be specified in the HACCP plan. These actions should ensure that the cause of non-compliance is identified; the parameters checked for the CCP are brought back under control and recurrence is prevented.

If corrective or preventive actions identify new hazards or changes in these or the need for new controls or changes to these, procedures shall require that the proposed actions be examined prior to their implementation, through a process of risk assessment.

3.2.9 Improvements

3.2.9.1 Corrective/Preventive Actions and Improvement

Management shall ensure the continuous improvement of the effectiveness of the IMS through policy, objectives, audit results, data analysis, measurement, monitoring, corrective and preventive actions and management review.

Management must also develop, implement and maintain documented procedures designed to control non-compliance, treatment and preventive and corrective actions related to the processes reported to the IMS.

The procedures shall define requirements for:

- identifying and correcting non-compliance and undertaking actions to mitigate its consequences;
- investigating non-compliance to determine its causes and take appropriate actions in order to avoid recurrence;
- determining potential nonconformities and their causes;
- evaluating the need for action to prevent non-compliance;
- assigning relative executive responsibilities;
- recording and communicating the nature of the findings, subsequent actions and results of corrective and preventive actions;
- archiving the documentation of corrective and preventive actions;
- reviewing the effectiveness of the corrective and preventive actions.

If corrective or preventive actions identify new hazards or the need for new checks, procedures shall ensure that the proposed actions be examined prior to implementation, through a process of risk assessment.

For all stages of the production processes that are not considered CPP, but only CP management shall implement, maintain and document specific preventive measures.

Management shall establish and implement corrective actions and reference procedures in the case where the checks find a fault to the equipment due identified foreign bodies capable of contaminating the product.

Every corrective and preventive action designed to remove the causes of actual or potential non-compliance shall be appropriate to the magnitude of the problem and commensurate with the risks and impacts identified.

Management shall ensure that any necessary changes resulting from corrective or preventive actions shall be included in IMS documentation.

Establishment of conditions detrimental to the IMS can be made:

- during the performance audit (Certification Bodies, internal, etc.);
- in the ordinary course of business, the occurrence of serious and/or recurrent irregularities;
- following complaints from stakeholders;
- in response to periodic reviews by top management;
- following reports of other functions involved in the implementation of the IMS.

3.2.9.2 Management Review

Top management must, at planned intervals, review the IMS of the organisation to verify its adequacy, effectiveness and efficiency.

The systemic evaluation of the IMS can identify any eventual opportunities for performance improvement, possibly by making appropriate changes to the IMS itself, hence defining new goals and new responsibilities.

The review process uses as input all the data produced by the IMS. These are outlined below:

- results of internal and external audits, performed by objective, knowledgeable and impartial evaluators;
- feedback from stakeholders;
- results of monitoring and measurement of processes and evaluation of the impacts and risks;
- data and information on organisational performance;
- status of corrective and preventive actions;
- actions arising from previous management reviews;
- opportunities for improvement;
- changes in the organisation (internal and external context), including any changes to legislative obligations and other requirements that may affect the IMS;
- results of compliance assessments in respect of existing legislative requirements and other requirements;
- achievement of objectives and targets;
- type, frequency and severity of non-conformities;
- reports on training needs and training.

This is to define, in the short term, the decisions and actions relating to:

- optimising of system effectiveness, processes and indicators;
- improving processes to meet the demands of the stakeholders;
- the resources necessary for the improvement of the IMS and its processes.

In its review, management must draw conclusions consistent with the requirements of the objective and scope of the LCA and in the case of consistency, prepare a final report with recommendations for the target audience of the LCA.
Management must also make a critical review in order to verify that the LCA meets the following requirements:

- the application of sound methodology in scientific and technical terms;
- the use of appropriate data, coherent to the use of the study;
- ensuring that the interpretation reflects the limitations identified and the objective of the study;
- preparation of a final report on the study that is transparent and consistent.

The review must be conducted by an internal or external expert, with the appropriate technical and scientific expertise, or by a committee of "stakeholders" (composed of a chairman who is an independent external expert appointed by the person who commissioned the LCA study and at least three other members). On the basis of the objective, the scope of the study and the economic resources available, the President appoints additional qualified and independent auditors.

Finally, management must identify areas where improvement of the assumptions made during the LCA could be developed, i.e., during the phases of defining the objective, drafting the inventory, assessing impact, and interpreting and analysing results. The aim is to prepare various proposals for improving its environmental profiles in order to choose the most appropriate option.

Records of management reviews must be kept properly and the significant elements in the output must be available for communication and consultation.

As regards food safety, if necessary, the HACCP plan, procedures and instructions that specify the programmes and prerequisites must be modified by updating the following information: product characteristics; intended use; flow charts; the process steps; control measures.

3.3 Conclusions

The methodology used for the model of integration of MSs is based on a process approach. It aims at rendering unique objectives, responsibilities and expected outcomes. In practice, the IMS is no longer viewed as a set of activities (even though they may be systemically integrated), but a proper system which implements its strategic-operational mission through interconnected elements. It aims towards supplies of products/services that consistently meet the requirements of different stakeholders.

It also aims to provide synergies and the full integration of all aspects related to management and the implementation of a “quality culture”.

The model is characterised by innovative operational value for the agri-food sector, because it facilitates integrated and synergic management of the versatile nature of all aspects of food quality, referred both to those required by law (i.e., HACCP) and those voluntarily adopted (ISO 9001, ISO 14001, etc.). In addition, the model has been articulated on the basis of a multiple perspectives regarding not only the integration of MSs, but also process and product.

In reference to the latter, in fact, the requirements of the most widespread agri-food products standards, promoting sustainability and food product safety, have been considered (BRC, IFS).

As a consequence, the model is a flexible framework that can be applied to various organisations, tailored for the specific needs of SMEs, operating in the agri-food sector on the global market.

It can be applied either as a tool for the modular integration of MSs or as an additional, complementary tool for improving competitiveness and sustainability of agri-food firms.

Recently, trends show a marked inclination towards a common vision of the different dimensions of quality in the agri-food sector and the suggested model integrates some or all these aspects, highlighting similarities and synergies wherever possible and avoiding unnecessary duplication and fragmentation.

IMS model fosters a holistic view of the continuous improvement of quality in the agri-food sector for maximising. In short, the effectiveness and efficiency of both internal and external performances of organisations, facilitating the spread and potential growth of competitiveness and sustainability in the sector.

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Chapter 4
The Implementation of Integrated Management System in Agri-Food SMEs

Maria Proto, Ornella Malandrino and Stefania Supino

4.1 Introduction

The proposed model for the integration of MSs and product standards in the agri-food sector has been experimented thanks to the involvement of the Petti S.p.A., a brief profile of which is set out below.

Antonio Petti S.p.A.

ANTONIO PETTI S.p.A., located in Nocera Superiore (SA), is a well known company producing processed tomatoes and established in the agri-food industry since 1925.

250 permanent staff and about 200 temporary workers are employed by the Company.

The current range of products includes:

- Tomato Paste in all its variations
- Sieved Tomatoes.

The Company A. Petti S.p.A. was established in 1955 when the Company, founded in 1925 by Antonio Petti (1886–1955) expanded. Antonio Petti, the descendant of an ancient family of landowners from the Agro Nocerino-Sarnese area, initially processed the tomatoes by hand, boiling the tomato

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extract in open containers prior to filling the tin cans. The experience gained in the sector, market development and various technological innovations led to expansion of production to the extent that in 1971, the A. Petti S.p.A. became leader in Europe for canning tomatoes, with a production equal to 1,500,000 cases per annum and a workforce of 400 employees.

The company, positioned among the top in Europe for the production of tomatoes and tomato paste during the period 1980–1993, was among the first in the world to turn to the market outside Europe for the export of tomato paste, enough to satisfy in 2000, 70 % of the tomato paste needs of the African Continent.

In 2001 the Company formed the Group Petti, made up of SO.GE.CO. SpA and four manufacturing establishments, the annual turnover of which in 2002 exceeded 100 million Euros.

In 2005, to deal with Chinese competition, increasingly aggressive in the African territory, which absorbs about 35 % of exports of tomato paste, the Group inaugurated a new manufacturing plant in Lagos, Nigeria, which took the name CONSERVERIA AFRICAN LIMITED.

2006 was the turning point for the establishment ITALIAN FOOD SpA Venturina (LI), Arrigoni taken over by the Petti Group in 1973, when it was transformed into a new larger company in direct contact with international clients (Petti 2012).

In recent decades, the pressures emerging from the competitive arena in which the company Petti S.p.A. operates, have led management to redefine their approach, strategies, and organisational planning in order to achieve better economic, environmental and ethical performance.

In particular, it has been necessary to develop and control business activities in relation to an ever-wider range of evaluation parameters that include not only safety factors and the wholesomeness of products but also environmental protection, occupation health and safety as well as the social dimension or what could be called the "quality" of all-round performance. In this perspective, the implementation, over the years, of different Management Systems (Quality and Environment) and Product Certification (BRC and IFS)—at times to meet the pressing demands of English, French and German retailers—has improved the effectiveness and efficiency of process outputs and the relationships with the socioeconomic context in which the company operates.

The many internal and external audits (Second and Third part), conducted to evaluate compliance with the standards adopted have helped to improve not only the implementation and operation of the systems in place but also the organisational structure and management of the company, ranging from monitoring the suitability of the technologies used in the structures and procedures for managing environmental impacts to logistic staff management.

However, the use of such tools (Management Systems and Product Certification) has required considerable resources, especially human resources, engaged in collecting and processing the large production of documents and data.

The need adopt measures to simplify documentation, resolve problems and inefficiencies to resulted in policies for resource optimisation and synergy creation. Management made a preliminary attempt to integrate two existing Management Systems (Quality and Environment) taking into account similarities in terms of methodological approach and goals. However, this did not achieve the desired results.

No specific team was set up to examine and select methodological criteria and added to the lack of involvement on the part of human resources, a critical preliminary analysis of documentation was not put in place.

In practice, the staff tended to carry on as in the past, obtaining the certification: working on what was to be shown or demonstrated, as effective rather than implementing decision-making and management based on processed data.

The problems, highlighted in the exploratory audit, dampened enthusiasm and the desire to continue the integration project.

The company's involvement in the EMAF Project, in 2010, rekindled the interest of management, which resulted in the integration of systems ISO 9001, ISO 14001, BRC and IFS.

The IMS model, proposed by the Research Unit of Salerno, was applied to Petti S.p.A. and the main steps are described below together with a critical analysis of the strength and weak points encountered.

4.2 Implementation of Integrated Management System in a Pilot Firm of the Tomato Processing Sector

In Petti S.p.A. the shift from separate to a single integrated management system required the setting up of a team to plan, organise and define IMS goals and objectives.

The team was made up of quality coordinators and representatives from key areas of the organisation and included two researchers of the EMAF project (University of Salerno) to provide the guidance and input needed to design, develop, implement and assess the IMS.

Once the management system team was established, meetings were organised to assess the "state-of-the-art" of existing systems and to define, through discussion common goals, the purposes and procedures of the IMS (Holdsworth 2003) (Table 4.1).

Priorities included an overview of organisational structure and processes as well as the assessment of existing systems, in order to:

Table 4.1 Main goals and operational steps of the integration process

No.	Main goals and operational steps
1	Eliminate duplication/redundancy: use same administrative controls to drive all programme elements
2	Ensure compliance with applicable regulatory requirements
3	Ensure compliance with company/industry standards ISO 9001 ISO 14000 BRC IFS
4	Optimise resources and synergies from the different systems
5	Clarify responsibilities for managing, performing and verifying the work
6	Put due emphasis on processes
7	Maximise cost efficiency/business results including the transition period for implementing change in the system
8	Provide flexibility/adjustability within the new system to facilitate continuous improvement
9	Develop a management system where performance can be measured
10	Perform internal and external audits more efficient and effectively
11	Improve management efficiency as a wholly

1. analyse the company documents (to eliminate any outdated material related to the subject matter, no longer in use but still saved or kept in the management system);
2. assess documentation needed to ensure alignment with new regulatory and corporate requirements;
3. analyse the gaps between existing documented programs and regulatory and corporate requirements;
4. evaluate the control tools adopted for managing safety management processes, risk management programmes, occupation safety and health and environmental activities.

The critical analysis of existing documentation and processes at the company highlighted the need for rationalisation and optimisation of existing procedures.

In the latter stages of work, with a view to simplifying and synchronising synergies, procedures were rewritten; a series of meetings arranged and a working plan to implement the model "Integrated Management System" put in place.

The operational plan provides for four main steps to implement the project of integration.

The first step, of a strategic nature, aimed at devising a policy of integration and the identification of principles, objectives and actions for constant improvement of economic, environmental and food safety.

The content framework ensures that it:

- is appropriate to the aims of the organisation as well as taking into account the nature and risk of the activities, products or services offered;
- is inclusive of the commitment to meet the requirements applicable to the company and to continually improve the effectiveness of the management system;

- provides a framework for establishing and reviewing environmental objectives;
- is reviewed for continuing suitability;
- is documented, communicated and understood within the organisation, kept up and communicated to all staff;
- is available to the public.

From the basic principles of company policy depend the overall objectives of the IMS. The latter, to be measured and achieved within a defined period of time, has the following priorities:

- total customer satisfaction;
- improved environmental performance and food security;
- continuous process improvement;
- greater organisational effectiveness and efficiency.

These general objectives are the fundamental basis of reference for designing and implementing the IMS and, therefore, define the activities and resources required. This involves commitment and regular updating to satisfy customer needs. To achieve objectives, management takes into account findings from analysis of data resulting from tests performed on the products or service delivery processes, as well as customer satisfaction and management review.

The document originates from a systemic evaluation of the IMS and verifies the adequacy, effectiveness and efficiency of the system, identifying potential opportunities for improvement eventually making appropriate changes to the IMS and defining new objectives.

For each objective, performance indicators are defined in term of environmental and measurable targets representing how the company estimates achievement over time and the timescale of procedures and the staff responsible for its implementation. Objectives are pursued for each area and expertise from all the relevant departments exploited.

The second step, of a "systemic nature", involves issues related to organisation and management of resources as well as a documented plan of key activities:

- definition of roles, responsibilities and resources necessary to implement and maintain the IMS;
- preliminary identification and definition of the integrated system processes;
- determining the documentation necessary to the implementation of the IMS;
- planning the analysis, monitoring, measuring and assessing the performance and efficiency of business management;
- identification of specific training and experience requirements for operators;
- definition and verification of any improvement of the Integrated System.

The documentation of the Integrated System, in particular, consists of a collection of documents organised and updated, the documented procedures and records and other documents required by the reference standards and laws of payment applicable. During this phase, the manual describing the company Integrated Management System is drawn up, designed in accordance with standard

Table 4.2 Correlation between ISO 9001, ISO 14001, BRC, IFS and paragraphs of the Manual of IMS in the pilot firm Petti S.p.A

Description	PAR.	ISO 9001:2008	ISO 14001:2004	BRC issue 5	IFS issue 5
Introduction	0	–	–	–	–
Purpose and scope	1	1	1	–	–
Normative references	2	2	2	–	–
Terms and definitions	3	3	3	–	–
Integrated management system	4	4	4	–	1.2
4.1 General requirements	–	4.1	4.1	2.1, 1.10, 1.11	1.2
4.2 Documentation requirements	–	4.2	4.4.4, 4.4.5, 4.5.4	3.7.1, 1.8, 2.12, 3.2, 3.7	2.2, 2.3
Integrated systems policy	5	5	4	–	–
5.1 Planning	–	5.1, 5.3, 5.4	4.2, 4.3.3	1.3, 1.4, 2.2, 2.3, 2.4, 3.1, 3.9	1.1, 4.1, 2.1.1, 4.16, 4.17
5.2 Identification and assessment of aspect, impacts and risks	–	5.2, 7.2.1, 7.2.2	4.3.1	2.6, 2.7, 2.8, 3.4, 3.7.2, 4.8, 4.11, 5.2, 7.4	1.3, 2.1.3, 4.2, 4.9, 4.10, 4.18, 5.6
5.3 Identification of legal requirements and other	–	5.2, 7.2.1	4.3.2	2.2.2, 4.10.2, 4.10.3	4.8.1, 4.18.1, 5.5.1
5.4 Preparation and response	–	8.3	4.4.7	3.10, 3.11	5.8, 5.9, 5.10
5.5 Roles, responsibilities and authorities	–	5.5	4.4.1	1.1, 1.5, 1.12, 2.1, 3.3	1.2, 2.1.2
5.6 Communication	–	5.5.3, 7.2.3	4.4.3	1.2	–
Resources management	6	6	4	–	–
6.1 Management of human resources, infrastructure and work environment	–	6	4.4.1	1.1, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 5.3, 6.3, 7.2, 7.5	3.1, 3.2.2, 3.4, 4.6, 4.13, 4.14, 5.4, 5.5.3
6.2 Training, induction and awareness	–	6.2.1, 6.2.2	4.4.2	7.1, 7.3	3.2, 3.3, 4.7,
Implementation and functioning	7	7	4	–	–
7.1 General	–	7.1	4.4	–	4
7.2 Operational control	–	7.3, 7.4, 7.5	4.4.6	3.6, 3.9, 4.9, 4.10, 4.12, 5.1, 5.4, 6.1, 6.2	4.1, 4.3, 4.4, 4.5, 4.8, 4.11, 4.12

(continued)

Table 4.2 (continued)

Description	PAR.	ISO 9001:2008	ISO 14001:2004	BRC issue 5	IFS issue 5
Monitoring and measurement	8	8	4	–	–
8.1 General	–	7.6, 8.1, 8.2.1, 8.4	4.5.1	2.5, 2.13, 3.4	–
8.2 Assessment of compliance	–	8.2.3, 8.2.4	4.5.2	2.9, 2.11, 5.5, 5.7	4.15, 5.3.1, 5.5.2, 5.7
8.3 Internal audit	–	8.2.2	4.5.5	3.5	5.1, 5.2
8.4 Management of non-compliance act	–	8.3	4.5.3	1.13, 5.6	5.3.2, 5.9, 5.10
Improvement	9	8	4	–	–
9.1 Corrective actions, preventive actions and improvement	–	8.5	4.5.3	2.10, 3.8	5.11
9.2 Management review	–	5.6	4.6	1.6, 1.7, 1.9	1.4

ISO 9001:2008, ISO 14001:2004, BRC Issue 2008, IFS Issue 2007, as reported in Table 4.2.

The Handbook is the main document describing the IMS in which policy, organisational structure key responsibilities and operating procedures relating to all essential elements applicable to the System are formally defined. The Handbook is regularly updated by the IMS manager, who circulates the same to staff.

The framework document for all IMS procedures clearly details the processes and delineates the structure. It consists of nine chapters and the index follows the same structure as the IMS model. In the IMS structure and its reference documentation all applicable ISO 9001:2008 requirements were considered, except for those concerning the design and development (relevant to Sect. 7.3 of the standard), and the parties relating to the validation and the editing of the project. The exclusion stems from the lack of planning by the Company manufacturing products by means of largely standardised processes regulated by rules, laws and codes of best practice.

The IMS of A. Petti S.p.A. is implemented scrupulously respecting the provisions in the Handbook and the procedures, operating instructions, forms and any other documents it contains. The integrated system provides for application to all business processes related to each other directly or indirectly, affecting the quality of products/services offered or that interact with the environment, so as to ensure that they comply with the requirements of customers and other conditions applicable. To this purpose, the company has defined the relevant processes for quality management, environment and product safety, dividing them into "primary" and "support". The primary processes are directly related to the production of concentrates and tomato sauce and customer satisfaction (purchase orders, warehousing, procurement, manufacturing and controls), the processes of "support", however, are those without immediate impact on the final customer but which support the activities of the company by determining the correctness and efficiency of the primary processes (such as resource management, measurement, analysis and improvement, managerial responsibility).

The third step aims at full integration of the operational aspects, namely those related to procedures and instructions.

Procedures are documents that describe the manner in which activities are to be performed, the purpose of which is to keep up systematically continuous processes considered in line with those indicated in the Handbook and in compliance with the requirements of standards reference.

The procedures and guidelines adopted by Petti S.p.A. were divided and structured in conformity with the following level of integration:

- common or general system procedures, provided in all implemented standards and scaled to all the organisations with respect to the implementation of IMS;
- specific procedures provided for in one or more standards;
- embedded operating instructions as provided for in most standards;
- specific operating instructions for each standard.

Table 4.3 The procedures in the pilot firm Petti S.p.A. prior to the introduction of IMS

System procedures	Management of documents and records
Management of documents and records	Human resource management
Human resource management	Maintenance management
Maintenance management	Management of the workplace
Management of the workplace	Management site security
Management site security	Internal audits
Internal audits	Management non conformity
Management non conformity	Analysis of data
Analysis of data	Management for improvement actions
Management for improvement actions	Management of regulatory requirements
Management of regulatory requirements	Management of the instrumentation
Management of the instrumentation	Communication management
Communication management	Management review
Management review	Management of documents and records

The system procedures, in place at Petti S.p.A., listed in Table 4.3, have been rewritten and integrated. The specific procedures, however, are still subject on being rewritten and integrated with other documents.

Table 4.4 illustrates in brief, the work entailed in putting an IMS in place. All the documentation, relative to Quality and Environmental Management System in place at Petti S.p.A., has been recoded, in line with the guidelines detailed in the Manual as well as the corresponding index of the IMS Model; integrating the procedures, streamlining and reducing the number of procedures; duplication has been eliminated and where possible, similar types of documents incorporated into single categories—resulting in much more simplified procedures.

The working group created *ex novo* procedure no. 54.0 "Managing emergencies" and the Instruction no. 61.0 "Instructions for the cleaning and maintenance of the plant". The first procedure defines the method of intervention and relative responsibilities and coordination in the event risky situations or events occur in terms of personal safety or the safeguarding of the environment. This particular procedure contains all the following instructions: 54 Danger from broken glass, 54 Danger from jagged blades, knives or other sharp metal objects, Danger from chemical or other contamination, 44.7 Management of Debris in the event of Storms/Flooding, Regeneration of Ground, 44.6 Ground Pollution, Emergencies, Unexpected Events, Fire Emergencies. As concerns the latter, the existing Emergency Fire Plans are highlighted.

The purpose of the instruction is to define and manage the clearing and maintenance of the plant, the equipment and production plants referred to in the procedures, highlighting at the same time, the instructions for the sterilising of the tubes and for washing the product tunnels/shafts.

In the fourth step, the documents were examined together with Company staff in order to enlighten everyone and to discuss suggestions: this was preliminary to the operative phase of application of the IMS.

Table 4.4 Revision of procedures, instructions and documents in the pilot firm Petti S.p.A

Corresponding to chapters in the handbook	Type of document	Previous document	New Code and brief description of process of integration in place
4	Procedure	42 0 Dealing with documents and registration	The procedures and documents reported in the column on the left have all been integrated in a single *procedure no. 42.0 managing documentation*, focussed on the managing of documents internal and external to the organisation.
	Procedure	43 2 dealing with norms and regulations	
	Document	List of relevant laws	
5	Procedure	52 Company policies	The management of objectives procedure and the relative documents attached have all been integrated in *Sect. 5 of the SGI Handbook* which deals with among other things**, t**he aspects relative to the communication, planning and defining of roles, responsibilities and authorities.
	Procedure	54 Managing objectives	
	Document	Planning	
	Document	Goals register	
	Document	55 Organigram	
	Instruction	55 Substitute profiles	
	Document	Register for environmental communications	
	Procedures	44 3 Managing communications	
6			*Procedure 61.0 resource management* derives from the revision and merging of the three procedures reported in the column on the left. It defines how the Management of A. Petti S.p.A. should ensure that the necessary resources for implementing strategies and for pursuing organisational objectives are found. The procedure illustrates, furthermore, the method with which the Company carries out the management of the equipment by means of which product conformity to quality specifications in terms of safety and environmental elements, is judged.
	Procedure	62 Human resource management	
	Procedure	63 Maintenance management	
	Procedure	76 Management of tools and instruments	
6	Procedure	64 Management of work environment	*Procedure 61.1 Management of work environment* incorporates the procedures and instructions described in the column on the left and has the aim of a defining and managing the work environment to ensure conformity with the required product specifications including consumer safety
	Procedure	64 Management of safety on the premises	
	Instruction	62 Rules relative to personal hygiene	
	Instruction	64 Instructions for procedures of sterilisation	

(continued)

Table 4.4 (continued)

Corresponding to chapters in the handbook	Type of document	Previous document	New Code and brief description of process of integration in place
7	Procedure	74.0 purchasing	*Procedure 72.1 Purchasing* combines the procedure and instructions reported in the column on the left. The procedure regulates the company activities necessary for the compiling, checking, approving and issuing of Purchasing Orders made on behalf of Petti S.p.A. and regulates the relative actions of control to impede the non conformity of the products supplied.
	Instructions	64.0 Regulations relative to hygiene and suppliers	
	Instructions	74.3 Taking samples and testing of raw materials	
	Instructions	Hygiene controls relative to incoming goods	
7	Procedure	75.5 Warehouse and deliveries management	*Procedure 72.2 warehouse and deliveries management* illustrates general criteria, applicative methods and responsibilities inherent to the phases of conservation, movement and storage of raw and related materials, of tomato pastes and end products housed in the Company Petti S.p.A.
	Instruction	75.5 Loading report	
7	Procedure	73 Product development and related processes management of product development and processes	The following procedures and instructions have been integrated in a single procedure *72.0 management of operational control b*y means of which the company devises, implements and maintains direct control of operational criteria devised within its integrated management system. This ensures conformity with company policy, established objectives and goals, in reference to the following processes: • product planning, validation and changes in the phases of development; • supplies and checking products purchased; • putting in place and validation of production processes and delivering services; • product identity and traceability
	Procedures		
	Procedures	71 Planning production	
	Procedure	75.3 Management of traceability and recall	
	Instruction	Self-assessment	
	Instruction	Assessing programme	
	Instruction	74.3 Debagging tomato paste	
	Instruction	Removal of packaging	
	Instruction	82.3 Checkingfilters	
	Instruction	82.3 Checking weights on the production line	
	Instruction	82.3 Checking weight in the tubes	
	Instruction	64 Checking water in wells	
	Instruction	Unloading fuels	

(continued)

Table 4.4 (continued)

Corresponding to chapters in the handbook	Type of document	Previous document	New Code and brief description of process of integration in place
	Istruction	Shifting inorganic liquids	
	Instruction	46.6 Operator for cleansing plant	
	Instruction	44.6 Storage of lubrificants	
	Instruction	46.6 Management of waste waters	
	Instruction	44.6 Waste management	
	Instruction	44.6 Purfication plant management	
8–9	Procedure	82 2 Internal audits	The procedures, instructions and related documents reported in the column on the left hand side have been integrated in a single procedure *81.0 integrated system management* which analyses the monitoring and measuring of the integrated system as well as the actions for continual improved performance, in a PDCA perspective.
	Instruction	Audit of glass	
	Procedure	83 Management of non-conformity	
	Document	Register of non-conformity	
	Procedure	84 Data analysis	
	Procedure	85 Management of improvement strategies	
5	Procedure	43.1 Environmental management	The procedures, instructions and related documents reported in the column on the left hand side are all part of a single procedure *52.0 aspects, impacts and risks management.* The procedure describes the means of evaluating environmental and food safety, the related responsibilities and the relative impacts produced by the company in the course of its activity, in the light of company findings and respect for the regulations in force. Significant environmental impact and the HACCP plan constitute the fundamental elements to take into account when determining the objectives and goals the company intends to pursue.
	Instruction	44.6 Air emissions	
	Flow chart	71 Analysis of risks with reference to cans for tomato paste	
	Flow chart	71 Analysis of risks with reference to tubes for tomato paste	
	Flow chart	71 Analysis of risks with reference to bricks for sieved tomatoes	
	Document	Self-assessment HACCP plan	
	Document	75.2 HACCP evaluations	
	Document	75.1 HACCP validations	

4.3 Conclusions

The integration process carried out at Petti S.p.A. shows the validity of the IMS model realised in the EMAF Project by the research Unit of the University of Salerno. It proposes a framework containing requirements necessary for the integration of key management systems in organisations of the agri-food sector: maximum effectiveness and efficiency of the various processes involved being the key aim.

During the complex and articulated integration process at Petti S.p.A., some strong points emerged. Those relative to internal processes include: the focus on a holistic approach and underpinning relationships; synergies in terms of capabilities linked to the early use of routine MSs; fewer unnecessary documents and less bureaucracy; improvements in organisational efficiency and effectiveness.

Strong points relative to external processes mainly concerned the worldwide spread of multiple MSs in the agri-food sector and the enhancement of synergies; the use of best practices to meet strong competition on the global market; widespread adoption of tools for continuous improvement and benchmarking.

The weak points, on an internal scale, emerging during the process of implementation concerned: the need for a change in attitude among employees and management; the difficulties in attempting to re-allocate roles, responsibilities and skills and the need for resources for training, knowledge sharing and dissemination. The lack of market information relative to IMS approaches pursued in managerial and organisational processes and the difficulties encountered in fostering IMS as a tool for creating value on the market appeared to be the most significant barriers emerging in the external context.

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Part III
Simplified Life Cycle Assessment (s-LCA)

Chapter 5
Life Cycle Assessment for the Agri-Food Sector

Ioannis Arzoumanidis, Luigia Petti, Andrea Raggi and Alessandra Zamagni

5.1 Introduction

The food supply chain has become an important contributor to a number of environmental impacts (including climate change), mainly due to a notable increase in food production (Schau and Fet 2008), to major shifts in dietary patterns (Delgado 2003; Kearney 2010) and to the way in which agricultural processes and all the processes involved in the food chain are generally carried out. The increase in the global population and the development and industrialisation of the underdeveloped (and commonly overpopulated) countries are amongst the reasons identified for this increase in food production, which has resulted in agriculture accounting for more than half of global vegetated land and being responsible, amongst other things, for roughly 1/5 of all anthropogenic Greenhouse Gas (GHG) emissions (although the exact proportion depends on the definition of the system boundaries) (Woods et al. 2010).

On the other hand, Lomborg (2001) claims that it is not overpopulation, but rather population density, along with the poverty levels, that can be regarded as

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problematic for a country. Furthermore, the problem is heightened by the fact that it is cities that are becoming larger and thus the Earth's entire landmass is not populated in a balanced way. Finally, Lomborg questions whether food production is increasing, arguing that it has actually been decreasing since 1984 and that there is "space" for more intensive agricultural production (ibid). This line is supported by Mueller et al. (2012), who point out the importance of "sustainable intensification" as a way of increasing yields on underperforming lands, in order to meet the growing demand for food. These authors stress that this intensification could be achieved while reducing the environmental impact, by cutting down on the overuse of nutrients and ensuring better water management.

Detailed figures on the environmental impact of the food and drink sector were provided by the Environmental Impact of PROducts (EIPRO) study (Tukker and Jansen 2006). This study, which aimed at identifying the products consumed in the EU that, along their whole life cycle, have the greatest environmental impact, identified food and drink products as accountable for 20–30 % of the overall environmental impacts of private consumption in Europe. Within this group, meat products have the greatest environmental impact (with a contribution to global warming in the range of 4–12 % of all products), followed by dairy products and then by a variety of other products, such as plant-based food products, soft drinks and alcoholic drinks.

Every stage of the production-consumption chain—from growing crops (livestock) to transport and storage, processing, distribution, purchasing and consumption, and the waste treatment and disposal—has environmental effects. The most significant environmental impact related to food consumption arises from food production and processing in Europe and in other regions of the world (EEA 2005).

In order to take into account the whole chain, a life cycle approach is necessary, according to which the entire life cycle of a product, a process or a service should be considered "from cradle-to-grave" (i.e. the entire supply chain and involving the various actors in a product supply-chain) in order for its environmental sustainability to be evaluated.

Among the several methods based on a life cycle approach, the Life Cycle Assessment (LCA), as regulated by the ISO series 14040 standards, stands out as the only standardised methodology for the environmental assessment of a wide set of environmental impact categories. Its main features can be summarised as follows: it avoids the shifting of environmental problems along the different life cycle phases and environmental impact categories; it enables the measurement of the contribution of each elementary flow of the unit processes to the environmental impact, a comparison of different products that would fulfil the same function and the optimisation of the system under study whenever trade-offs arise.

The LCA methodology dates back to the 1960s, when concerns over the limited availability of raw materials and energy resources led to new ways of accounting for energy use and the consequences of these uses. In the early 1990s, LCA was used for external purposes, such as marketing (Elcock 2007). In more recent decades its application has broadened into a number of fields, including building materials, construction, chemicals, automobiles, and electronics. This was primarily because of the formalisation of LCA standards in the ISO 14040 series (since 1997) and the launch of the Life Cycle Initiative by the United Nations Environment Programme (UNEP) together with the Society of Environmental Toxicology and Chemistry (SETAC) in 2002.

The application of LCA to the food products and systems is not straightforward, as many challenges arise at methodological level, due to the still incomplete knowledge of some environmental mechanisms and to the inherent complexity of the systems to be analysed. In fact, aspects such as genetically modified organisms, desertification, pesticides, antibiotic-resistant strains of microorganisms and growth hormone residues in food, just to mention a few, are not adequately addressed (Notarnicola et al. 2012, p 3). Moreover, while there have been attempts to address biodiversity, water use, toxicity impacts and erosion, these still need to be adequately developed.

Nevertheless, while developing the methodology, it is also important to distinguish the “latest science” from the “good practice” (Baitz et al. 2012), in order to make the method fully applicable on a day to day basis. In fact, given the way the sector is structured and the predominance of small- and medium-sized enterprises (SMEs) (Eurostat 2011) that generally lack the knowledge and resources required to implement LCA, simplification strategies that aim to facilitate access to reliable, accurate and relevant life cycle information are deemed relevant (Zamagni et al. 2012). A number of simplification techniques have been developed and are available in the scientific literature. In the framework of this EMAF project, a simplified LCA tool needs to be selected that can be regarded as suitable for agri-food SMEs, with the overall goal of improving the business decision making in terms of strategic planning, setting priorities, product designing, enhancing databases concerning the products under study, and identifying improvements in relation to product/process/supply chain developments.

This chapter examines existing LCA studies and reviews of case studies on food supply chains so as to identify methodological state-of-the-art cases. In addition, an attempt is made to identify those stages of a product’s life cycle that have greater impacts on the environment. Later on, a review of existing simplified LCA tools and approaches is outlined (Chap. 6). From the analysis of these tools and with the aid of decision-making approaches, a simplified LCA tool is selected that can be regarded as suitable for SMEs in the agri-food sector. What follows is a case study implementation of the selected simplified LCA tool to test its effectiveness in the agri-food sector, and the appraisal of its results with reference to those of a full LCA (Chap. 7) in order for its robustness to be evaluated.

5.2 Literature Review: Critical Analysis and State-of-the-Art of LCA in the Agri-Food Sector

5.2.1 Method

In order to identify methodological state-of-the-art cases of LCA concerning food supply chains a review of the literature was carried out (Arzoumanidis et al. 2011; Salomone et al. 2011). In addition, an attempt was made to identify: (a) whether there could be a tendency for some environmental impacts to be more important than others when it comes to food products, and (b) whether there were specific stages in the products' life cycle that seem to be more impacting than others.

The bibliographic search focused on scientific databases and citation indexes, such as Science Direct, Scopus, CASPUR Virtual Library (an Italian inter-university database search engine), and Google Scholar, but also LCA-specific conference proceedings. The keyword logical expression used for this purpose was as follows: "food" AND ("LCA" OR "Life Cycle Assessment" OR "Life Cycle Analysis"); the term of the expression before the AND operator ("food") was searched both in the article/book title field and in the entire text, whilst the term of the expression after the AND operator was searched only in the article/book title field. The review focused only on reviews of case studies, as the results contained a great number of case studies on the sector. It was therefore presumed that such reviews are representative of the entire spectrum of the case studies. The literature search resulted in a fair amount of review papers being identified, notably: four peer-reviewed journal papers (Hospido et al. 2010; Roy et al. 2009; Schau and Fet 2008; Usva et al. 2009), two reports (Foster et al. 2006; Tatti et al. 2008) and five papers published in conference proceedings (Mungkung and Gheewala 2007; Notarnicola 2008; Petti et al. 2010; Salomone et al. 2010; van Kernebeek et al. 2010). All papers are very recent; indeed, they all came out over the last six years, with more than half of the papers identified having been published in the last three years. This attests to the recent growth in interest in this field which has led to an increase in contributions to identify the relevant state of the art.

Generally the criteria identified and used to critically review the selected papers concerned LCA methodology and were as follows: reasons for carrying out the case studies, object of the case studies, the definition of the functional unit (FU), the system boundary, the multi-functionality issue, the data issues, results of the case studies (Peacock et al. 2011).

5.2.2 Main Findings from the Review

5.2.2.1 Reasons for Carrying out the Case Studies

The LCA case studies examined in the review papers were conducted for a variety of reasons (although in some reviews these reasons were not mentioned).

The objectives of the studies were in most cases to focus on: identifying and assessing the environmental burdens of the food products (Foster et al. 2006; Hospido et al. 2010; Mungkung and Gheewala 2007; Notarnicola 2008; Petti et al. 2010; Roy et al. 2009; Schau and Fet 2008; Tatti et al. 2008; Usva et al. 2009); identifying the environmental weak points of the product life cycle (Foster et al. 2006; Mungkung and Gheewala 2007; Notarnicola 2008; Petti et al. 2010; Usva et al. 2009; van Kernebeek et al. 2010); comparing the environmental performance of different products (Petti et al. 2010; van Kernebeek et al. 2010); comparing alternative processes (Mungkung and Gheewala 2007; Petti et al. 2010; Roy et al. 2009; Tatti et al. 2008; van Kernebeek et al. 2010); or finally comparing different tools and approaches (Petti et al. 2010; Roy et al. 2009; Salomone et al. 2010). Other goals mentioned include: identifying mitigation options, measuring variations, temporal comparison, spatial comparison (van Kernebeek et al. 2010), and development of eco-labelling criteria (Mungkung and Gheewala 2007).

5.2.2.2 Object of the Case Studies

The LCA case studies reviewed in the papers selected referred to a fair variety of food products:

- basic carbohydrate foods, e.g., bread, potatoes, pasta (Foster et al. 2006; Mungkung and Gheewala 2007; Notarnicola 2008; Schau and Fet 2008; Roy et al. 2009);
- fruit, e.g., apples, grapes (Foster et al. 2006; Schau and Fet 2008; Tatti et al. 2008);
- vegetables, e.g., carrots, tomatoes, peas (Foster et al. 2006; Schau and Fet 2008; Tatti et al. 2008; Roy et al. 2009; Usva et al. 2009; Hospido et al. 2010);
- dairy products, e.g., milk, cheese, yoghurt, ice-cream (Foster et al. 2006; Notarnicola 2008; Schau and Fet 2008; Tatti et al. 2008; Roy et al. 2009; Usva et al. 2009; Hospido et al. 2010; van Kernebeek et al. 2010);
- meat products, e.g., beef, lamb, pork, poultry (Foster et al. 2006; Schau and Fet 2008; Tatti et al. 2008; Roy et al. 2009; Usva et al. 2009; Hospido et al. 2010);
- aquacultural products, e.g., cod, lobster, trout, shrimp (Foster et al. 2006; Mungkung and Gheewala 2007; Schau and Fet 2008; Tatti et al. 2008);
- drinks, e.g., beer, wine (Foster et al. 2006; Notarnicola 2008; Usva et al. 2009; Petti et al. 2010);
- mixed or highly processed products, e.g., ready-to-cook pizza, snacks (Foster et al. 2006);
- cereals, e.g., wheat, oat, corn, rice (Schau and Fet 2008; Tatti et al. 2008; Usva et al. 2009);
- others, e.g., olive oil, coffee (Salomone et al. 2010; Notarnicola 2008; Roy et al. 2009).

5.2.2.3 Functional Unit

An LCA study takes as a reference the function of the system under study (typically a product), i.e. the service provided by that system, which also depends on the performance characteristics of the product under analysis. Through the FU a certain amount of system function, to which all environmental inputs and outputs and related impacts will refer, is identified and quantified.

As in any LCA study, the choice of the FU is greatly dependent on the aim of the study and is a very critical issue (Peacock et al. 2011; Salomone et al. 2010; Schau and Fet 2008). In his review, Notarnicola (2008) noted that for comparative studies the FU depends on the complexity and multiplicity of the different functions. In fact, Salomone et al. (2010) state that when comparing different types of olive oil, the FU (e.g.: 1 L) should adequately consider the different organoleptic characteristics of the oils under study.[1] Actually, the primary function of food is to satisfy the human need for nutrition, i.e. to provide the human organism with energy and various nutrients. However, food also has other functions, such as arousing the pleasure that derives from a meal that looks good and tastes delicious (psychological functions). The FU can, and probably should, reflect one or several of these aspects.

In most of the cases examined, however, the FU tended to be simply based on mass or volume, mainly depending on whether the product under study was solid or liquid (Foster et al. 2006; Mungkung and Gheewala 2007; Roy et al. 2009; Schau and Fet 2008; Tatti et al. 2008; Usva et al. 2009). Nevertheless, according to Foster et al. (2006), the mass or volume of a packed product is commonly used as the FU when the final use phase is not examined (cradle-to-gate).

Given the peculiarity of the properties of food, Schau and Fet (2008) identified a more sophisticated way of defining it by including quality aspects in its definition (for instance, viscosity, texture, energy or nutrient content). As regards this last aspect, Marshall (2001, cited by Schau and Fet (2008), p 257) related the FU to the nutrient content in three different ways:

1. amount of food to provide 1 kg of a nutrient[2];
2. amount of food to provide the daily recommended dietary intake (RDI) for a nutrient;
3. amount of food to provide the summation of the amounts that provide the daily RDI for each nutrient.

Therefore, according to the proposals above, the FU can be either the provision of 1 kg of a given nutrient, the provision of the RDI for a given nutrient, or the

[1] The FU however must be the same when comparing two or more products. What changes is in fact the reference flow.

[2] What is proposed here is actually the reference flow. Peacock et al. (2011) have discussed the confusion often encountered even in the scientific literature when defining the functional unit and the reference flow.

provision of the summation of the amounts that provide the daily RDI for each nutrient, respectively.

Schau and Fet (2008) suggested considering various nutrients simultaneously with the Quality Corrected Functional Unit (QCFU). These quality elements would include fat, protein and carbohydrates. The general formula for the proposed QCFU is (Schau and Fet 2008):

$$\text{QCFU} = \textit{yield}[\text{kg}] \cdot (\text{X} \cdot \textit{fat}[\text{g/kg}] + \text{Y} \cdot \textit{protein}[\text{g/kg}] + \text{Z} \cdot \textit{carbohydrate}[\text{g/kg}] + \text{k}) \tag{5.1}$$

X, Y and Z are factors and k is a constant which should be agreed upon among experts on different food products. Other factors could be added to the equation to account for other quality functions of food.

After examining case studies in aquaculture and agriculture Mungkung and Gheewala (2007), with the same idea of taking into consideration various nutrients, suggested a method to normalise the amounts of nutrients gained with the daily nutritional values required, which they called the "normalisation factor" (see Eq. 5.2). These authors referred to results on a "per Nkg" basis, i.e. the amount of nutrients gained per kg of food consumed. This factor can later be used to calculate the "normalised impact indicator" (Eq. 5.3).

$$Normalisation\_factor = \sum_{i=1}^{n} \frac{nutrient\_gained}{daily\_nutrient\_required} \tag{5.2}$$

$$Normalised\_impact\_indicator = \frac{impact\_indicator\_value}{normalisation\_factor} \tag{5.3}$$

The FU could also be based on other factors, such as land use, and even biodiversity. For instance, Mungkung and Gheewala (2007)—amongst others—state that, apart from the classic use of mass to define the FU, the area (in hectares) could be used to measure the land productivity of diverse agricultural products. However, specifically in the case of agriculture, Hayashi et al. (2006) have proposed the use of plural FUs, such as a farm, an area, a livestock unit and a product such as milk. In this way, the occupation of the countryside and essential functions of production can be taken into account at the same time. Similar conclusions also derive from the report of Tatti et al. (2008) who state that for proper use of LCA in agriculture, it appears to be preferable to keep a dual analysis of potential impacts per unit area and per unit of output.

5.2.2.4 System Boundary

The system boundary establishes which processes throughout a product's life cycle have to be included in the LCA study. In general, comparable system boundaries are crucial when comparing different products. It is commonly accepted that there are at least two issues for system boundaries (Schau and Fet 2008): (1) where to set the system boundaries between the system under study and other man-made systems, and (2) where to set the system boundaries between the technosphere and nature. The second issue is of special interest for the LCA of food products, where the inclusion of biological processes may render the distinction between technological systems and nature somehow unclear.

Most frequently, the issue of which phases are included is discussed throughout the reviews considered. The analysis of the reviews showed that not all phases of food products' life cycles have been taken into consideration, when it comes to the system boundary. Petti et al. (2010) reported that in the wine case studies which they reviewed, the product use phase was considered irrelevant by all researchers and, furthermore, that the end of life of the bottle was also not included in the system boundaries. The phases normally included: grape cultivation and transport to wine-making company, wine production and storage, bottling and packaging, and transfer of the final product. Similarly, for food products in general (Schau and Fet 2008) most of the case studies did not include the waste treatment phase in their models.[3] In addition, Foster et al. (2006) state that the whole life cycle (including consumer activities and waste disposal) have been studied in detail for very few foods (either basic or processed). Most research carried out has focused on primary production—agricultural stage, ending at the farm gate—sometimes extended to cover processing.

In other cases, the waste management stage of the life cycle was examined, but in separate LCAs, thus not including an overall "cradle to grave" approach (Roy et al. 2009). In most of these cases different treatment options were compared such as, for example, incineration, incineration after bio-gasification, bio-gasification followed by composting, and composting. Tatti et al. (2008) conclude that the system boundary should go beyond including the life cycle up to the farm gate to also include processing, packaging, distribution, consumption and final disposal. In this way, the key elements of the environmental performance of products throughout their entire life cycle could be actually highlighted.

5.2.2.5 Multi-Functionality Issue

When modelling a product system, the multi-functionality issue occurs whenever one has to deal with multi-output (or multi-input) processes, while being interested in focusing on the environmental impacts attributable to just one of these outputs (or inputs).

Food products are usually characterised by closely interlinked subsystems thus rendering the multi-functionality issue important (Schau and Fet 2008). According to ISO Standard 14044:2006 (ISO 2006), the multi-functionality issue should

[3] In the case of food products, the waste treatment refers mainly to the packaging at its end of life, but also to the agricultural phase (e.g., stems, grape skins etc., in the case of wine production).

preferably be dealt with by splitting a multi-functional process into more detailed sub-processes or by means of system expansion, leaving allocation as a last resort. This should be done in order to obtain the most reliable results. Nevertheless, the system expansion approach is considered to be more complex and generally needs more data from other systems. It has to be noted here, in addition, that the ILCD Handbook (European Union 2010) states that for cases of multi-functionality that cannot be solved by subdivision or virtual subdivision, the approach of system expansion shall be adopted, substituting the avoided process as its market mix (excluding the to-be-substituted function/route). If system expansion is applied without substituting the additional function, the FU will encompass more than intended, which makes it very difficult to use when the product must be assigned to a product category. For instance, in a milk production system that also produces beef, system expansion without substituting would lead to a system with a function of delivering both milk and beef. This product blend could belong to the product category of food, but not just to milk or meat. According to van Kernebeek et al. (2010), system expansion has not been widely used throughout case studies as a means of avoiding allocation; indeed, they noted that this method had been applied in only two out of 47 studies examined.

For those cases where allocation cannot be avoided, physical or economic relationships are normally used in order for the inputs and the outputs of the system to be partitioned between its different co-products or functions. Of the physical criteria, mass, in particular, was found to be the most commonly used criterion in the literature (Usva et al. 2009), with the exception of biofuels (which can however be considered as agricultural products, but are not food products) such as rape and soy oil, where the allocation between oil and oilcake was made according to economic value (due to the high marketing value of the oilcake). Nevertheless, according to Schau and Fet (2008) the economic allocation is the one most commonly used. This is due to the fact that the economic value of a product is the producer's driving force. In the case where a cow was considered as a production system with co-products such as meat, milk, manure and skin, allocation was again performed according to their economic value (Hospido et al. 2010). Indeed, the economic benefits of milk appeared to be such an important factor (87 % for milk and 13 % for meat) that the researchers used economic allocation.

Finally, it is argued that the QCFU proposed by Schau and Fet (2008) (see Sect. 5.2.2.3 above) may be a means of overcoming the co-product allocation issue or could be used as a basis for co-production allocation, although the authors do not describe how exactly such an achievement could take place. To give an example, in fisheries catching different species, the fuel needs to be allocated between different species. If the FU in this case is considered to be the energy content in the delivered fish, no allocation is required between the different fish species (Schau and Fet 2008). In the same way, if the FU is defined as a given quantity of species *x*, then for allocating fuel on the different species, either the energy content or the protein content (or both), can be used as proposed by Ayer et al. (2007, cited by Schau and Fet (2008)). However, it could be argued that the amount of energy needed to catch a given wild fish species is not closely related to its energy content in terms of nutritional value (e.g. if species A is fatter than species B, ceteris paribus, A has a higher energy content, in terms of nutritional value, than B; this does not necessarily mean that A is harder to catch than B, or that more energy is needed to catch A than B). If, instead of wild fish, the focus is on fish breeding, energy for breeding might actually be related to the fish energy contents (e.g.: more fodder is used to breed fatter fish).

Finally, what could be considered as a special case of allocation in food LCA regards allocating a given product a certain amount of fuel (as well as related emissions) for transporting it by car from the point of sale to a consumer's home. As noted by Foster et al. (2006): "Is the environmental impact associated with bringing 1 kg of pasta home from the supermarket in a car as part of 10 kg of shopping, 10 % of the total fuel and emissions associated with the journey, or 100 % of that total since the fuels used and associated emissions will be roughly the same whether the car has 1 kg or 30 kg of shopping in it?".

5.2.2.6 Data Issues

As far as data collection, a part of the phase of Life Cycle Inventory (LCI) analysis, is concerned, LCA processes are in general divided into two systems: one in the foreground and one in the background (Tillman 2000; Petti et al. 2010). Normally, the data referred to the foreground system are collected on site and for the specific case study (Hospido et al. 2010; Petti et al. 2010). On the other hand, the data referred to the background system normally reflect research found in the literature or come from statistical sources.

Food products can also be characterised by their properties of complexity and diversity to such a degree that collecting the meticulous data of specific quality required for an LCA to be carried out can become a difficult task. Lack of data often leads researchers and LCA practitioners to assumptions and eventually to limitations in their results. For this reason, the data collection phase is often characterised as one of the most important during an LCA. However, according to Fullana et al. (2011), the importance also depends on how the goal and scope are defined.

An example of data collection limitations and assumptions has been highlighted by Gonzalez et al. (2006) for the case of wine production. For instance, no sufficient values could be found for fertilising and irrigation processes. Furthermore, they used values taken from papers by the Australian Wine Industry for the wood supporting the vines (ibid).

Finally, Roy et al. (2009) claim that data collection, which is often time consuming, can occupy less time if good databases are available and if customers and suppliers are willing to help. In general, data related to transport, extraction of raw materials, processing of materials, production of commonly used products such as plastic and cardboard, and disposal can be found in an LCA database.

5.2.2.7 Results

The results of the LCA case studies were reviewed in order to identify: (a) whether there could be a tendency for some environmental impacts to be more important than others when it comes to food products and (b) whether there were specific stages in the products' life cycle that seem to be more impacting than the others.

Firstly, it has to be stressed that since different assumptions and methodologies were used in these case studies, it is obvious that different studies cannot be compared to each other. For example, only by including the same stages of a product's life cycle (e.g., from "cradle to grave") and using the same databases, the same FUs, and by performing similar allocations where necessary and so on, would the results be comparable to each other (Usva et al. 2009). Furthermore, it has been seen that uncertainties mainly attributable to climate conditions can affect production and therefore could lead to diverse results in the LCAs (Petti et al. 2010).

As far as the question of "whether there could be a tendency for some environmental impacts to be greater than others" is concerned, a general remark has been that case studies mostly take into consideration the Global Warming Potential (GWP), thus giving extra significance, for example, to CO_2 emissions. This can be partially explained by the contemporary global concern for climate change, which is linked to the GWP. In the case of CO_2 emissions in the production of wine, Ardente et al. (2006, cited by Petti et al. (2010)) noted that the highest impact was caused by stages like transport, use of electricity and consumption of fertilisers and biocides, which all are defined as indirect impacts (for a summary of the findings, please refer to Table 5.1).

Usva et al. (2009), who reviewed several case studies of diverse food products (such as fodder, barley, hard cheese, oat flakes, potato flour, beer, etc.), concluded that the contributions of the supply chain phases to GWP differ amongst the product systems. There is a moderate correlation between energy use and GWP, but in the context of cattle-based products, direct methane emissions from rumen fermentation correspond to the largest contribution in the agricultural phase. However, when household cooking was considered in the systems, it appeared to be highly contributing to GWP. Finally, in the case of greenhouse-grown tomatoes it was observed that GHG emissions from cultivation were also important and depend on the type and construction of the greenhouse (or any similar structure) (Roy et al. 2009).

Another environmental impact, which is considered relevant in the food supply chains, is eutrophication. The report by Gonzalez et al. (2006) shows that eutrophication has been amongst the highest impact categories for wine production. Usva et al. (2009) stated that the emissions from cultivation (via the movement of nitrogen and phosphorus to water) have dominated in terms of eutrophication. For animal-based products, emissions from manure (in the form of ammonia) had a considerable effect on this impact category. These facts render the contribution of the agricultural phase even higher when compared to the entire supply chain. Eutrophication was also identified as important in milk and sugar beet production

Table 5.1 Summarised findings for several food products based on the papers reviewed

Product	Findings	Important stage(s)
Bread (2 studies)	Organic production of wheat, industrial milling and a large bread factory is the advantageous scenario	Primary production
	The scale of production is important: e.g. industry/home baking	Transport
	Eutrophication seems to be more affected	Agricultural stage
Beer production	By introducing the recycling phase of bottles diverse results can be reached	In order of significance: 1. Wort production 2. Filtration 3. Packaging 4. Fermentation and Storage
Medium strength beer	–	Primary production was mostly responsible for Eutrophication, whilst for Acidification and Global Warming the phases of industry and packaging/delivery appeared to be more important
Oat meal	–	Primary production was found to be more impacting, especially as regards Eutrophication
Wine	Production is strictly related to climate conditions	Transport (is subject to distance)
	Use of pesticides causes the highest environmental impacts	Use of electricity
	Phases of production may vary enormously from one producer to another (depending on the desired quality)	Consumption of fertilisers and biocides
	Recycling can alleviate the impact of glass production	Packaging (for Global Warming)

(continued)

Table 5.1 (continued)

Product	Findings	Important stage(s)
Olive oil	Supply chain must include systems for waste treatment and recovery (of biomass and compost for use in cosmetics and pharmaceutical industry)	Production and use of pesticides, herbicides and fertilisers
Milk	Organic milk production can reduce pesticide use and mineral surplus in agriculture, but requires substantially more arable land than conventional production	In order of significance: 1. Agricultural phase 2. Packaging 3. Waste management
Meat (2 studies)	Environmental impacts of beef-fattening system are reported to be dependent on the length of feeding period	Agricultural production Feeding stage Infrastructure
	Organic farming reduces pesticide use but requires more land and leads to higher global warming impacts than non-organic systems in UK conditions	Only agriculture was taken into account in the study
	The extensive production methods result in more land occupation and mostly higher eutrophication and acidification levels	
Cheese	–	Primary production was found to be more impacting, especially as regards Eutrophication and Acidification
Dairy products (in general)	Eutrophication and GWP were found to be greatly affected For milk and yogurt packaging selection is important Energy consumption for storage is relatively high, especially for ice-cream	Agricultural/farming stage
Potatoes (2 studies)	By shifting from conventional to organic production, energy in fertilizer production is replaced by energy for additional machines and machinery operation, but more land is required in organic systems	Production: Methods Location
	Eutrophication seems to be more affected	Agricultural stage

(continued)

Table 5.1 (continued)

Product	Findings	Important stage(s)
Greenhouse cucumber	–	Mostly primary production
Tomatoes (2 studies)	Food intake results in the highest toxic exposure (about 103-105 times higher) than through drinking water or inhalation	Method of cultivation Variety Location Packaging Distribution
	GHG emissions from tomato cultivation in greenhouses are dependent on the type and construction of the greenhouse (or any similar structure) Environmental significance depends on location and on whether forced heating is required	Production stage
Rice	GHG emission is dependent on location, size of farms and the variety of rice	Production: Location Size of farms
	Environmental load was greater for parboiled rice compared to untreated rice	Variety of rice
Carrots	Frozen carrots appear to have higher impacts	Use phase Transport Packaging
Cereals	Use of fertilisers is the dominant cause for almost all environmental impacts Organic farming shows higher impacts for acidification, eutrophication and land use due to lower yields	Only agriculture was taken into account in the study

(continued)

Table 5.1 (continued)

Product	Findings	Important stage(s)
Sugar beet	Genetically modified (GM) herbicide tolerant sugar beet production would be less harmful to the environment and human health than growing the conventional crop	Production
Pasta	Egg-containing pasta increases the energy requirement for raw material production	Cooking stage more important for total energy requirement
Fish (2 studies)	Land use was considered to be important for both agriculture and aquaculture	Results were demonstrated only for energy use and land use and not per phase of the life cycle
		Fish farming
	Consumers' habits play an important role	Use phase
	Global Warming is greatly affected by fuel consumed for fishing	

(Roy et al. 2009) (which is also linked to the leakage of nitrogen and phosphorus from the use of fertilisers in production).

As far as acidification is concerned, the contribution of agriculture tended to be quite dominant (Usva et al. 2009). This was especially so for animal based products due to ammonia emissions from manure. As regards wine production, Gonzalez et al. (2006) also verified acidification to be of high impact. Roy et al. (2009) concluded that the geographical location of the production systems plays an important role in the high levels of acidification potential that they identified in the case of tomato ketchup. Packaging, in the case of eggs and intensive farming for sugar beet, were moreover discovered to be, respectively, an important sub-system and phase for acidification.

Other impact categories have also been referred to by the researchers at a lower degree of appearance within their studies. Amongst these: (a) tropospheric ozone formation (Usva et al. 2009); (b) human toxicity (Gonzalez et al. 2006; Roy et al. 2009); (c) land use, for organic milk production (Roy et al. 2009), and for dairy and meat products (Mogensen et al. 2009). In most cases researchers emphasised that the agricultural phase was responsible for these impacts.

An overall consideration means it is impossible to identify and confirm whether one or more environmental impacts are of greater importance than others since the researchers decided to focus on specific ones each time and for different reasons. Furthermore, no definite results can be drawn with regard to which phase is more impacting than the others, with the agricultural phase being, however, that most commonly mentioned by the researchers. Nevertheless, it has to be highlighted once again that given the fact that different approaches and system boundaries were used, no absolute results can be found here.

5.3 Conclusions

Life Cycle Assessment is a tool which has been increasingly used in order to identify the environmental impacts of goods and services. Furthermore, global overpopulation in conjunction with the eating habits of humans has caused a dramatic increase in food production worldwide. For this reason, several case studies have been carried out across the world using LCA as a tool, in an attempt to improve the environmental performance of food production systems. This Chapter examined reviews of LCA studies on food supply chains in order to identify methodological state-of-the-art cases, in terms of their definition of the FU, the issue of data availability and quality, the system boundary and the multi-functionality issue.

In the case studies reviewed, different assumptions and methodologies were used. Furthermore, it has been seen that uncertainties caused mainly by climate conditions can affect production and could therefore lead to diverse results among the LCAs. Consequently, it is impossible to identify and confirm one or more environmental impacts as being more important than others since the researchers decided to focus on specific ones each time and for different reasons. Furthermore, no sure conclusions can be drawn regarding which phase has had greater impact than the others, although the agricultural phase was mentioned most frequently overall in the case studies.

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Chapter 6
A Model of Simplified LCA for Agri-Food SMEs

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6.1 Introduction

Simplification is a crucial question for a widespread use of life cycle information, especially for small- and medium-sized enterprises (SMEs) that are unlikely to have the knowledge and resources necessary to implement LCAs. Facilitating the access to reliable, accurate and relevant life cycle information means a reduction in the costs of the product's environmental improvement and a more effective communication along the supply chain.

The topic of simplification has been discussed since the 1990s, in parallel with the development of the LCA methodology. However, a general agreement on which strategy towards simplification is more robust, and thus more applicable than others, has not yet been found.

In order to identify a framework for LCA suited to SMEs in the agri-food sector, a two-step approach was adopted: firstly, a literature review was performed

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(Sect. 6.2), aimed at identifying and characterising the existing simplified approaches and tools; then, criteria were defined (Sect. 6.3) for selecting the most suitable simplified tool for this particular application, i.e. the agri-food sector.

6.2 Simplified Life Cycle-Based Approaches and Tools: A Literature Review

6.2.1 Method

A literature review was carried out, covering about 20 years of LCA developments and applications. The bibliographic search focused on scientific databases and citation indexes, such as Science Direct, Scopus, CASPUR Virtual Library (an Italian inter-university database search engine), and Google Scholar. The keyword logical expression used for this purpose was as follows: ("simplified" OR "simplification" OR "streamlined" OR "streamlining" OR "screening") AND ("LCA" OR "life cycle assessment").

A fair number of papers came to be reviewed following a screening process based on the titles and abstracts of the articles. The criteria used for this screening process aimed at selecting those papers that actually referred to some kind of simplified LCA or life-cycle-based tool or approach.

Overall, 41 papers were reviewed, of which only six were directly related to food, three were somehow related to the food sector (for instance, packaging) and the rest focused on a variety of other products/sectors. The papers were analysed according to certain criteria:

- ISO compliance, i.e. the extent to which the approach is compliant with the ISO standards;
- robustness, i.e. the extent to which the approach has a sound scientific basis, and thus delivers reliable results, guaranteeing completeness and transparency at the same time;
- approaches to simplification, both at the level of the methodology and of its implementation in the software tools.

Prior to this, two other important aspects were analysed, so as to better understand how the different strategies were developed: (1) the definition of simplified LCA; (2) the reason why a simplification is deemed necessary, and in which contexts. To this aim the review was complemented by the results of a survey on users' needs conducted in a previous project (Rydberg et al. 2008).

6.2.2 Main Findings from the Review

The literature review resulted in the identification of the main strategies and criteria underlying the simplified approaches and tools developed, irrespective of the sector/application for which they were developed.

As far as the definition of what a simplified LCA is, it is worth noting that several definitions have been provided in literature, although these are not detailed enough to explain precisely what a simplified LCA entails.

Some authors make reference principally to the aim of a simplified approach more than to what it is about. For example, Goglio and Owende (2009) define it as a method aimed at the identification of environmental hotspots or processes where emissions of particular interest occur in the life cycle of a product or process. Others explicitly say that a simplified approach is a less accurate one, which is applicable to situations where less-than-perfect results can still be considered better than no results at all (Bala et al. 2010). It is generally agreed that simplifying or streamlining (the two terms are often used interchangeably) can be viewed as a way of "cutting" whilst still meeting the study goal (Eide 2002; Todd and Curran 1999), even if Weitz and Sharma (1998) claim that there is no hard distinction between what constitutes a "full" LCA and a "streamlined" LCA. Instead, there are many different LCAs, each unique at its level of comprehensiveness, detail, and scope.

Guinée and colleagues (Guinée et al. 2002) provide what can be considered as the most complete definition of simplified LCA: "[…] a simplified variety of detailed LCA conducted according to guidelines not in full compliance with the ISO 14040 standards and representative of studies typically requiring from 1 to 20 person-days of work".

The non-compliance with the ISO standards as a requirement for a simplified LCA is an aspect that cannot always be evaluated in a transparent way. In fact, if on the one hand some authors (Bala et al. 2010; Bewa et al. 2009; Hochschorner and Finnveden 2003; Masoni et al. 2004; Tolle et al. 2000) explicitly state the compliance of the developed approach, in many other cases it is not clear whether the compliance was taken for granted or simply it was not considered to be an important requirement.

Regarding the second aspect analysed, i.e. the reason why a simplification is deemed necessary and in which contexts, the positions found in the literature were more closely agreed and homogenous. Most authors identify that the need to simplify an LCA lies within the time and cost parameters of carrying out a full LCA. In fact, decision makers cannot always afford (in terms of time) to wait for the results of a full LCA. The cost issue was furthermore identified to be more impacting for SMEs. It was also mentioned that a simplified LCA can be carried out to deal with difficulties in full LCA such as data gaps and asymmetries (Zamagni et al. 2008) and to obtain a more pro-active attitude in the design phase.

Simplification in LCA can be achieved in many ways, and the literature gave evidence of the wide range of approaches and strategies adopted. In this review, they were classified according to the phase in which they were applied, resulting in the following structure:

- strategies at the level of life cycle inventory (LCI), aimed at simplifying the modelling and/or at reducing data collection efforts;
- strategies at the level of life cycle impact assessment (LCIA), aimed at reducing the set of impact categories analysed and thus at facilitating the communication of results;
- strategies at the level of both LCI and LCIA.

In addition, another criterion was added, namely the user-friendliness of the interface, as this is considered an important requirement by the users themselves (Rydberg et al. 2008). Finally, brief considerations about the robustness of the simplified strategies discussed in literature are presented.

6.2.2.1 Strategies at the Level of LCI

The majority of simplification strategies focus on the LCI analysis. In agreement with Rebitzer et al. (2004) the main approaches to LCI simplification—which depend on several factors such as the goal and scope of the analysis, the level of detail, the resources available—could be the following: (1) the direct simplification of process-oriented modelling; (2) LCA based on economic input–output analysis; (3) the hybrid method, which combines elements of process LCA with input–output approaches. These last two approaches based on input–output have not been considered in the present review, because they lack the product resolution, which is necessary for the development of the LCA tool targeted in this project.

The simplification in process-oriented modelling can be obtained by applying a horizontal cut-off and/or a vertical cut-off. The horizontal cut-off consists in reducing the scope of the study by excluding some phases of the system (Bala et al. 2010; Bribian et al. 2009; Hur et al. 2005; Tolle et al. 2000). The vertical cut-off consists in completely leaving out some minor elementary flows (Rebitzer et al. 2004) and of reducing data needs through the use of surrogates, which may already be available, or generic databases for one or more steps of the life cycle (Bewa et al. 2009; Hur et al. 2005; Kellenberger and Althaus 2009; Valkama and Keskinen 2008; Verghese et al. 2010; Zah et al. 2009).

Nicoletti and Notarnicola (1999) and Todd and Curran (1999) analysed several different approaches to simplification in LCI, applying the same criteria described above, i.e. horizontal and vertical cut-offs. They are described in Tables 6.1.

Having in mind criteria that refer to data, Todd and Curran (1999) examined approaches such as: (a) using qualitative or less accurate data; (b) using surrogate process data.

A general conclusion by Todd and Curran (1999, p. 20) was that:

- "streamlining methods that excluded the least amount of data (or processes) were, rather predictably, the most successful in producing identical rankings; and

Table 6.1 Criteria for simplification described by Nicoletti and Notarnicola (1999) and Todd and Curran (1999) addressing horizontal and vertical cut-offs

Criterion for simplification	Nicoletti and Notarnicola (1999)	Todd and Curran (1999)
Horizontal cut-off	*Cradle to gate* Removal of downstream components: all processes after primary material manufacture are excluded	Removing downstream components
	Gate to grave Removal of upstream components: all processes prior primary material manufacture are excluded	(Partially) removing upstream components;
	Gate to gate Removal of up-and-downstream components: only primary material manufacture is included	Removing up- and downstream components
Vertical cut-off	Limit raw materials (10 %): raw materials comprising less than 10 % by mass of the LCI totals were excluded	Limiting raw materials
	Limit raw material (35 %): raw materials comprising less than 10 % by mass of the LCI totals were excluded	-
	Specified entries used to represent the LCI: inclusion of some substances which are considered representative	Using specific entries to represent LCI

- excluding processes and data that were dominant in the LCI totals was less likely to give identical results."

On the other hand, Nicoletti and Notarnicola (1999) summarise their findings by stating that the "cradle-to-gate" streamlining method appears to provide insufficient results (when compared to a full LCA of car tyres where the pre-production phase is not taken into consideration) due to the fact that the use stage is not taken into consideration, whilst the "gate-to-grave" one seems to represent the system adequately. Finally, the method "limit raw materials (10 %)" was found to provide results very similar with those of the full LCA.

Another approach to simplification within the LCI phase was the method identified by Mourad et al. (2007) for generating a simplified LCI with particular interest for the agri-food sector. This method was based on well-accepted universal principles of stoichiometry applied to the grain or fruit growth, where minimum estimations were introduced in the inventory mass balance, basically considering the elementary composition of the agricultural produce and the photosynthesis principles.

After considering that the principles applied to the LCI phase of LCAs of food products are often not very clear, Mourad et al. (2007) proposed what they defined as a simplified method for creating a useful dataset for different stakeholders in the agricultural chain with limited LCA skills (farmers, environmental managers and decision makers) as a reference for perennial crop evaluation.

In fact, they actually provided some recommendations concerning which stages should be included in the system boundary of what they defined the "basic agricultural inventory", as well as the time and geographical coverage. For instance, they recommended that data should be collected for at least two years' crops, in order to account for the large variations that may take place over the years as regards yields, and amount of inputs, such as energy, fertilisers and pesticides used. However, not all their suggestions are clearly explained and motivated.

They aim to standardise the process of data collection and their processing into inventory data. Specifically, they suggested that agricultural data should be collected by means of a specific questionnaire including questions about the inputs used, such as fertilisers, correctives, pesticides, water, diesel, natural gas, electric energy, and so on. Additionally, they stress the need that every stage be accurately mass balanced (each input should be associated to an output in each stage considered).

As regards the carbohydrate mass balance, this should be calculated stoichiometrically based on the elementary composition of the produce (grain or fruit) under assessment. An average carbohydrate formula should be established for the produce (output) by calculating the C/H, C/O and H/O molar fractions and the amount of carbon dioxide and water (inputs) should be subsequently calculated according to the basic principles of the photosynthesis reaction. As a limitation of this methodology, it should be stressed that only the marketable parts of the plant (the product itself) are considered for the mass balance, and not the whole plant growth.

As regards the mineral mass balance, it is suggested that the output from the systems are calculated as the differences between the total input of macronutrients (N, S, P), micronutrients (K, Ca, Mg, B, Cu, Fe, Mn, Zn) and other minor constituents, and the mineral composition of the produce (Mourad et al. 2007).

A different approach is provided by the case where a production system can be regarded as a "black box" (Eide and Ohlsson 1998; Hospido et al. 2003). In this case, for instance, instead of measuring energy consumption for each process and then summing them together, the whole farm or factory can be considered and the entire energy consumption can be allocated to the main product. According to the authors, the main benefit of this method is the time aspect. They added, furthermore, that by comparing the simplified approach to a full one, they came to the conclusion that the latter was more responsible for information being "lost": indeed, by calculating the energy and water consumption, some information is lost due to the fact that equipment may not operate at its suggested capacity (ibid). On the other hand, finding the "hot spots" and therefore the margins of improvement is identified as a disadvantage for the "black box" approach, as it appeared to be so difficult a task.

Another example of simplification at the level of LCI is given by the "Bilan-Produit" worktool (Bewa et al. 2009). Designed by ADEME (France) to offer industrial stakeholders and researchers a software utility, the tool allows for a simplification in the modelling of the product system under study, by means of taking into account the principal stages of its life cycle: the materials of which it is made, manufacturing procedures, means of transport and sources of energy (ibid).

A broad range of products' life cycle inventories is provided to the users of the tool for eco-design–intended LCAs. Nevertheless, this tool deals with all non-energy and non-food products derived from plant matter. BilanProduit uses a fair size of uniform and recognised databases. In addition, these databases offer the advantage of often including references relating to fossil-based products, facilitating comparative LCAs (ibid). Finally, when it comes to allocations for co-products, which are marginal in terms of mass, they may be disregarded.

Mori et al. (2000) introduced Component Manufacturing Analysis (CMA), a standardised and broadly applicable method for establishing non-arbitrary and reproducible LCIs concerning the manufacturing stage of complex industrial products, thus avoiding the arbitrary omissions of processes which, according to those Authors, may take place in screening LCAs.

The focus of the CMA is on the manufacturing stage; indeed, Mori et al. (2000) maintained that this is the stage where no simple applicable methodologies or readily usable databases are available, especially for complex products. On the other hand, to cover the whole life cycle of a product, LCI data for the other life cycle steps can be obtained from conventional LCA databases.

In CMA the studied product (typically, a manufactured product) is regarded as an integration of a number of components, each of which may in turn be seen as a combination of simpler components, etc., up to the original raw materials. In the case of chemical products, ingredients and reactants can be considered as a product's components. Instead of collecting specific data for the actual manufacturing processes involved—which might not be all known in practice—for each component the type of factory where that component is made is identified, and a database concerning the environmental inputs and outputs related to that factory type is set up and used to develop the LCI. Such databases, once developed in the framework of one specific case study, can be easily used in other applications where the same factory types are involved. Factory types can be defined based on existing sectoral classifications of industries or based on representative processes. When generic factory-type databases are available and widespread as standardised manuals, CMA application is even easier (Mori et al. 2000).

Finally, Koffler et al. (2008) claimed that they disregarded the traditional streamlining methods—mainly proposed by Todd and Curran (1999)—and in the framework of the LCI phase they adopted a tool in order to automate the manual labour. The proposed method (slimLCI) is mainly an IT-based one, and it allows for the workload in preparing detailed LCA studies to be cut, improving both the consistency and quality of the LCA models. This approach is being applied in the car industry (e.g. Volkswagen AG 2010).

Often simplification strategies in LCI refer not only to interventions at the level of modelling but they also combine with data collection. In fact, this is usually a critical step in any LCA study because of the limited availability of data, especially in early design phases, and due to the confidentiality of some information (Mueller et al. 2004). Exchange of relevant data along the supply chain and the possibility of having averaged data concerning a product range, rather than specific products, could represent a solution to this problem.

In this regard, the development of databases, which was initiated almost in parallel with the first LCA applications, is a strategy that needs to be further promoted and strengthened. In fact, this could potentially greatly improve the work of practitioners, and would allow for the completeness of the assessment to be maintained, and the life cycle principles to be preserved (Masoni et al. 2004; Mori et al. 2000). Some approaches have been identified for strengthening this strategy (Zamagni et al. 2012):

- enlargement of the number of products and processes covered, and interest towards a global consistency of databases;
- further investigation of analytical models to produce life cycle inventory of products for which data availability is a critical aspect. Indeed, there are some sectors such as the chemical one, where, a detailed inventory analysis would be difficult—if not unfeasible—in the near future due to the vast number of chemicals in production and the problem of data confidentiality (Geisler et al. 2004; Hischier et al. 2005). Approaches have been proposed to overcome this problem, based on the development of models which provide estimates for inventory data of chemical production based on the molecular structure of a chemical (Wernet et al. 2008). These models can also be used for estimating the LCA impact factors, even if the proposed approach of Wernet et al. (2008) has only been tested on cumulative energy demand;
- investigation of approaches to data transposition, i.e. use of European background data for countries outside Europe. In the long term, national life cycle inventory databases may become available. In the meantime it is necessary to provide practitioners with an intermediate solution to properly take regional issues into account. First approaches (Colodel et al. 2009) should be further investigated and tested in real case studies;
- use of proxy data and generalisation. Roches et al. (2010) focused in particular on the food sector and suggest a tool called “MEXALCA”, which derives LCIA results for a crop in a specific (target) country using the LCIA data of the same crop in another (original) country. In order to overcome the problem of data that is lacking in LCA, without excluding potentially important inputs or processes, the MEXALCA method uses the geographical extrapolation of existing detailed life cycle inventories and impacts in order to enable a simplified assessment for agricultural and horticultural crops. The geographical extrapolation consists in the adaptation of existing LCIA data for production in a given location, to new LCIA data for production in another place.

6.2.2.2 Strategies at the Level of LCIA

A common strategy adopted at the level of LCIA consists in reducing the set of indicators. An example is provided by the Cumulative Energy Demand indicator (CED), which represents energy-related impacts. It is suggested that outside DfE, the method should be capable of facilitating simplified LCAs in general, but, in order to guarantee consistency, the method should be applied as a stand-alone method, without advocating the LCA for the impact assessment evaluations. The appropriateness of the fossil CED as an indicator for the environmental performance of products and processes was discussed by Huijbregts et al. (2006). They carried out a regression analysis between the environmental life-cycle impacts and fossil CEDs of 1,218 products. The results show that the fossil CED correlates well with most impact categories, such as global warming, resource depletion, acidification, eutrophication, tropospheric ozone formation, ozone depletion, and human toxicity (explained variance: between 46 and 100 %) and that it may therefore serve as a screening indicator for environmental performance. They also observed that the usefulness of fossil CED as a stand-alone indicator for environmental impact is limited when non-fossil energy related emissions and land use are particularly relevant. Overall, the robustness of an assessment that makes use of just one indicator as proxy for the environmental performance of products is also questioned when other approaches based on single scores such as the Carbon Footprint (Bala et al. 2010; Bribian et al. 2009; Mori et al. 2000; Pattara et al. 2012) are used. An example is given by Carbonostics (Teixeira 2012), a software tool where each data record is identified with a production method, time period and geographical region, and associated with it are $CO_{2\text{-eq.}}$ emissions, cost and nutrition. The use of such a reduced set of indicators increases the communicability to the final users, and offers an answer to the growing concern about specific environmental issues, such as climate change and water scarcity, which have been raised by several stakeholders. While this tool is not fully ISO-compliant, it is PAS2050—and BPX—compliant, user-friendly and includes the calculation of EPDs, enabling the drawing up of a report of the results.

Other approaches exist in literature in which indicators were kept to a minimum to reduce complexity of interpretation (e.g. Verghese et al. 2010; Fleischer et al. 2001). However, in most of these approaches the risk of bias exists as the environmental implications of the assessment could be misunderstood, and the basic principle of LCA—its comprehensiveness and holistic view that preserves from burden shifting—could be lost (SETAC Europe LCA Steering Committee 2008).

Other approaches exist which consider the whole spectrum of impact assessment indicators but lower the requirements for the quality of non-energy related emissions data. A semi-quantitative method for the Impact Assessment of emissions is presented by Fleischer et al. (2001). This method, which has been developed for the assessment of non-energy related environmental impacts as a part of ISO-LCA, a simplified LCA method that already exists (Fleischer and Schmidt 1997), combines two approaches: an ABC-assessment for the identification of hot-spots (what is emitted[1]) and an XYZ-assessment, which is a measure for the quantity of a material flow between the observed product system and the environment (how much is

[1] A, B and C indicates the degree of seriousness of an environmental impact (from A—serious—to C—not significant).

emitted[2]). For each emission of the three environmental media (air, water, soil) ABC/XYZ-scores are assigned. Having identified the highest score, i.e. the emission with the highest potential impact, for each process, the process scores are aggregated using qualitative mass factors. Then, the scores across all three categories of media are aggregated using a weighting matrix.

This approach allows the use of both quantitative and qualitative inventory data, since both can be categorised in the ABC- and XYZ-system. Thus, it can be used even when only qualitative or incomplete quantitative LCI data for all or some of the involved processes are known.

6.2.2.3 Strategies at the Level of Both LCI and LCIA

Other strategies were identified in the literature, which encompass both the inventory and the impact assessment phase, such as the matrix approach (Zamagni et al. 2008). Matrix methods are usually considered as simple methods for presenting information about a product's environmental aspects in a systematic and clearly arranged manner while in many cases quantitative information is lacking (Hur et al. 2005). Hoschorner and Finnveden (2003), for example, evaluated and compared the results of a detailed LCA with two simplified methods: the Environmentally Responsible Product Assessment (ERPA) matrix and the Materials, Energy, Chemicals and Others (MECO) method.

ERPA method is a semi-quantitative matrix method developed by Graedel and Allenby (1995). One of the significant features of this assessment is a 5 × 5 matrix where one dimension is the life cycle stages and the other is the environmental concerns or categories (Hur et al. 2005). Environmental performance is graded for five environmental categories over five life-cycle stages. Each matrix cell is assigned an environmental performance score, which ranges from 0 (lowest environmental performance) to 4 (highest environmental performance), according to a checklist. A product's total environmental responsibility is calculated as the sum of the matrix element values (Hochshorner and Finnveden 2003; Petti et al. 2006). Each life cycle stage and each environmental category can be given a weight to reflect the difference in relative significance, resulting in a double-weighted matrix (ibid).

As far as MECO is concerned, it is a method intended for SMEs and developed by the Danish Institute for Product Development and dk-TEKNIK, based on a principle described by Pommer et al. (2001, cited by Hochschorner and Finnveden 2003). The assessment is based on four areas (Materials, Energy, Chemicals and Others), in accordance with the underlying causes of a product's environmental impacts (Wenzel et al. 1997). For each area of concern qualitative and quantitative information on the studied product is collected about the main inflows and outflows throughout the product's life-cycle. The information collected is then

[2] X = great; Y = medium; Z = insignificant quantity.

structured in the MECO chart, which is a matrix with four rows (one for each of the above-mentioned areas) and five columns (one for each of the main life-cycle steps, notably: Materials, Manufacture, Use, Disposal and Transport). All inflows and outflows must be considered for one category at a time on the basis of the functional unit and the specific life cycle phases.

As regards the suitability of the above methods, Hoschorner and Finnveden (2003) observed that a differentiation could be made between a study aimed at supporting a choice between several alternatives and a study aimed at identifying critical aspects and suggesting mitigation strategies. They proposed the use of the ERPA method as a checklist to identify critical aspects, because the arbitrariness of the scoring system does not allow quantitative comparisons. They found the MECO method more suitable for comparing alternatives because it enables a quantitative dimension to be added to the qualitative evaluation. Moreover, they suggested the use of this method as a complementing study to an LCA to overcome the problem of neglecting qualitative information in the interpretation phase. Hur et al. (2005) arrived at the same conclusion: the ERPA method can be used in eco-redesign to identify the potentials for improvement and alleviate harmful environmental impacts since it identifies areas where environmental improvements are needed and can be made.

6.2.2.4 User-Friendly Interface

Other approaches to simplification focused on developing user-friendly interface (Bewa et al. 2009; Gonzalez et al. 2006). An example is the "Sustainability Quick Check for Biofuels" (SQCB) tool, developed by Zah et al. (2009). It is an online-questionnaire tool, which focuses strongly on data entry for the agricultural phase (mineral and organic fertilizers, pesticide use, irrigation, yield, former land use). However, a few disadvantages are perceived, including: (1) the applicability of the SQCB only to supply chains which are similar to the reference one in the tool (as a result, complex bio-refineries with multiple co-products and feedstock cannot be modelled), and (2) the need for in-depth know-how on land transformation, cultivation and fuel processing of the specific biofuel chain to obtain an accurate environmental impact assessment.

Another simplified tool with a user-friendly interface is eVerdEE (Masoni et al. 2004; Porta et al. 2008). This tool, which is available on-line (ECOSMES 2012) and has a user-friendly interface, is based on a simplification approach at the level of both inventory and impact assessment. At the level of inventory, complex methodological problems (system boundary definition, choice of elementary flows and impact categories, data quality estimation and documentation) are simplified, according to the SMEs' needs, and pre-elaborated solutions are proposed. The tool is supported by a general and sector-specific database, which stores environmental indicators and metadata of the most common materials, components, and processes (Buttol et al. 2011). As far as the impact assessment is concerned, in eVerdEE elementary flows, impact categories, characterisation and normalisation methods are predefined and selected on sound scientific bases. In particular, only those impact categories on which agreement exists in the scientific community have been considered. The characterisation factors, when applicable, are extracted by the CML 2001 method.

Initially conceived for industrial products, eVerdEE has been further developed so as to include the capabilities to address agricultural products. Furthermore, a simplified Environmental Product Declaration (EPD) procedure was also developed, which allows the use of eVerdEE for certification purpose. This procedure extracts general information and LCA-based data from the eVerdEE studies. The additional information that is required by the Product Category Rules of reference is input into predefined forms. Finally the declaration can be printed.

6.2.2.5 Robustness of the Simplification Strategies

The robustness and completeness of the simplified approaches were also discussed, in order to see whether results comparable to those of detailed LCA can be achieved. Some authors compared the results of a simplified LCA with those of a detailed LCA, showing a moderate or at least acceptable discrepancy (Bala et al. 2010; Hochschorner and Finnveden 2003, 2006; Hunt et al. 1998; Masoni et al. 2004; Porta et al. 2008). Moreover, the results offered are considered to be very helpful during the first iterations of LCA, in order for the main focus of environmental burdens along life cycle of the product to be detected and for further efforts on them to be planned (Gonzalez et al. 2006). However, some authors also pointed out the limitations of the developed approaches; aspects that in some cases make the tools useful only as a first screening and not as a replacement or substitute for full LCA (Verghese et al. 2010; Zah et al. 2009). For example, the sensitivity analysis performed by Roches et al. (2010) for their proposed tool "MEXALCA", points out that even if some benefits in terms of the amount of data and time required exist, the tool is still considered as inaccurate for eutrophication and acidification and unsuitable for toxicity impact categories.

6.3 A Model of Simplified LCA for Agri-Food SMEs

6.3.1 Criteria for Developing/Identifying a Simplified LCA Tool

In Sect. 6.2, both the supply (developments of methods and tools) and demand (what stakeholders desire from a life cycle tool) side of the simplification problem were analysed in order to identify criteria for selecting a simplified LCA tool targeted to the agri-food sector.

The analysis of the demand side considered two main aspects: (1) the need for simplification, i.e. the main reasons for developing a simplified tool; (2) the stakeholders of interest and their needs, i.e. how they would like a life cycle tool to be developed to become more useful in the decision making.

Regarding the main reason that led to the development of a simplified approach, most of the authors point out that it stems from the consideration that detailed LCA can be time- and resource-consuming and this is an obstacle to its wider adoption, especially amongst SMEs (Bala et al. 2010; Todd and Curran 1999; Verghese et al. 2010; Weitz and Sharma 1998; Zah et al. 2009). Moreover, some authors suggest that simplified methods can be useful in the early product design phases, when it is difficult to assess the potential environmental impacts because only a limited amount of information is available (Rydh and Sun 2005), and in green procurement, to identify critical aspects of products and then criteria for procurement (Hochschorner and Finnveden 2003). These considerations have also been confirmed by the survey on users' needs carried out within the CALCAS project[3] (Rydberg et al. 2008). In fact, the majority of those interviewed consider the LCA methodology to be complicated and impractical due to a combination of factors such as: models that are too time-consuming and difficulties in integrating the whole supply chain in the assessment and data availability, which was the most frequently mentioned problem.

For these reasons, a common practice in the business sector is to develop simplified tools (sometimes they are in-house tools), allowing users to carry out environmental life cycle analyses in a short time by focusing on those impacts of greatest relevance to the organisation and on the use of qualitative instead of quantitative data. The survey showed that some industries apply these tools in the product development phase where time is a key factor. The main reason is that a detailed analysis is considered too time-consuming for application on new products, whilst the use of simplified tools could halt or change the development of a product.

Regarding the needs expressed by the business stakeholders' group, they can be summarised as follows (Rydberg et al. 2008):

- to increase the validity and credibility of simplified methods used, for example, in the product development phase;
- to develop tools applicable to specific industrial sectors. While it was recognised that the production of a great many specific tools is not feasible, some consider

[3] In this survey, four categories of stakeholders were addressed, namely: public authorities; business (industry, retailers); NGOs (incl. consumer associations), and R&D programmers (national funding organisations and research institutes). To get relevant information, questions were targeted to selected stakeholders, using both interviews and questionnaires. In total, 25 interviews were conducted which were distributed among the stakeholder groups. The questionnaire was sent out to 220 stakeholder representatives; however, the response rate was only 6 % of which 70 % represented businesses. For the purposes of the present report (the development of a simplified LCA approach for SMEs), the results of two stakeholders' categories were considered: business and consumers.

that non sector-specific tools are not very useful. Moreover, there is also a need to include regional variations in production in models, an aspect that requires model flexibility;
- to increase user-friendliness of tools. This request includes not only simplifying the interface of tools but also integrating application-oriented examples to show how system models could be applied. In addition, there is also a need to improve the availability and accuracy of data along with an update of the average industrial data;
- to develop methods that make it easier for companies to manage supply chain communication in a life cycle analysis. Some respondents recognised that data collection from actors in the supply chain could sometimes be difficult due to a reluctance to share data;
- to increase model transparency;
- to develop methods together with industry, rather than scientists alone.

Most of the needs identified by businesses are also shared by consumers, which in CALCAS were analysed together with NGOs.

Thus, the priority messages regarding future needs and evolution of LCA can be summarised as follow:

- to increase flexibility, accuracy and user-friendliness (tools need to be adapted to the required application or sector);
- to develop less time consuming models;
- to increase transparency of methods and tools;
- to develop clear standards for data gathering;
- to provide data that are representative to different levels of resolution (geographical coverage);
- to develop methods together with the industry, rather than scientists alone;
- to develop strategies on how life cycle approaches can be better communicated; and
- to make consumers aware of their role in the life cycle of products.

The main outcomes of this survey, together with the main findings from the literature review (analysis of the supply side), were used by our research team, which, by means of brainstorming, defined the following preliminary criteria for the development/identification of the simplified tool (Salomone et al. 2011):

- ISO-compliance;
- broad focus (a number of impact categories to be considered, not just one, as for example in Carbon Footprint);
- user-friendly interface;
- limited data requirement or adaptability to existing databases;
- relevance to life cycle steps identified in our review;
- ease of integration with EPD, POEMS and/or other communication tools.

Moreover, because of the limited resources available under this research project, the development of a tool from scratch was considered to be unfeasible. Therefore, the selection (or adaptation) of an existing tool was set as an *a priori* criterion.

6.3.2 Selection of the Simplified LCA Tool

Having set the selection criteria (Sect. 6.3.1), it was necessary to define a way of selecting the most suitable LCA tools that would comply with the criteria. Considering that the task of ranking alternatives based on a set of criteria can be seen as a decision making problem (Figueira et al. 2005), a set of well-established methodologies were identified that could be of help, such as (1) Delphi method (Linstone and Turoff 1975); (2) Analytic Hierarchy Process (AHP) (Saaty 1990); (3) Multi-criteria Decision Analysis (Voogd 1983); (4) rough sets theory (RST) (Greco et al. 2001). In the end the decision making tools described by Martìnez et al. (2009) were used, as described below.

6.3.2.1 Domain Description

The set of alternatives to be evaluated and ranked consisted of 10 tools and methodologies, as shown in Table 6.2.

Each alternative was evaluated according to a set of six criteria (see Sect. 6.3.1). Furthermore, in order to define the relative importance of each criterion with respect to the decision to be made, each one of the previously defined criteria was given a weight in a range [1–9] that was obtained by averaging the weights independently assigned by a board of eleven experts (from the EMAF project). Criteria and associated average weights are shown in Table 6.3.

Note that there are no requirements that a tool must satisfy in order to be acceptable. However, criterion C_6 (weight 8.28) has a higher impact on the evaluation than the other criteria, whose associated weights are quite homogeneous in the range [6.34–7.47].

Once the list of alternatives and the weighted criteria were defined, each alternative (tool or methodology in this domain) was evaluated against all criteria by some experts and tool developers who allocated scores ranging from 1 (worst compliance with a criterion) to 10 (best compliance with a criterion).

Indeed, two members from the research team contributed to this evaluation by assigning two sets of scores. In addition, all developers of the simplified tools were sent *ad hoc* questionnaires for evaluating their own tools in terms of the predefined criteria. Two completed questionnaires were returned.

Each evaluation resulted in a set of scores a_{ij}, representing how the alternative A_i fits the criterion C_j. A set of five score assignments have been considered, as described in Sect. 6.3.2.3.

Table 6.2 Simplified LCA tools and methodologies to be evaluated and ranked

Code	Simplified tool or method	Source
A_1	eVerdEE	Masoni et al. (2004)
A_2	MEXALCA	Roches et al. (2010)
A_3	BilanProduit	Bewa et al. (2009)
A_4	MECO	Hochschorner and Finnveden (2003, 2006)
A_5	Carbonostics	Teixeira (2012)
A_6	ERPA matrix	Graedel and Allenby (1995)
A_7	CMA	Mori et al. (2000)
A_8	ABC/XYZ assessment method	Fleischer et al. (2001)
A_9	Black-box production system	Eide and Ohlsson (1998), Hospido et al. (2003)
A_{10}	Basic agricultural inventory	Mourad et al. (2007)

Table 6.3 Weighted criteria for LCA tools evaluation

Code	Criterion	Weight w_i
C_1	ISO-compliance	7.47
C_2	Broad focus	7.36
C_3	User-friendly interface	6.65
C_4	Limited data requirement[a]	6.55
C_5	Relevance to identified life cycle steps[b]	6.34
C_6	Ease of integration with EPD, POEMS[c]	8.28

[a] Full specification: limited data requirement or adaptability to existing databases.
[b] Full specification: relevance to life cycle steps identified in our review.
[c] Full specification: ease of integration with EPD, POEMS and/or other communication tools.

6.3.2.2 Methodologies

In order to rank the different alternatives, three decision making methodologies have been used. Amongst the many alternatives, the ones belonging to the family of Multi-Attribute Utility Theory (MAUT) were chosen, where the criteria are aggregated into a function. This allows some compensation between different criteria, in the sense that high scores for some criteria can compensate low scores for others. The function is used to assign a ranking value to all alternatives, which are then ranked according to their ranking value. The following MAUT methods have been considered:

- SMART: where the ranking value x_i of alternative A_i is computed as follows (Barron and Barrett 1996):

$$x_i = \frac{\sum_{j=1}^{m} w_j a_{ij}}{\sum_{j=1}^{m} w_j} \tag{6.1}$$

$$\forall i = 1, \ldots, 10,\ \forall j = 1, \ldots, 6$$

In this way the ranking values x_i are obtained as the weighted algebraic mean of the corresponding utility values.

- Meszaros and Rapcsak: where weighted geometric means are considered, as follows (Meszaros and Rapcsak 1996):

$$x_i = \prod_{i=1}^{m} a_{\mathrm{ij}}^{w_j/w} \tag{6.2}$$

$$\forall i = 1, \ldots, 10,\ \forall j = 1, \ldots, 6$$

The idea, here, is that good values for x_i can be determined by considering multiples of the weighted geometric means.

- Entropy optimisation: where an entropy optimisation problem is considered, as follows (Lofti and Fallahnejad 2010):

$$x_i = f^{-1}\left(\sum\nolimits_{j=1}^{m} \frac{w_j}{w} f\left(a_{\mathrm{ij}}\right)\right) \tag{6.3}$$

where

$$w = \sum_{j=1}^{m} w_j,\ \forall i = 1, \ldots, 10,\ \forall j = 1, \ldots, 6.$$

This method is based on determining values for x_i in the form of generalised mean. Note that the function f is a strictly monotone function.

After the application of each methodology, ranking values were then normalised in the range [0–10] to make the comparison clearer.

6.3.2.3 Results

Score Assignment SA1

The first score assignment, provided by a member of the research team on the basis of a theoretical description of the tools/methods evaluated found in the available scientific literature, is reported in Table 6.4, where the descriptions of alternatives A_i and criteria C_j (with the corresponding weights) are reported in Tables 6.2 and 6.3, respectively.

The ranking values assigned to each simplified LCA tool or methodology, according to the three decision making methods described in the previous section,

Table 6.4 Score assignment SA1

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}
C_1	6	5	9	9	6	9	5	5	5	5
C_2	7	7	8	7	5	7	6	6.5	7	7.5
C_3	8	5	8	5	8	5	5	5	5	5
C_4	5	8	7	7	8	7	6	6.5	5	7
C_5	8	8	7	3	8	3	5	4	6	9
C_6	7	5	5	5	8	5	5	5	5	5

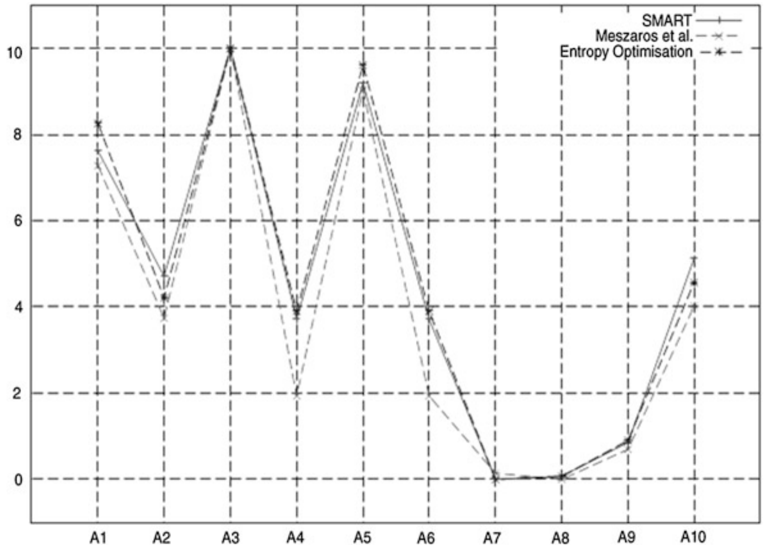

Fig. 6.1 Evaluation of score assignment 1

are reported in Fig. 6.1. The results show that all the methodologies rank the tools BilanProduit, Carbonostics and eVerdEE as the best three tools, in the given order.

Score Assignment SA2

The second score assignment, provided by a different member of the team on the basis of a theoretical description of the tools/methods evaluated found in the available scientific literature, is reported in Table 6.5, where the descriptions of alternatives A_i and criteria C_j (with the corresponding weights) are reported in Tables 6.1 and 6.2, respectively.

It is worth noting that in this assignment, very high values (9) are assigned to the eVerdEE tool (A_1).

Table 6.5 Score assignment SA2

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}
C_1	9	5	7	4	6.5	4	8	5	5	5
C_2	9	8	8	9	1	5	5	5	5	7
C_3	9	8	5	7	9	7	7	4	7	8.5
C_4	9	9	5	7	4	7	8	8	8	5
C_5	9	5	7	8	9	4	3	9	7	7
C_6	9	5	8	5	6	5	5	5	5	5

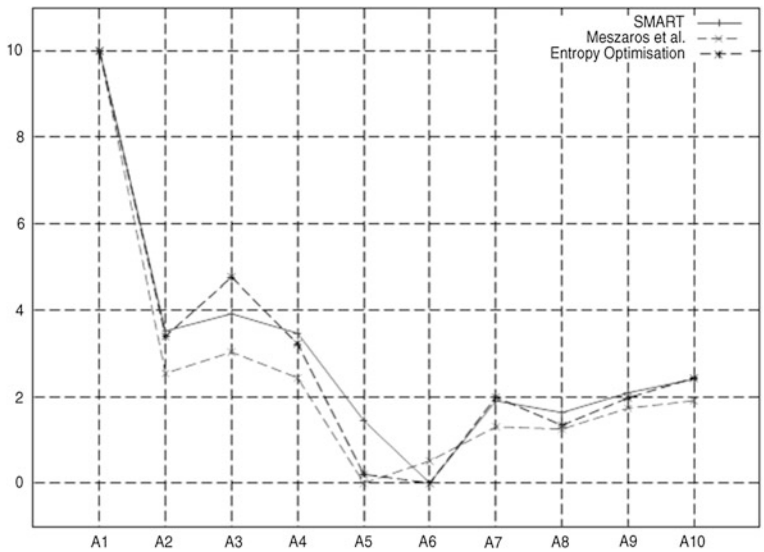

Fig. 6.2 Evaluation of score assignment 2

The ranking values assigned to each LCA methodology, according to the three decision making methods described in the previous section, are reported in Fig. 6.2.

Based on this score assignment, the eVerdEE tool clearly outperforms all the others. Second and third best tools are BilanProduit and MEXALCA, respectively.

Score Assignment SA3

The third score assignment was obtained by averaging the scores assigned in SA1 and SA2. The resulting scores are shown in Table 6.6, where the descriptions of alternatives A_i and criteria C_j (with the corresponding weights) are reported in Tables 6.2 and 6.3, respectively.

Table 6.6 Score assignment SA3

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}
C_1	7.5	5	8	6.5	6.5	6.5	6.5	5	5	5
C_2	8	7.5	8	8	3	6	5.5	6	6	7.5
C_3	8.5	6.5	6.5	6	8.5	6	6	4.5	6	7
C_4	7	8.5	6	7	6	7	7	7.5	6.5	6
C_5	8.5	6.5	7	5.5	8.5	3.5	4	6.5	6.5	8
C_6	8	5	6.5	5	7	5	5	5	5	5

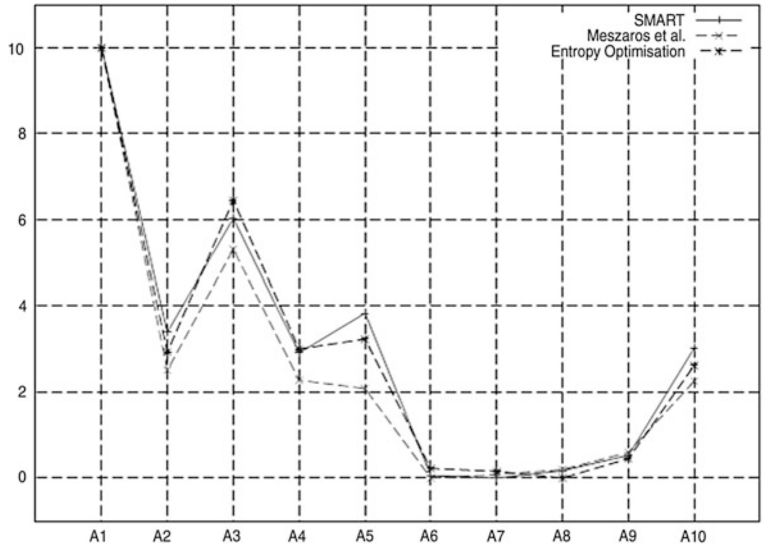

Fig. 6.3 Evaluation of score assignment 3

The ranking values assigned to each LCA methodology, according to the three decision making methods described in the previous section, are reported in Fig. 6.3.

The results are similar to the ones assigned according to SA2, showing that SA2 dominates over assignment SA1. Indeed, also in this case, the best two tools are eVerdEE and BilanProduit, while Carbonostics ranks third.

Score Assignment SA4

The forth score assignment was obtained by considering SA3 and replacing the scores assigned to the Carbonostics tool (A5) with the scores provided by the tool producers. The resulting score assignment is shown in Table 6.7, where the

Table 6.7 Score Assignment SA4

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}
C_1	7.5	5	8	6.5	5	6.5	6.5	5	5	5
C_2	8	7.5	8	8	7	6	5.5	6	6	7.5
C_3	8.5	6.5	6.5	6	10	6	6	4.5	6	7
C_4	7	8.5	6	7	9	7	7	7.5	6.5	6
C_5	8.5	6.5	7	5.5	9	3.5	4	6.5	6.5	8
C_6	8	5	6.5	5	7	5	5	5	5	5

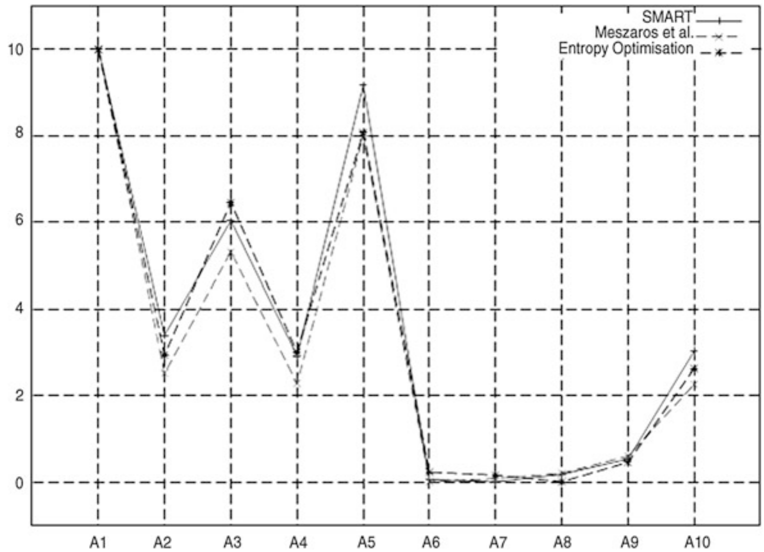

Fig. 6.4 Evaluation of score assignment 4

descriptions of alternatives A_i and criteria C_j (with the corresponding weights) are reported in Tables 6.2 and 6.3, respectively.

The ranking values assigned to each LCA methodology, according to the three decision making methods described in the previous section, are reported in Fig. 6.4.

As expected, this assignment increased the evaluation of Carbonostics (whose producers' evaluation was used in the score assignment). Nevertheless, the best tool is still eVerdEE, followed by Carbonostics and BilanProduit.

Score Assignment SA5

The fifth score assignment was obtained by considering SA3 and replacing the scores assigned to the eVerdEE tool (A1) with the scores provided by the tool's

Table 6.8 Score Assignment SA5

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}
C_1	6	5	8	6.5	6.5	6.5	6.5	5	5	5
C_2	8	7.5	8	8	3	6	5.5	6	6	7.5
C_3	8	6.5	6.5	6	8.5	6	6	4.5	6	7
C_4	6	8.5	6	7	6	7	7	7.5	6.5	6
C_5	8	6.5	7	5.5	8.5	3.5	4	6.5	6.5	8
C_6	7	5	6.5	5	7	5	5	5	5	5

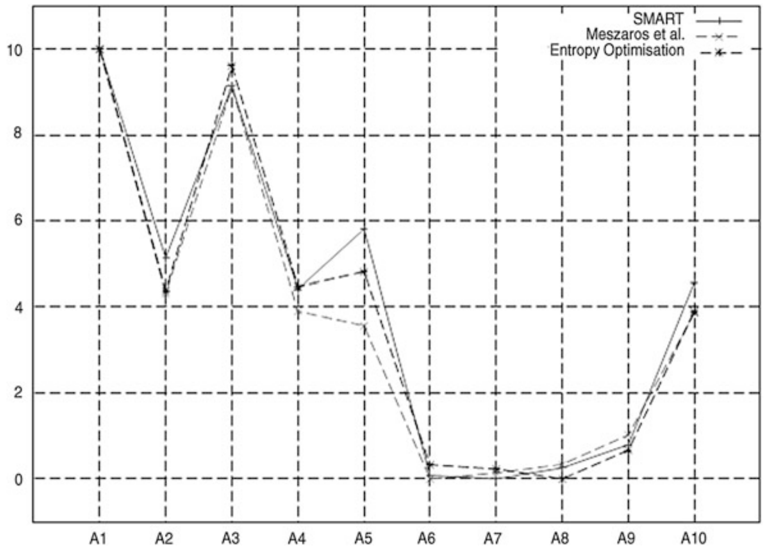

Fig. 6.5 Evaluation of score assignment 5

producers. The resulting score assignment is shown in Table 6.8, where the descriptions of alternatives A_i and criteria C_j (with the corresponding weights) are reported in Tables 6.2 and 6.3, respectively. Interestingly, the scores assigned to eVerdEE by its producers are lower than the ones assigned by the member of the research team in SA2.

The ranking values assigned to each LCA methodology, according to the three decision making methods described in the previous section, are reported in Fig. 6.5.

Average Ranking Values

As a comprehensive evaluation, the average values amongst all the five different ranking values were computed, as shown in Fig. 6.6.

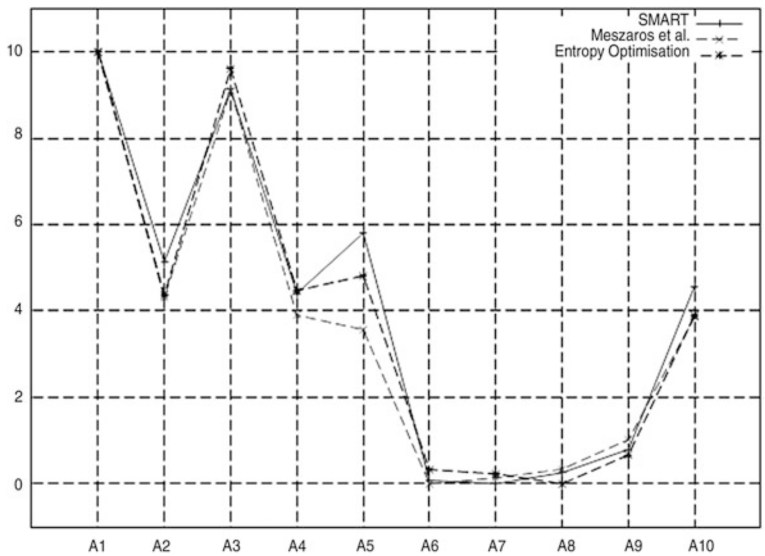

Fig. 6.6 Average ranking values

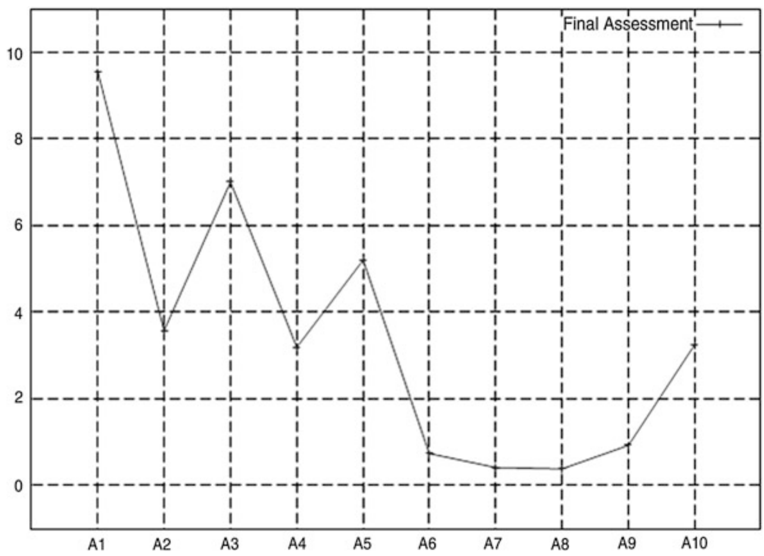

Fig. 6.7 Final ranking values

Table 6.9 Final Ranking

Rank	Code	Simplified tool or method	Score
1st	*A*1	eVerdEE	9.54
2nd	*A*3	BilanProduit	7.01
3rd	*A*5	Carbonostics	5.20
4th	*A*2	MEXALCA	3.57
5th	*A*10	Basic agricultural inventory	3.24
6th	*A*4	MECO	3.19
7th	*A*9	Black-box production system	0.92
8th	*A*6	ERPA matrix	0.74
9th	*A*7	CMA	0.41
10th	*A*8	ABC/XYZ assessment method	0.38

The final step was the computation of the average value amongst the outputs given by the different decision making methods (that is the average value amongst the values reported in Fig. 6.6). This also corresponds to the definitive assessment of the ten alternatives, on which to base the decision. The final evaluation is reported in Fig. 6.7 and the final ranking is shown in Table 6.9, together with the ranking score for each alternative.

According to the final evaluation, the eVerdEE tool is the one that best fits the criteria. As a next step, this result needs to be validated through the practical use of the tool, to verify that the different criteria are actually met in practice. In fact, the number of score assignments considered was quite limited, and it was not possible to acquire an evaluation from the producers of all the tools under analysis. Furthermore, some of the criteria are difficult to evaluate on an objective basis, thus subjective judgements need to be confirmed by practical experience.

To this end, the ranking provided by the decision making process can also be exploited to practically test other tools (in particular BilanProduit and Carbonostics) should the first one not be completely satisfactory.

6.4 Conclusions

This chapter has addressed the topic of simplified LCA approaches in order to identify and characterise the existing simplified approaches and tools suited for SMEs in the agri-food sector. For this purpose, a literature review was carried out, which indicated that there is no single simplified LCA method which is suitable for all product categories. For some product categories one method would work quite well, but it would not work well for other product categories (Hur et al. 2005). Different strategies have been developed, but since the risk exists of reducing reliability and/or completeness of the assessment (Hospido et al. 2003; Todd and Curran 1999), the choices should be made very carefully and on a case-by-case basis.

Certain criteria were then defined for selecting the most suitable simplified tool for the application at hand: ISO-compliance; broad focus (in terms of number of impact categories); user-friendly interface; limited data requirement or adaptability to existing databases; relevance to life cycle steps identified in our review; ease of integration with EPD, POEMS and/or other communication tools.

The most suitable tool that complied with the criteria was subsequently selected by applying well-established decision making methodologies belonging to the family of MAUT, which resulted in the choice of eVerdEE. This is a simplified LCA tool based on a sector-specific database, with data for the most common processes, materials and components of the sector analysed, fully integrated within the software. Besides having a user-friendly interface, the tool is also programmed so to develop a simplified Environmental Product Declaration EPD, which potentially allows the use of eVerdEE for certification purposes.

Although eVerdEE is the tool that best fits the criteria identified as the most relevant for a simplified LCA tool, this result needs to be validated through the practical use, and also in parallel with the results of detailed LCAs, to verify that the different criteria are actually met in practice.

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Chapter 7
The Implementation of Simplified LCA in Agri-Food SMEs

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7.1 Introduction

In Chap. 5 a review of LCA case-studies reviews was performed in order to identify the various impact categories and life cycle phases that can be regarded as relevant from an environmental point of view for the agri-food sector. A further review was then carried out in order to identify simplified LCA tools and approaches that could be suitable for SMEs, especially in the food sector (see Chap. 6). What followed was a decision making methodology (see Chap. 6) that allowed for one simplified tool to be selected on the basis of predefined criteria.

In order for the selected simplified LCA tool (eVerdEE) to be tested for its robustness and suitability, it was applied in the framework of an SME in the agri-food sector. The firm chosen was *Palazzo Centofanti*, a small winery located in the Abruzzo region of Italy (for a full description of the firm, please refer to the following box). In order for the evaluation to be performed, two different tools were used; a full LCA (see Sect. 7.2) and the simplified one (see Sect. 7.3), so that the latter could be assessed by relating its results to those of a detailed LCA. It should be noted furthermore, that the evaluation performed was carried out with the parallel objective of assessing the appropriateness of the decision making methodology used in Sect. 6.3.2. In other words, the implementation of the simplified tool aimed also at

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evaluating whether the simplified LCA actually meets the criteria against which it was assessed in the framework of the decision making methodology.

The type of wine selected to be analysed was *Montepulciano d'Abruzzo*, a DOC[1]-classified red wine made from Montepulciano grapes. Palazzo Centofanti has 1.10 ha organically grown vineyards planted in Montepulciano, which, in the crop year 2010–2011 (November 2010 to October 2011) yielded 7,000 kg of grapes, finally turned into about 5,000 L (6,660 0.75 L bottles) of wine.

Palazzo Centofanti

The winery Palazzo Centofanti is situated in Giuliano Teatino, a small municipality in the province of Chieti, in the Abruzzo region of Italy. This firm was originally founded in the second half of the 1800s and served immediately as a stopping-point for the refreshment and respite of travellers who were heading from the Adriatic coast into the inland of Abruzzo and of Italy.

Today, this firm is a small family managed winery, whose mission is represented by the environmental protection and the preservation of traditions, shown by the strong bond and respect for the land. The company is in fact a "garrison" in the territory of Giuliano Teatino, where wine is not just a product, but is synonymous with hospitality and conviviality, a reflection of direct human relations. The winery management also demonstrates significant environmental sensitivity by adopting a sustainable agriculture, as evidenced not only by the conversion to organic production and by the concept of "minimum tillage", which consists in practicing minimum working of the soil so as not to stress it—thus also reducing CO_2 emissions as a consequence of reduced mechanical working—but also by the adoption of other techniques such as green manure cropping (field bean), which allows the nitrogen to enter the soil in a natural way, and restoring grooves. These, along with allowing native grass to grow between the rows and controlling them through periodical mowing, results in a controlled reduction of the impetus of rainwater, thus limiting soil erosion.

Several grape varieties (including new ones) are cultivated on the 10 ha of vineyards, which are worked by the Centofanti family, who personally take care of all the stages of cultivation.

[1] The acronym DOC (*Denominazione di Origine Controllata*) refers to a label awarded to wine products with a controlled designation of origin, which acts as a quality assurance designating a product whose features are connected to the natural environment and human factor specific to a given region and meet a specific production regulation.

The wines produced by Palazzo Centofanti include: *Montepulciano d'Abruzzo* D.O.C, *Cerasuolo* D.O.P, *Pinot Grigio* I.G.T. *terre di Chieti*, *Pecorino* I.G.T. *terre di Chieti* and two products that are typically traditional of the Abruzzo region, namely *Vino Cotto* and *Mosto Cotto.*

7.2 Implementation of a Full LCA

In this section the application of a full LCA methodology is described, using SimaPro 7.2.4 (Pré 2012) as a software tool and following the ISO 14040 series standards.

7.2.1 Goal and Scope Definition

The aim of the study was to identify the environmentally most critical phases of the life cycle of Centofanti's *Montepulciano d'Abruzzo* as well as the impacts to the environment that seem to be more greatly affected by the product system analysed. Another question that also needs to be answered is: "where can any improvement possibilities be found in the life cycle of the product?" The intended audience of this study would be scientists, wine-making companies in Italy and elsewhere, and consumers.

The object of the analysis is wine delivered in a bottle along with its overall packaging. For this reason, the functional unit for this study was defined as a 0.75 L bottle of organic red wine "*Montepulciano d'Abruzzo*", including its primary packaging (bottle of green glass, cork, heat-shrink capsule and label), its secondary packaging (corrugated cardboard box) and its tertiary packaging (wooden pallet and plastic film).

The system boundary includes the agricultural phase, the production of wine, and the distribution. The study was therefore a cradle-to-market one, including the distribution phase (see Figs. 7.1 and 7.2).

As far as allocation is concerned, this was performed by mass in the case of lees brought to a distillery to be processed into alcohol, which was therefore considered as a by-product.

As regards impact categories selected, these were the default categories existing in the ReCiPe (H) impact assessment method.[2] This is a hierarchist method that

[2] This method was developed by RIVM, CML, Pré Consultants, Radboud University Nijmegen and CE Delft (Goedkoop et al. 2009).

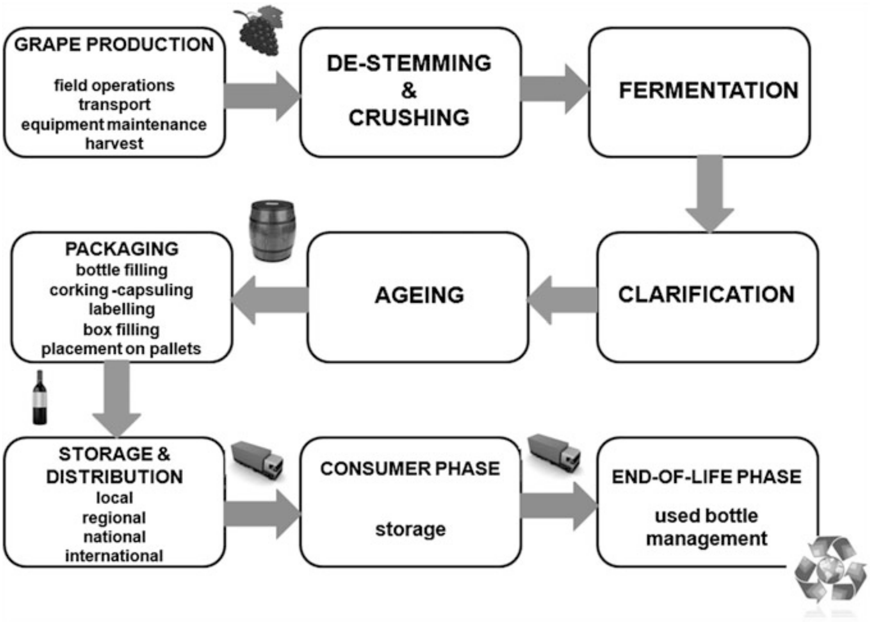

Fig. 7.1 Generic wine life cycle flow chart (please note that transport can occur elsewhere in the life cycle depending on the site-specific means of processing)

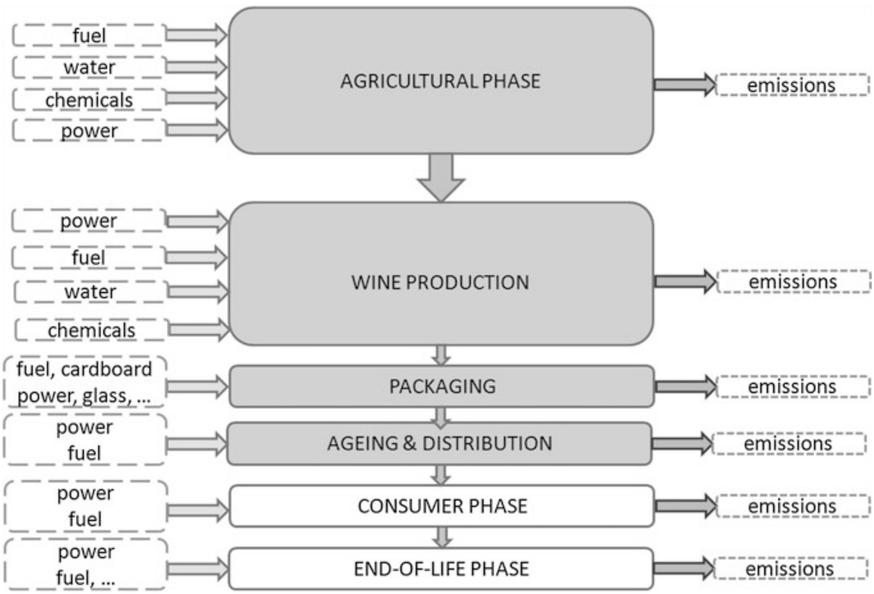

Fig. 7.2 Centofanti's wine life cycle flow chart (please note that the stages in *grey* refer to the foreground system—data collected on-site; the consumer and the end-of-life phases were not included in the product system)

uses average weighting set, includes harmonised category indicators and delivers results at both the midpoint and endpoint levels (Goedkoop et al. 2009).

Finally, regarding the cut-off criteria these were set for processes that are minimal by mass (provided that they are not considered as toxic substances) or for cases where available data was lacking in the database. In the latter case, the possibility of the process being important was first evaluated. The sum of the entries excluded was 0.1 % of the total mass of the inputs.

7.2.2 Life Cycle Inventory

The inventory data were collected on-site for both the agricultural phase (Centofanti wine growing farm) and the wine production phase (local cooperative winery—*Cantina Sociale*), both situated in Giuliano Teatino at a distance of 1 km from each other. The data collected referred to the wine-making year 2010–2011 (November to October).

7.2.2.1 Grapes Production

The production of the grapes comprises the agricultural phase, where processes such as pruning, vine tying, fertilising, tillage, pest control, harvesting, and vineyard maintenance are included. Primary data were mainly used for this stage.

However, in some cases data were taken from the EcoInvent 2.2 database (Ecoinvent Centre 2012) (which was integrated in the SimaPro software). For example, in the case of tractors, even if the firm provided information on the three different types of tractors used, in the end the process referred to a tractor with trailer that was available in the EcoInvent database.

Due to lack of data availability within the database, the *Bacillus thuringiensis* bacteria, which is used in the process of pest control, was omitted.

For emissions to air and water from the substances included in the fertilisers (such as nitrogen, potassium and phosphorus) the manuals provided by the EcoInvent database were used for the calculations.

Finally, as regards the copper and sulfur used in the pest control stage, they were assumed to entirely reach the soil, and thus calculated, even if a percentage may be withheld by plants.

7.2.2.2 Wine Production

After the production of the grapes is concluded, they are transferred by tractors with trailers to a wine-making facility at a distance of 1 km, where the wine production phase commences. This includes the following processes:

- *De-stemming and crushing*, where the grapes are separated from their stem and crushed. These procedures are carried out simultaneously by the same machinery. Here the first must is produced, containing the seeds and grape skin that are deemed necessary for giving red wines their colour. The stems are then spread onto the soil;
- *Fermentation*, where the sugars in the must are transformed into alcohol (ethanol) with the parallel emission of carbon dioxide. Here several yeasts and activators are used, such as *Saccharomyces bayanus*, arginine, proline. This is followed by a secondary malolactic fermentation which occurs spontaneously;
- *Pressing*, where the skins are pressed in order for the inherent colours and flavours to be released. In this phase the marc produced goes to waste;
- *Decantation*, where the must is stored in a tank and enriched with potassium metabisulfite ($K_2S_2O_5$) in order for the proliferation of bacteria to be prevented;
- *Clarification*, where unwanted substances are removed from the wine in order to provide it with a clearer appearance. Here, bentonite is added as a fining agent, i.e., for the absorption and settling of particles;
- *Filtering*, where any remaining bacteria, ferments or sediments are filtered out. Here, a PVC filter is used and any lees are brought to a distillery.

This stage finishes with the product ready to be bottled, after remaining for a period in a stabilisation tank.

Since the lees produced throughout wine making are sold to a distillery, they should be considered as a by-product and not as waste; therefore, the related multi-output processes were dealt with through allocation, which was carried out based on mass. The several yeasts and activators, along with the bentonite and the potassium metabisulfite were excluded from the calculations as they were not available in the EcoInvent database.

7.2.2.3 Packaging

As described before (Sect. 7.2.1), there were three different types of packaging considered.

In the first type (primary packaging), the wine produced in the previous stage is bottled in green glass, and the bottle is sealed with a natural cork. Then, a heat-shrink capsule is used over the cork and bottle neck and finally a label is placed on the side of the bottle. It should be emphasised here that the glue and the ink used for the adhesive label were not taken into account as they were regarded as negligible.

In the second type (secondary packaging), bottles are placed in corrugated cardboard boxes (six bottles for each box).

In the third type (tertiary packaging), the boxes are placed onto a wooden pallet (60 boxes on one pallet) in order for them to be easily transported; then they are wrapped up with a plastic film (made of PVC). It was furthermore assumed that pallets are recovered and thus reused at a rate of 80 % each year.

7.2.2.4 Distribution

The wine is sold only within the borders of Italy and transported on lorries:

- 70 % locally, within the region of Abruzzo, for which a mean distance of 50 km (one way) was considered;
- 20 % to the neighbouring region of Lazio, for which an average distance of 250 km (one way) was considered;
- 10 % of it to the region of Piedmont, for which an average distance of 750 km (one way) was considered.

It should, however, be noted here that the means of transport was considered to carry some kind of goods on the return trip so as not to travel empty.

7.2.3 Life Cycle Impact Assessment and Interpretation

As regards the LCIA step, SimaPro was set to perform the calculations on the basis of the European ReCiPe Endpoint (H) method. In this part, the classification, characterisation and normalisation (calculated per European citizen) phases of LCIA were carried out.

The default impact categories were considered, notably: climate change (human), ozone depletion, human toxicity, photochemical oxidant, particulate matter formation, ionising radiation, climate change (ecosystem), terrestrial acidification, freshwater eutrophication, terrestrial ecotoxicity, freshwater ecotoxicity, marine ecotoxicity, agricultural land occupation, urban land occupation, natural land transformation, metal depletion and fossil depletion.

The results of the characterisation step are shown in Fig. 7.3, as they were exported from the software tool. In this figure, the impacts to the various environmental categories are expressed as percentages for the four life cycle phases: agricultural phase (grapes), wine-making phase (wine), distribution and packaging. On the other hand, normalised results are presented in Fig. 7.4.

Figure 7.3 demonstrates that the agricultural phase is the most impacting one for terrestrial ecotoxicity (almost entirely due to the spreading of copper in the agricultural phase, see Table 7.1), metal depletion (mainly due to the use of copper as an input for the pesticides), agricultural land occupation (use of 1.1 ha of land for 20 years), freshwater eutrophication, freshwater ecotoxicity and marine ecotoxicity. On the other hand, the stage of packaging is more impacting for most of the categories such as natural land transformation, ozone depletion, ionising radiation and, to a lesser degree for climate change (both human and ecosystem), urban land occupation and photochemical oxidant formation. It has to be highlighted here that for all categories mentioned, the process that impacts most in terms of percentage of the sum of the overall processes is the one of green glass: from 92.8 % (for urban land occupation; see Table 7.2) to even 97.8 % (for ionizing radiation; see Table 7.3). In terms of life cycle stages it appears that the

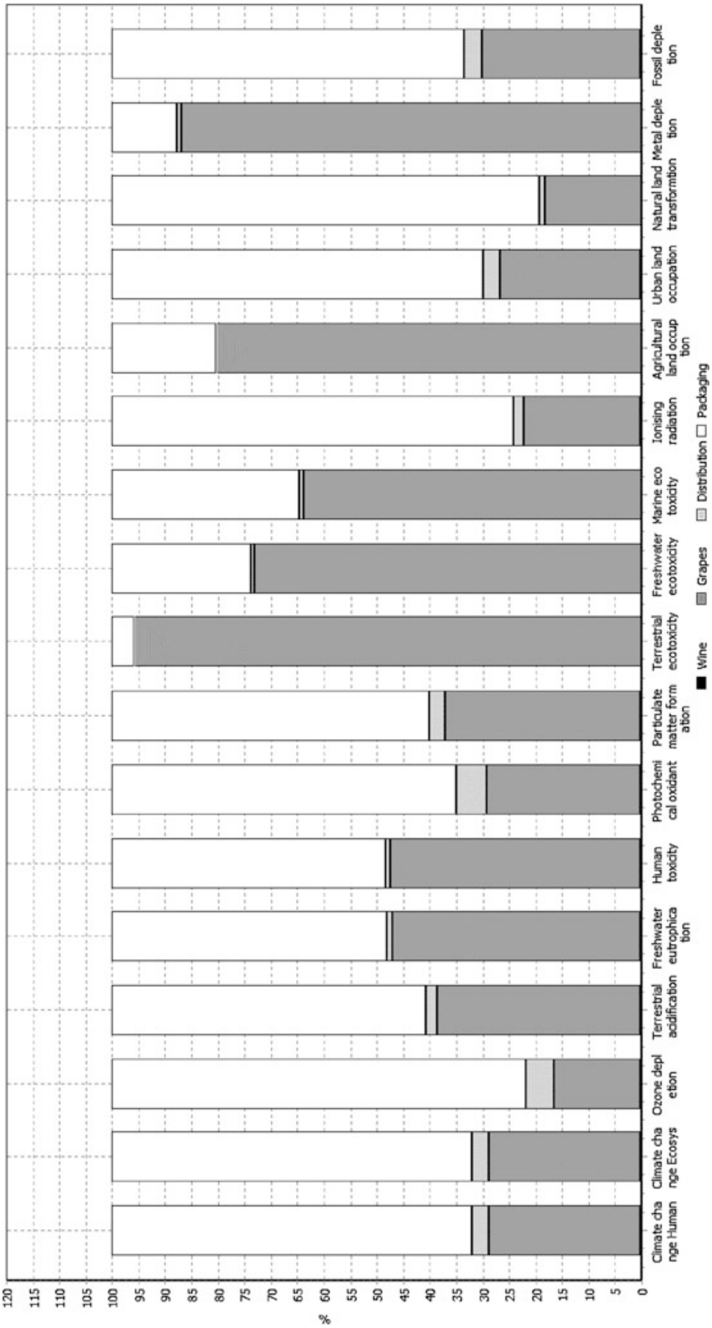

Fig. 7.3 Characterisation results

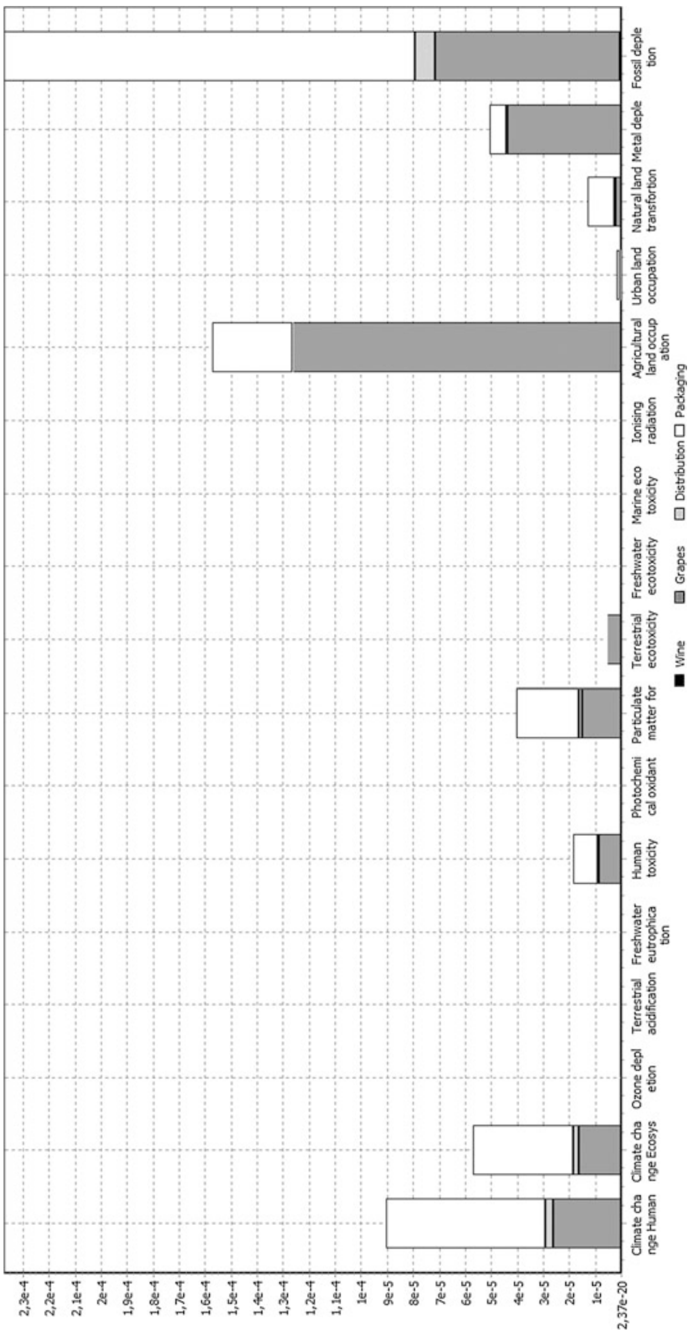

Fig. 7.4 Normalisation results

Table 7.1 Contribution of the various environmental aspects to the characterisation scores for terrestrial ecotoxicity (first ten entries)

No	Substance	Compartment	Wine	Grapes	Distribution	Packaging	Total (species·year)
1	Copper	Soil	1.58E-15	9.73E-10	1.65E-14	3.64E-13	9.73E-10
2	Selenium	Water	4.03E-16	7.99E-14	2.19E-15	2.11E-11	2.12E-11
3	Phosphorus	Soil	6.1E-17	1.18E-11	1.25E-15	7.3E-13	1.25E-11
4	Cypermethrin	Soil	9.8E-17	1.84E-12	5.53E-15	7.49E-12	9.34E-12
5	Phosphorus	Air	1.35E-14	1.07E-12	2.85E-13	5.62E-12	6.99E-12
6	Copper	Air	2.45E-15	8.61E-13	4.44E-13	1.72E-12	3.03E-12
7	Chlorothalonil	Soil	1.15E-18	2.53E-16	2.25E-17	1.4E-12	1.4E-12
8	Zinc	Air	3.65E-15	4.83E-13	1.64E-13	4.03E-13	1.05E-12
9	Mercury	Air	5.83E-16	6.84E-13	2.19E-14	2.62E-13	9.68E-13
10	Vanadium	Air	6.56E-15	2.13E-13	1.31E-14	5.79E-13	8.11E-13

Table 7.2 Characterisation scores for urban land occupation (packaging phase)

No	Substance	Total (species·year)	Percentage of total
	Sum of all processes	1.26E-10	100
1	Packaging glass, green, at plant/RER S	1.17E-10	93.44
2	Transport, lorry 16–32 t, EURO3/RER S	3.26E-12	2.59
3	Raw cork, at forest road/RER S	2.97E-12	2.37
4	Paper, wood-free, coated, at regional storage/RER S	1.6E-12	1.28
5	Thermoforming, with calendering/RER S	3.68E-13	0.29
6	Transport, lorry >32 t, EURO3/RER S	2.33E-14	0.02
7	Polyethylene, HDPE, granulate, at plant/RER S	5.64E-15	0.004

Table 7.3 Characterisation scores for ionizing radiation (packaging phase)

No	Substance	Total (DALY)	Percentage of total
	Sum of all processes	1.8E-09	100
1	Packaging glass, green, at plant/RER S	1.76E-09	97.75
2	Transport, lorry 16–32 t, EURO3/RER S	2.02E-11	1.12
3	Thermoforming, with calendering/RER S	1.45E-11	0.8
4	Paper, wood-free, coated, at regional storage/RER S	5.51E-12	0.31
5	Transport, lorry >32 t, EURO3/RER S	1.65E-13	0.009
6	Raw cork, at forest road/RER S	1.52E-13	0.008
7	Polyethylene, HDPE, granulate, at plant/RER S	4.4E-14	0.002

Table 7.4 Characterisation scores for fossil depletion

No	Substance	Wine	Grapes	Distribution	Packaging	Total (US$)
1	Oil, crude	4.19E-05	0.011286	0.002166	0.021249	0.034742
2	Gas, natural/m^3	7.82E-05	0.006176	0.00018	0.021449	0.027884
3	Coal, hard	2.86E-05	0.003688	9.96E-05	0.003417	0.007233
4	Coal, brown	3.23E-06	0.000591	2.76E-05	0.002383	0.003005
5	Gas, mine, off-gas, process, coal mining/m^3	3.45E-07	6.65E-05	1.92E-06	6.73E-05	0.000136

agricultural phase and the packaging phase are more impacting than the wine making and distribution of the product. This can partially be explained by the fact that most of the wine (70 %) is distributed locally (within 50 km on average) and, furthermore, distribution does not occur outside the Italian borders. It has to be noted here that the distribution phase has a relatively high score for the fossil depletion most probably due to the consumption of diesel in order for the product to be transferred (for the characterisation scores for fossil depletion please refer to Table 7.4).

Both figures demonstrate that the wine-making phase (wine) is the least impacting one for all environmental categories. This can be explained by the fact

Table 7.5 Characterisation scores for the packaging phase and for the climate change (human health category)—first ten entries

No	Process	Primary packaging	Secondary packaging	Tertiary packaging	Total (DALY)
1	Packaging glass, green, at plant/RER S	9.16E-07	-	-	9.16E-07
2	Corrugated board, recycling fibre, double wall, at plant/RER S	-	1.76E-07	-	1.76E-07
3	Production of carton board boxes, offset printing, at plant/CH S	-	5.5E-08	-	5.5E-08
4	Disposal, packaging cardboard, 19.6 % water, to sanitary landfill/CH S	-	3.14E-08	-	3.14E-08
5	Transport, lorry 16-32t, EURO3/RER S	1.97E-08	5.12E-09	2.69E-09	2.75E-08
6	Disposal, polyethylene, 0.4 % water, to municipal incineration/CH S	3.17E-09	2.19E-24	2.48E-09	5.65E-09
7	Polyethylene, HDPE, granulate, at plant/RER S	5.4E-09	-	-	5.4E-09
8	EUR-flat pallet/RER S	-	-	5.28E-09	5.28E-09
9	Polyethylene, LDPE, granulate, at plant/RER S	-	2.45E-10	4.59E-09	4.83E-09
10	Thermoforming, with calendering/RER S	2.19E-09	-	-	2.19E-09

that during this stage the environmental interventions considered are mostly related to the functioning of power-operated machinery and equipment with limited running times (only a few seconds per functional unit).

The normalisation scores, as can be seen in Fig. 7.4, show that the impact with the highest score is fossil depletion, to which the packaging and then the agricultural phase mostly contribute. Moreover, the agricultural land occupation appears to be significantly influenced, as well (greatly affected by the agricultural phase). Finally, climate change (an impact that is greatly discussed and considered as a major one today) seems to be somehow less affected. In this case, packaging is the dominant phase, of which the use of glass seems to play by far the most important role (see Table 7.5).

7.3 Implementation of the Simplified LCA Tool

The eVerdEE tool (ECOSMES 2012) is a simplified LCA tool available online that allows its users to directly fill it in and obtain results with regard to the environmental performance of a product (see also Sect. 6.2.2.4). A preliminary version available offline, named VerdEE, was originally developed by the Italian National Agency for New Technology, Energy and Sustainable Economic Development (ENEA), ERVET Politiche per le Imprese S.p.A. and the University of Bologna under the supervision of the Italian Ministry of Industry (Masoni et al. 2004; Raggi et al. 2005). The more recently developed eVerdEE tool is the evolution of VerdEE and is entirely available online, and is free of charge following registration.

For this study, the most recent version of eVerdEE was used, which, at the time of the study, was not yet available online to the public. The research team acquired permission to use it before its official upload to the internet. This beta version contains the European reference Life Cycle Data system (ELCD) database, made available through the European Platform on LCA, integrated into the existing database of eVerdEE. The latter consists of sector-specific data that have been collected during product-chain studies, in the framework of several European projects. Nevertheless, the ELCD database was not used by the authors due to the fact that it was not updated at the time of the study (Scalbi S, 2012, Italian national agency for new technologies, energy and sustainable economic development (ENEA), Italy, "Personal communication").

7.3.1 Goal and Scope Definition

In the very beginning, the user is asked to choose between two different kinds of system that can be analysed: (1) industry and (2) agriculture. At first glance, the latter option seemed to be more suitable for the product under analysis (wine). However, on further examination, the "agriculture" modelling option, as designed in eVerdEE, seemed to be suitable only for agricultural produce, which does not undergo further processing after harvesting. In contrast, wine can be considered an agri-industrial product; indeed, besides the obvious grape-growing agricultural phase, there is also an industrial one, where wine is made, bottled and then packaged. Selecting the "agriculture" option would not allow the authors to easily model the industrial steps of the product system under analysis. Nevertheless, the software also contained a by-pass procedure that in the end the authors decided to follow. According to this, the agricultural phase was modelled using the "agriculture" option and the wine-making phase using the "industry" one. The agricultural phase was then saved as a component within the software and then inserted in the wine-making phase in its pre-manufacture phase, thus creating a model that includes both phases. In the same web-page, users need to fill in basic information required for performing the LCA, such as: (1) goal; (2) functional unit; (3) reference flow; (4) study boundary, where they can choose amongst three options: from cradle to finished product, from cradle to market and from cradle to grave (and thus for the entire life cycle of the product); (5) cut-off rules and allocation criteria; (6) choice between a free or a guided procedure to be followed. Figure 7.5 shows the data inserted for this case study.

As far as allocation is concerned, this was performed by mass in the case of lees brought to a distillery to be processed into alcohol, which was therefore considered as a by-product.

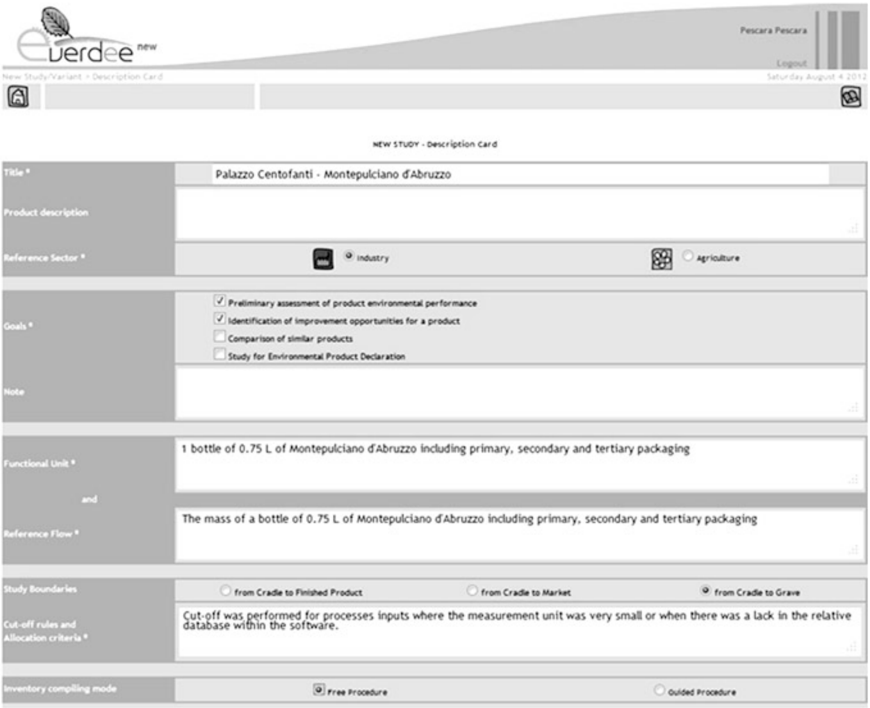

Fig. 7.5 Screenshot of the filled-in first page of eVerdEE online tool

7.3.2 Life Cycle Inventory

The implementation of the tool then requires the data to be filled in directly online, providing its own database to complement on-site data, according to separate life-cycle phases and categories, such as:

- *Pre-manufacture*: here the categories "Materials and semi-finished products" and "Components" are included;
- *Manufacture*, which comprises: auxiliary materials, energy consumption, airborne emissions, waterborne emissions, waste, transport between manufacturing plants, and external manufacturing processes;
- *Product packaging*, which consists of: packaging materials, and waste from packaging;
- *Product distribution*, which includes: transport and energy consumption.

For all entries, users are asked to specify whether the process entered is the actual or a similar one. Moreover, for each entry they are asked to indicate whether the value entered is accurate or not. All this information, which provides indications about the data quality, will support the interpretation of results. Inputs in eVerdEE need to be entered per functional unit; therefore in this case for one

0.75 L bottle of *Montepulciano d'Abruzzo*. As a consequence, all the calculations needed to refer the available data to the single functional unit have to be preliminarily carried out off-line.

For this study, as described before, the agricultural phase was considered separately as a model and then saved as a component within the software. Then, the wine-making one was considered as a separate model that included the agricultural model as a component within the pre-manufacturing category. The model of the wine-making phase (where the "industry" option was selected) also included the phases of packaging and distribution, which were considered within their homonymous categories.

7.3.2.1 Model of the Agricultural Phase

In this model, the process inputs related to the agricultural phase were entered. For example, the cement poles used for the vineyard were inserted under the entry "materials and semi-finished products", while other entries, such as pesticides, fertilisers, water consumption, tying string, etc., were placed under "materials" within the "cultivation" entry. It has to be noted, however, that even if there were numerous pesticides to be selected from the eVerdEE database, a generic entry "pesticides" was used instead of entering the specific substances themselves, due to lack of data. Furthermore, the fact that the pesticides entries are not currently connected to environmental impacts, and therefore do not demonstrate the impact of their use in the agricultural phase, can be regarded as a limitation of the tool. So far, they are used only as a means of complementing the inventory of the study.

The emissions from the agricultural phase, both waterborne and airborne, as calculated for the case of SimaPro and using the EcoInvent manuals, were also entered in this stage. Nevertheless, the eVerdEE database was lacked data regarding emissions to the soil and they were therefore neglected. In addition, CO_2 emissions related to the combustion of the diesel fuel used for the agricultural treatments were calculated by the authors and inserted in the tool.

Finally, eVerdEE categorises waste into hazardous and non-hazardous, and then, for each sub-category, into disposed and recovered waste. Here, waste from the agricultural phase was included, mainly considering the empty containers of pesticides and fertilisers.

7.3.2.2 Model of the Wine-Making Phase

Here, in the "pre-manufacture" stage, the agricultural model (see Sect. 7.3.2.1) was included as a component.

In the "manufacture" stage and as far as the "energy consumption" is concerned, all consumption related to the electricity was taken into consideration. The electricity refers to the power consumption of machinery during the wine-making phase (pumps, filters, bottling equipment, etc.).

Furthermore, the transport of 1 km from the vineyard to the wine-making facilities was taken into consideration here and since data for tractors were missing from the database, those for trucks were used instead (also throughout the entire study).

In the packaging category, all materials used (glass for the bottle, paper for the label, PE for the heat-shrink capsule, corrugated cardboard for the boxes, PVC for the wrapping film and wood for the pallets) were entered. It has to be highlighted here that the cork was neglected due to lack in the database of the relevant entry, and that for the materials, similar processes were used.

The same overall amount of materials referred to the end-of-life packaging was entered as non-hazardous waste from packaging, partially to be disposed of and partially to be recovered.

For the distribution, the mass travelling for each destination was calculated as a percentage of the functional unit (FU), since the percentages for the sales in Lazio (Rome), Piedmont (Turin) and locally (in Abruzzo) were known, and since—as stated before—calculations need to be performed per functional unit. For instance, only 10 % of the product is sold to the region of Piedmont; therefore the mass calculated was $0.1 \times$ FU. The distance that the product needs to travel was also inserted in a separate entry. It has to be noted here, however, that the mass was calculated per FU, but also included primary, secondary and tertiary packaging.

7.3.3 Life Cycle Impact Assessment and Interpretation

After all data had been entered, the software went on to calculate the characterisation (Fig. 7.6) and the normalisation results and produced tables. It has to be highlighted here that the impact assessment method used by eVerdEE is different both in terms of characterisation and normalisation, from ReCiPe (see Sect. 7.2.3). Though being well aware that using different impact assessment methods can be considered as a bias when relating the two implementations, the research team decided to keep this choice because one of their objectives was to assess the robustness and reliability of the simplified eVerdEE tool by parallelising its outcome to the results of a full LCA carried out by using a recent assessment method, such as ReCiPe.

As can be seen in Fig. 7.6, Pre-manufacturing (corresponding to the agricultural phase) seems to be by far the most responsible stage for the consumption of mineral resources ($\sim$93 %) as well as for eutrophication. As regards climate change, packaging and distribution appears to be highly impacting (74.5 %), and pre-manufacturing (corresponding to wine making) (22.8 %) to a lesser degree. Finally, regarding photochemical oxidation, consumption of non-renewable energy, consumption of biomass, ozone layer depletion and acidification, the packaging and distribution phase appear to be more impacting. As a result, it can be noted that eVerdEE declares the pre-manufacturing and packaging and distribution stages as more impacting than the others.

Indicator	Total	Pre-manufacture	Manufacture	Packaging and Distribution
Consumption of mineral resources (kg antimony eq)	100%	92.7%	0%	7.3%
Consumption of biomass (kg)	100%	< 0.1%	0%	100.0%
Consumption of fresh water (m^3)	100%	41.8%	44.0%	14.1%
Consumption of non-renewable energy (MJ)	100%	12.9%	2.7%	84.5%
Consumption of renewable energy (MJ)	100%	27.2%	6.3%	66.4%
Climate change (kg CO_2 eq)	100%	22.8%	2.8%	74.5%
Acidification (kg SO_2 eq)	100%	43.4%	4.5%	51.9%
Eutrophication (kg PO_4 eq)	100%	64.5%	0.6%	35.0%
Photochemical oxidation (kg ethylene eq)	100%	19.6%	4.2%	76.0%
Ozone layer depletion (kg)	100%	7.5%	1.5%	91.0%
Production of hazardous waste (kg)	100%	28.6%	0%	71.4%
Total waste production (kg)	100%	10.4%	0%	89.6%

Fig. 7.6 Screenshot of the characterisation results

The normalisation scores demonstrate that consumption of non-renewable energy has the highest score, followed by eutrophication and climate change. Acidification and consumption of renewable energy received relatively high scores as well.

7.4 Parallelism and Discussion of the Two LCA Tools' Implementation Results

After obtaining the results of both the LCA tools, an attempt to parallelise the results was made, in terms of methodologies, interfaces and outcomes (characterisation and normalisation results).

7.4.1 Interface and Methodology

As far as the interface and methodology for each tool are concerned, they appeared to be considerably different, which was clearly expected since the eVerdEE is a simplified tool.

In the "goal and scope definition", the same ones were defined in both LCA tools in order for the results obtained in the end to be as closely comparable as possible.

Regarding the "Life Cycle Inventory" it has to be highlighted that the data collection was obviously the same for both studies. The difference lies within the interfaces and the databases available for entering the data collected. In several cases, the inherent database of the simplified tool seemed to be inferior to the one of the full LCA, in terms of variety of data. In many cases, for example, similar processes or goods, and therefore inaccurate entries, had to be used. This increases the probability of errors resulting, depending on whether the similar process used refers to a significant one for the supply chain. Furthermore, for the full LCA 20 years of production were taken into account and averaged, which comprise three initial years (when the plants are planted and then grow without producing grapes) and 17 years of grape production. On the other hand, for eVerdEE only one specific year was taken into consideration, following the philosophy that since it is a simplified tool, it is addressed to users with limited available time and skills.

As far as user-friendliness is concerned, the full LCA required some basic knowledge of LCA methodology in order to structure and design the different phases of the life cycle of wine, as well as an adequate knowledge of the specific software tool. The simplified tool, instead, appeared to be friendlier as it was already structured for different phases. In this study, for instance, the different phases identified for wine production were attributed to the ones already existing within the online software.

Finally the limitation of the software, which, as described in the beginning of this Section, does not allow for modelling an agro-industrial product (such as wine), must be highlighted. Such a product cannot be included entirely either in the "industry" option or in the "agriculture" option. This resulted in using the industry option in order to include both the wine-making phase and that of agriculture as a component within the wine-making phase.

7.4.2 Outcomes

The characterisation results of the two LCA tools showed several similarities but also some obvious differences. It has to be noted, however, that the same impact categories were not taken into consideration by both tools, since different methods were used for each of them (see Sect. 7.3.3).

For agriculture and wine making:

- The full LCA resulted in terrestrial ecotoxicity, metal depletion, agricultural land occupation, freshwater ecotoxicity and marine ecotoxicity being more affected;
- The simplified tool demonstrated that the categories affected were: eutrophication, consumption of mineral resources and of fresh water (mainly in the agricultural phase).

For the packaging and distribution phases:

- The full LCA showed that natural land transformation, ozone depletion, ionising radiation and, to a lesser extent, climate change, urban land occupation and photochemical oxidation (for the phase of packaging) were more affected. The phase of distribution gave the minimum contribution to the impact categories;
- On the other hand, the simplified tool demonstrated that climate change, consumption of biomass, photochemical oxidation, consumption of non-renewable energy and acidification received higher scores for the stages of distribution and packaging.

The normalisation results showed that the impacts with the highest score were fossil depletion and climate change (according to the full LCA) and, similarly, the consumption of non-renewable energy, eutrophication and climate change (for the simplified LCA).

All in all, both tools declare fossil depletion and climate change as the impacts with the highest normalised scores. Nevertheless, no safe considerations can be obviously drawn with regard to which phase is, overall, the most impacting one, as different stages contributed differently to the various impact categories.

After evaluating in parallel the results of the two LCA methodologies, an attempt was made to identify whether the various predefined criteria were actually met or not by the simplified LCA tool:

- *ISO compliance*: The simplified LCA tool (eVerdEE) was found to be compliant to the ISO 14040 standards series, as stated also by Masoni et al. (2004). This means that the general structure, proposed by the relevant ISO standard, was followed. Indeed, as described in Sect. 7.3.1, the goal of the study needs to be entered into the online tool, along with the functional unit, reference flow, system boundaries etc. Furthermore, the tool follows the standardised phases of an LCA, in terms of LCI (see Sect. 7.3.2), LCIA and interpretation (see Sect. 7.3.3), as well.
- *Broad focus*: The tool, as described in Sect. 7.3.3, takes into consideration a fair number of impact categories, namely consumption of mineral resources, consumption of biomass, consumption of fresh water, consumption of non-renewable energy, consumption of renewable energy, climate change, acidification, eutrophication, photochemical oxidation, ozone layer depletion, production of hazardous waste, and total waste production. This demonstrates that the tool has quite a broad focus, in contrast with other ones, such as Carbon Footprint or Water Footprint, which just focus on a single specific environmental issue.
- *User-friendly interface*: eVerdEE was found to be quite a user-friendly tool, as it was designed to be so (Masoni et al. 2004). Normally, a person with no LCA knowledge should be in a position to fill in the necessary entries, as the data required are generally well known. The user is asked to include data such as mass of products used; distance that they travel and waste that is produced. Nevertheless, the need to enter emissions data for several of the processes cannot always be regarded as an easy and straightforward task. For instance, in this study, the emissions from the use of pesticides during the agricultural phase were calculated using the EcoInvent manuals that were present in the SimaPro software. Otherwise, a research to identify such emissions would have been necessary. This means that for an SME employee it would have been rather difficult to come up with such data. On the other hand, the tool is provided with an option of technical guidance, which appears on every page under the icon of an open book. This can guide a non-expert user throughout the completing of the forms. Finally, in this software, once the user has inserted the initial entries required in the first page (see Sect. 7.3.1) and then moved on, it is impossible to actually return to change them. The only alternative is to create another model from scratch. This is quite an important limitation when it comes to the user friendliness of the tool.
- *Limited data requirement or adaptability to existing databases*: The databases of the simplified LCA tool were not always found to be sufficient to include a process or material. Especially when it comes to the pesticides, it has to be highlighted that the fact that no connection exists between the entries and the environmental impacts is considered a limitation for the tool (see Sect. 7.3.2.1). This limitation can obviously become more important when comparing two products, one of which uses a higher amount of (more toxic) pesticides than the other, e.g., conventional *versus* organic wine. The beta version used already contains the ELCD databases, with about 300 datasets on the most common material, processes and energy sources, in addition to some sector specific

datasets (Buttol et al. 2011; Scalbi S, 2012, Italian national agency for new technologies, energy and sustainable economic development (ENEA), Italy, "Personal communication"). However, a larger number of data may be needed, even when conducting a simplified study.

- *Relevance to life cycle steps identified in the LCA review*: eVerdEE was found to provide the option for selecting "industry" or "agriculture" in the very beginning of the information input, thus providing users with the possibility to "specialise" their study. In the literature review carried out in the framework of this study, agriculture was generally found to be more impacting than other life cycle phases (see Sect. 5.2.2.7). In principle, this tool seems to be meeting the need to focus on the most relevant life-cycle step identified. However, in this specific case study concerning wine, this tool was not in a position to control the agricultural and agri-industrial phases well due to its limitation of not including agri-industrial processes in the option for "agriculture" and thus obliging the research team to apply the option "industry". As described before, the agricultural phase had to be included as a component within the wine-making model, a task that most likely would not be very easy for a non-expert user. This can be regarded as an important issue when it comes to improving the simplified tool. As described in Sect. 7.3.3, after implementing the simplified LCA tool, the agricultural phase appeared to be far more responsible for the consumption of mineral resources, eutrophication, and for the consumption of fresh water. However, for many other impacts (e.g., acidification, photochemical oxidant, consumption of biomass, etc.) not agriculture, but packaging and distribution, was the most impacting stage. As far as the results of the full LCA are concerned, the phase of agriculture seems to mainly affect terrestrial ecotoxicity, metal depletion, agricultural land occupation, freshwater ecotoxicity and marine ecotoxicity (see Sect. 7.2.3). Nevertheless, there are other impacts, such as natural land transformation, ozone depletion, ionising radiation and climate change, which are mostly affected by the packaging stage. All in all, the full LCA demonstrated that the agricultural and wine-making phases are more impacting.
- *Ease of integration with EPD, POEMS and/or other communication tools*: The interface of the simplified LCA tool clearly allows for an Environmental Product Declaration (EPD) to be created directly. It has to be noted though that the first page that appears allows just the use of "cut flowers" and "flowers in vase" Product Category Rules (PCRs)—since this was a pilot project of ENEA (Porta et al. 2008).

7.4.3 Some General Considerations

The tool application demonstrated that performing a simplified LCA may require limited time and resources. Furthermore, simplified tools have clear and easy to understand calculation and visualisation methods and are considered to be suitable for effective communication of the environmental performance of products and services. Moreover, simplified LCA tools normally offer user friendliness, along with a Life Cycle Thinking orientation. When it comes to opportunities that can make such tools more easily adopted, these could include a proactive approach as regards the strategic management of the environmental variable, a sensitivity of the management to environmental issues and an interest for eco-labelling initiatives on the side of the market (Salomone et al. 2012).

On the other hand, such tools are characterised by their difficulty in incorporating the methodological differences across firms and sectors. Moreover, a reduced scope and an increased subjectivity are issues that can be considered as weaknesses of simplified LCA tools. As far as external threats are concerned, they are mostly connected to a general lack of environmental awareness by the firms combined with a central focus on short-term problems, mainly due to market pressure. In addition, the fact that as a general rule environmental management tools are not perceived as an opportunity for SMEs, has to be taken into consideration (Masoni et al. 2001). In parallel, a tendency for lack of time and/or willingness of the technical staff and the management for data collection was identified. Finally, the fact that environmental issues are often perceived as constraints and a source of additional and often unknown (or hidden) costs should also be noted (Masoni et al. 2004).

7.5 Conclusions

In this Chapter a case study was described after carrying out a data collection in the framework of a small Italian family managed winery. The study comprised the implementation of a full and a simplified LCA tool, as identified for this sector (see Chap. 6). For the purposes of the implementation, the functional unit was chosen to be the same for both cases, i.e., a 0.75 L bottle of organic *Montepulciano d'Abruzzo* red wine, including its primary packaging (bottle of green glass, heat-shrink capsule, cork and label), its secondary packaging (corrugated cardboard box) and its tertiary packaging (wooden pallet and plastic film). The results were then evaluated in parallel in order for the robustness and the reliability of the selected simplified tool to be evaluated.

It was found that both tools showed fossil depletion and climate change as the impacts with the highest normalised scores. Nevertheless, no safe considerations could be drawn with regard to which phase contributed more, as different stages contributed differently to the various impact categories.

Furthermore, an attempt was made to check whether the selected simplified tool actually met the predefined criteria for tool selection (see Chap. 6). This attempt showed that in general the criteria were met or partially met.

Finally, some general considerations regarding strengths and weaknesses of the implementation of simplified LCAs in SMEs were outlined, especially as regards data collection.

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Part IV
Environmental Labels and Declarations

Chapter 8
Environmental Labels and Declarations in the Agri-Food Sector

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8.1 Introduction

Environmental protection is currently one of the main issues both nationally and internationally discussed in social and political debates. It has stimulated the European Union (EU) to look for new strategies and instruments to be applied in environmental management which allows the operators of the economic system to manage the environmental variable in an efficient and proactive way (Andreis and Cusinato 2009). The preventive measures adopted against the negative impacts of production on the environment, obviously in line with the strategy of sustainable development, are treated by EU policies as an innovative approach which can change the paradigm whereby different strategic priorities can be defined and implemented. The forerunners who conceived these policies have helped make a better use of natural resources under all aspects, and they have also met the expectations of consumers who are more and more sensitive to environmental problems steering their purchases towards the sustainability of the products and of the companies which produce and trade in them.

For this reason, since 2001 European governments have embarked on an interesting initiative to promote strategies which strengthen and orient environmental policies towards the development of a market of more ecological products. The aim of this strategy, inspired by the Integrated Product Policies (IPPs), was the accomplishment of different environmental policies in order to reduce

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environmental impacts linked to the life cycle of the products (goods/services) (European Commission 2001a; European Commission 2003).

The capability of involving economic, institutional and social subjects is one of the most innovative and interesting aspects of the IPPs because, thanks to the use of the product as the centre of the analysis, all the environmental aspects associated with design, production, consumption and final disposal of the product can be taken into consideration.

Through the IPPs, all the forces operating in the market rally to protect the environment. As a matter of fact, from the supply point of view, companies are stimulated to develop products with a lower environmental impact in all the phases of their life cycle while, from the demand point of view, consumers tend to make a positive use of the advice and information given and thus become fully aware of the choices they have to make.

As a consequence, a new European strategy, termed Sustainable Production and Consumption (SPC), has been planned. It was launched by a Commission Communication on June 18th 2003 and it has been identified as one of the EU priorities for the next ten years: in this case the IPPs have played the major role.

This strategy has strengthened and improved the EU action in the field of environmental policies aimed at preventing, managing and improving the impacts of the life cycle of products. In 2008, with the publication of the "Policy of Sustainable Consumption and Production and of Sustainable Industrial Production", the actions necessary to influence the present models of production and consumption were also defined (European Commission 2008).

This strategy completed the policies on energy consumption, in particular the energy and climate packages adopted by the Commission in the same year which contained, among others, also:

- the GPP communication (Green Public Procurement), COM 2008/400 "Public procurement for a better environment";
- the revision proofs of the EMAS and ECOLABEL standard;
- the proposal of extending the directive to the ecological design of the products.

Trying to become more eco-efficient, the EU lines of action within the SPC were based on innovative instruments able to develop the capability of producers and consumers to make "sustainable" choices and to influence each other (SETAC 1993). These instruments refer to the Life Cycle Assessment (LCA), one of the most important tools for the IPPs implementation and the main operative instrument of the "Life Cycle Thinking" (LCT) (Del Borghi et al. 2007); such instruments, for example, figure in the so-called environmental labels/voluntary declarations (Baldo et al. 2005).

In these last years the labels and environmental communications (Forbes et al. 2009; Houe and Grabot 2009; Limnios et al. 2009) have received a great deal of attention in the international scene in order to implement a policy which, starting from the idea that awareness of environmental problems leads to a behavioural change of stakeholders, can encourage producers to improve the environmental performance of their products thus stimulating consumers to give up their habit of making purchases.

The aim of environmental labels is two-fold: firstly, environmental labels will be a marketing incentive regarding consumers because, being given clear information on the environmental impacts of a product, consumers will be urged to purchase consciously; moreover, labels will be an incentive for producers who can point out the better environmental performance of their products in comparison with competing products which are lacking in information thus obtaining a competitive advantage. Therefore, environmental labels are really important in orientating the demand towards goods and services with a low environmental impact. By encouraging producers to improve their environmental performance, they are also an asset for the companies which have chosen a "virtuous" way of production. Consequently, the adoption of environmental labels triggers a virtuous relationship between the consumer and the production chain whose environmental advantages benefit the entire production-consumption chain.

In order to reach this aim it is necessary that any environmental label should be believable, giving the consumer full information. As a consequence the information which lies at the bottom of any labelling system has to be weighted to be easily understood by the final customers. In relation to this last aspect some labels, defined mono-criterion, give information just about one impact, while others, defined as multi-criteria, give information about several impacts.

The voluntary environmental labelling experience began in Europe at the beginning of the '80s. Initially it was a marketing instrument but then it started acquiring wider connotations till it became a real programme which had to be followed and improved by EU environmental policies.

At the beginning these labels were simple self-certifications used by companies to describe some of the environmental eco-compatibility characteristics of their products, or certifications issued by private bodies specifying the single ecological characteristics of a product.

In order to reduce the unchecked diffusion of vague indications and so rather unclear labels, some countries started adopting some eco-labelling national programes with a voluntary participation.

These labelling systems were based on a strict evaluation of environmental impacts of the productive processes and on the control of the reliability of the given declarations, guaranteeing the right information and, above all, giving great importance to the enterprises in terms of improvement of the eco-efficiency of their processes and/or of their product performances.

Given the presence of different national systems of environmental labelling and in order to bring into line the methodologies to be adopted, the International Organisation for Standardisation (ISO) has elaborated and issued the ISO 14020 standard: the general conditions for the use of environmental indications, labels, logos and declarations were defined. Following the ISO, the aim of these labels/declarations is "to encourage the supply and the demand of those products and services able to cause lower damage to the environment stimulating a process of continuous environmental improvement guided by the market" (ISO 2002a).

The aim of this standard was both to encourage the request and the supply of the products which have a low impact on the environment and also to create at least some categories of clear self-explanatory environmental labels, which referred to common standards: the LCA methodology. In order to be efficient political instruments, these labels had to be based on clear and public standards and they had to point out significant environmental differences between the products with the labels and those without them.

Starting from the principles stated by the above-mentioned standard, the ISO has identified and regulated three types of labels/environmental declarations: Type I, II and III; there is another category which has not been regulated by the ISOs and which has been defined as "environmental labels of type IV"(Defra 2010). The environmental quality trademark is generally represented by a legally protected image: the logo which represents it (Fig. 8.1) attests that the product to which it has been assigned, meets predefined environmental criteria.

Below the general principles on which the four categories of labels are based have been outlined; in Sect. 8.2 there is a critical review of the most significant literature about environmental labels, referring in particular to food products; the aim is to investigate the role that environmental labels have played in the behaviour of consumers and of producers.

- The Type I, ISO 14024:2001 (ISO 2001) labels are based on environmental excellence criteria, single or multiple, proposed and developed by a third body following a pattern of multicriteria evaluation for different products or similar groups of products and for which a similar environmental impact is foreseen.

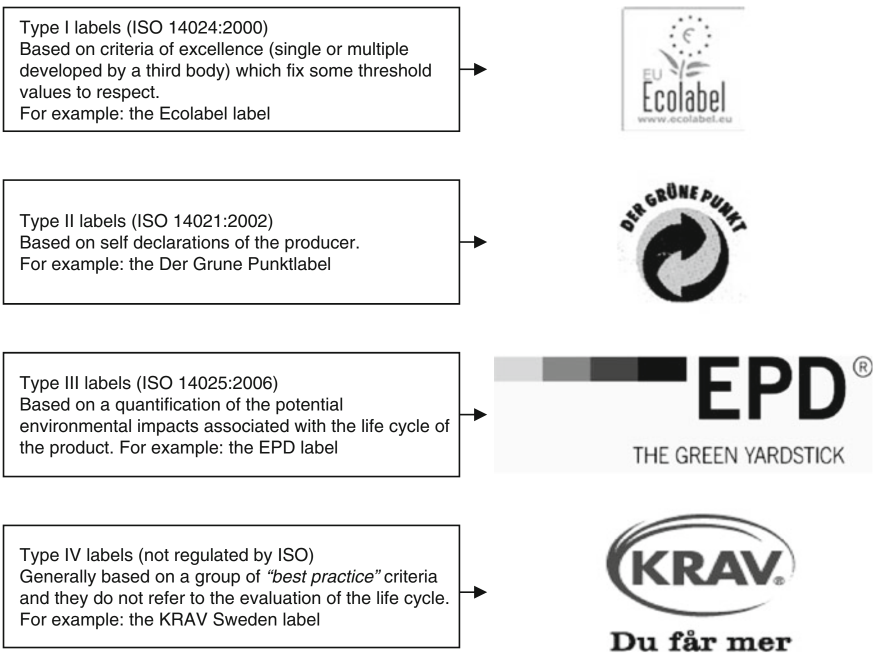

Fig. 8.1 Logo of different labels types

Following an LCA approach, the analysis has pointed out the most significant impacts of products, from the extraction of raw materials, production, transport, to the selling and final disposal. In general, the criteria try to encourage the reduction of impacts on natural habitats and associated resources, the reduction of pollutants in the environment and the reduction of the use of dangerous substances. The criteria also specify the characteristics of the information to give the consumer in order to ensure an efficient use of the product. In order to obtain the issue of the trademark the products have to respect the environmental impact threshold values fixed by the previous criteria. Type I labels are the Scandinavian White Swan (Miljömärkt) (OECD 1997), the German Blue Angel (Der Blaue Engel) (OECD 1997) and Ecolabel, a trademark of ecological quality introduced by the European Union at the beginning of the '90s and which is certainly the most common among type I labels (European Commission 1992).

- The labels of Type II, ISO 14021:2002 (ISO 2002b), are not verified by a third body and they include all the "self-declared environmental statements", that is the declarations, labels and symbols referring to the environment on the packages of the products, on the packaging or in the advertisements, used by the same producers as an instrument of environmental information (Proto et al. 2005). A certification from a third body is not necessary; therefore, for this type of labelling, the reliability guarantee is a very important aspect. As a matter of fact, for the producer ISO 14021 entails both respecting all the requisites conceived to ensure the reliability of the information transmitted to the buyer, and the guarantee of avoiding falling into any unexpected negative effects of the market as a result of an indictment of unfair competition due to deceiving statements. For this reason, the standard excludes the possibility of using generic expressions such as "friendly to the environment", "green" or "non polluting". On the contrary, it outlines the requisites for certain expressions such as "without…": it can be used only if an analytical laboratory verifies that the level of the specified substance is really lower than the substance detected as the bottom level or as the pollutant (Sibilio 2008). The standard also uses symbols without defining a specific icon, except for the one largely used and connected with the percentage of the recycled material in a product and represented by the Mobius Cycle (Beltramo et al. 2004).
- Type III, ISO 14025 (ISO 2006a) labels are based on LCA, like Type I labels, and they consist of a quantified declaration of potential environmental impacts. This type of labels does not determine threshold values of environmental impacts, but measures the environmental performances of the products using real data such as the quantity of emissions, leaving the related considerations to the consumers. Among the labels of type III, the Environmental Product Declaration (EPD) is arousing internationally a great interest. It is regulated by ISO 14025, was approved just in 2006 and has been applied to different programmes and assigned to hundreds of products; this confirms the extent to which the production community is interested in the Environmental Declarations which involve all the participants along the entire productive chain. It is of great importance because it is applied to all sectors, such as agriculture and food, and

is considered, among the voluntary management instruments, as an innovation able to communicate in a credible way the main characteristics and environmental impacts of a product/service, increasing its visibility and social acceptability. The label Earthsure, which is at an experimental stage in the USA, and the Carbon Reduction Label, which measures and determines the total of greenhouse gas emissions, belong to this group.

- The labels of Type IV are environmental trademarks, not regulated by ISOs and defined by several researchers as "environmental trademarks of type IV". As previously mentioned, they are absolutely voluntary trademarks, which exceed the definition of ISO labels of Type II, submitted to an independent check by a third body but their approach is not based on the evaluation of the life cycle or on real measurements. Generally, these labels are based on "best practice" criteria or on standards which are used to distinguish the product from the traditional ones according to the body which issues the label. Some examples of this kind of label are the trademarks Forest Stewardship Council, Dolphin safe and Fairtrade Global.

8.2 Environmental Labels and Declarations in the Agri-Food Sector: State-of-Art and Literature Review

Environmental labels and communications, as already said, are internationally and widely used to implement a policy which, starting from the awareness of environmental problems leads to a behavioural change of the partners, encouraging producers to improve the environmental performances of their products and stimulating consumers to change their buying habits.

As reported in the previous paragraph, the voluntary labelling system is really diversified and it makes it particularly difficult and complex for the operators to choose the most effective type of label to transmit the values of their environmental commitments. Consequently, companies have to choose a labelling system which suits the specific characteristics of their product and the distinctive features of their sector.

This is particularly important in some productive contexts like the agri-food sector, where the characteristics of the products depend on the interactions among different subsystems of the productive chain, from farming to transformation processes and marketing, which bring about some impacts in water, air and soil (Girardin et al. 2000).

In the European Union the environmental impacts due to the production and the transformation of foods, feeds and drinks make up between 20 and 30 % of the total environmental impacts produced by non-durable goods; in case of eutrophication they represent 58 % of the total impacts (Oakdene Hollins Research and Consulting 2011). As regards the consumption of resources, agricultural activities consume and use materials and energy as any other process of production; for example it is the sector with the highest consumption of water (70 % Agriculture; 22 % Industry; 8 % Civilian). A noteworthy fact is that public opinion is now more aware of the risks linked to the presence of environmental pollutants in foods. Therefore, consumers ask for safer products and this generates new opportunities for the market, new niches which draw the attention of a larger number of producers. Working and guaranteeing safe products means taking care of and respecting the environment, reducing the environmental impact, enhancing the sustainability of the productive process and preserving biodiversity and the ecosystem balance.

The organisations belonging to the agri-food sector have to be able to manage the environmental risks connected with their activities in order to remain always competitive, to protect their own reputation and to increase the value of their trademark. Moreover, for many of the agri-food companies which export their products in the international market, where customers and consumers are more senstive to environmental problems, the sustainability of the products is the key factor to their success and labels and the product declarations are the best marketing instruments since they give consumers all the necessary information regarding eco-sustainability values.

Since the first aim of environmental labels is to give the consumers clear information about the environmental impact of a product in order for them to opt for a more conscious purchase, labels have to be clear, readable and they should be integrated with health information (White et al. 2009). They should also help consumers to make a comparison between similar products, to reflect the different impact levels, to be validated by independent checkers/verifiers and, above all, they have to be clear and impartial about the entire productive process using some product "criteria" equal for any specific sector. Regarding this last point and considering, in particular, the distinctive features of the foods, some concern has been expressed about the difficulties defining unambiguous and reliable criteria regarding environmental impacts for the entire productive chain (Morris 1997; Zarrilli et al. 1997). For the same reason, after a careful revision, the Ecolabel trademark has not yet been extended to foods (Oakdene Hollins Research and Consulting 2011).

In the agri-food sector labelling systems are really proliferating both within the labels regulated by the ISO and those in force outside these standards. For this reason, efforts are being made to conciliate and standardise some environmental quality trademarks also in order to reduce the confusion both of the industry and of the consumers.

Given all the available labels and the remarkable relative literature, foremost consideration should be given to the state-of-the-art of the labelling schemes which can be used for the environmental information about agri-food products; subsequently a critical analysis of the scientific literature can be carried out.

8.2.1 State-of-the-Art of Environmental Labels and Declarations in the Agri-Food Sector

Although interest in environmental labels has increased worldwide, the number of useful ISO- regulated systems in the agri- food sector is not so high. Most of the labelling and communications indeed belong to type IV.

This probably depends on a set of factors including the characteristics of the foods and of the production systems and the complexity of pointing out and quantify clearly the environmental impacts of the entire productive chain.

Some of the labelling and environmental communications systems which can be used to transmit the environmental values of agri-food products are reported and analysed below. The selected schemes are treated following the classification reported in Sect. 8.1: Types I, II, III and IV. The Ecolabel scheme has not been taken into account because this label has not been extended to foods.

8.2.1.1 Type I Labels

In this kind of label, only one type is suitable for the agri-food sector: Ukraine Living Planet (Global Ecolabelling Network 2012). It is a non-governmental trademark of environmental quality for foods and other products, implemented in 2003 on the initiative of the "Living Planet", supported by the Committee of Verkhovna Rada (Ukraine Parliament) of Ukraine. Its implementation has been done following the eco-labelling programme for the environmental labels of type I, which means that it conforms to the ISO 14024 international standard. The ecological criteria of the products have been elaborated by the subcommittee "Life Cycle Assessment" which is an integral part of the National Technical Committee of Standardisation "Natural Environmental Protection of Ukraine" (TC 82).

8.2.1.2 Type II Labels

- Casino Carbon Index (CCI)
  It is a mono-criterion scheme of environmental labelling based on the LCA approach and developed by a French multinational company, CASINO Group, in order to give indications to consumers about the environmental performance of the products traded by the Group. Its trademark is a green leaf drawn on the front of the package; it clearly indicates the quantity of greenhouse gas emitted per 100 g of product and it also gives information about the recyclability of the package.
  At the moment this way of labelling has a low direct impact on consumer choices because the global economic conditions have worsened and it is the price which really influences purchases; however, in the future, consumer decisions will be more sensitive to environmental issues (Packaging-gateway 2011).

- "Environmental Label"

  The Environmental Label (Etichetta ambientale 2011) is a new model of environmental communication about the product, carried out in Italy in 2012.

  It is a multi- criteria label, based on the LCA approach and developed by the Environment Platform for Convenience Goods–PAB, created thanks to the collaboration between the communication experts from SPRIM, an international Society of Strategic Consulting which works in the area of Human and Environmental health, and the researchers of the Institute of Agricultural Chemistry of the University Cattolica del Sacro Cuore of Piacenza.

  It was set up following the indications given by ISO 14040 (ISO 2006b), 14044:2006 (ISO 2006c) and ISO 14021:2002 (ISO 2002a), the French guide lines AFNOR-ADEME and the Report Communicating environmental performance along the food chain (European Food Sustainable Council and Production Round Table 2012).

  In order to simplify environmental communication, the label shows a "global index" of the impact of the product along with another three sub-indicators which highlight the impact on the water, air and soil ecosystems, and it is expressed as a percentage figure compared to the average daily impact on a European citizen (European school for a living planet 2011). The global index which gives endpoint information has been calculated by aggregating—a with three different weights—the three macro-indicators water, air and soil which have been respectively obtained aggregating 18 ReCiPe indicators 2008 (Goedkoop et al. 2009).

  As far as food is concerned, the functional unit used for the LCA study is the daily portion of food recommended by the National Institute for Nutrition. It deals with day-to-day consumption and it gives a simple and fast result to the consumer who can have some difficulties understanding the absolute results expressed by often incomprehensible units of measurement.

  The label applied directly on the package of convenience goods helps consumers to be immediately aware of the environmental impact of the bought products thanks not only to the scale which indicates the total "environmental cost" but also to the three indicators for the single elements: air, water, soil.

- Genetech Free

  It's a mono-criterion label introduced in 2009 by the German Ministry of Agriculture and it is used by firms to communicate to consumers that the product does not contain Genetically Modified Organism (International service for the acquisition of agri-biotech application 2012). Nowadays it is principally used to distinguish the foods, such as meat or milk, obtained from animals which were never fed with animal feed produced by OGM plants (GMO compass 2012); it has been used for a dairy product distributed by Campina Company and by small producers. Lewis and other authors (Lewis et al. 2010) underlined that the wording "without gene technology" is not really precise, because this label is allowed to be used also for foods of animal origin which contain vitamins, enzymes or additives obtained using genetic engineering techniques.

8.2.1.3 Type III Labels

- Environmental Product Declaration (EPD)
  At the present time, environmental declarations and in particular the ones belonging to Type III, Environmental Product Declaration EPD Fig. 8.1, are brief documents which indicate the "environmental profile" of a product/service and which give objective, comparable and believable information, without specifying assessment criteria, preferability or minimum levels to be respected. Credibility is granted by the LCA methodology, while comparability is based on the elaboration of specific and common requisites for each type of product (RINA 2006).
  The European Commission is carefully following the development of this instrument within the strategies of "sustainable production and consumption", both for its clear interconnections with Ecolabel and for the capacity of spreading green information among European consumers (Baldo et al. 2005) and also because unlike Ecolabel, it can be applied to the agricultural food chain.
  The standards which determine the EPD modes are:

  – using the analysis of the life cycle (LCA), in line with the standard of the ISO 14040:2006 set (ISO 2006a);
  – applicability to all products and services, regardless of their position inside the productive chain;
  – verifications done by an independent and accredited body.
    It has to be underlined that the EPD contents are meant just for information: the final aim, in fact, is to improve the environmental communication among producers, on the one hand, and distributors and consumers on the other, allowing them to make a comparison between the products and the services which are basically equivalent. The EPD is addressed in particular to the professional purchaser, so the environmental information is intended to flow along the whole production line.
    Even if the EPD system seems to be a technical instrument, it is a dynamic communication method able to follow the development of the products in the national and international markets; it should be used as a support for product policies and it should make up for the lack of Ecolabel in the sector of certain durable goods and of agricultural and food products (Del Borghi et al. 2007).
    In the last decades, some agencies which operate internationally have arranged some schemes for the certification and registration of EPD. In Europe, since 1998, the most active scheme has been implemented by the Swedish Environmental Management Council (SEMCo), today known as the International EPD Consortium (IEC). Simply known as "EPD system", it is a voluntary scheme for product certification and it is based on the indications written in the international standard 14025:2006 and in the Swedish one MSR 1999:2 which was substituted in 2008 by the new "General Programme Instructions for EPD". After a period of transition and the test of the European Community, in 2003, this system has obtained a full supranational value and it has been managed by an international panel: the network, the Global Type III Environmental Product

Declaration Network (GEDnet) which also promotes information about this theme all over the world.
With the passing of time, the EPD system has been reviewed. On the whole, following the revision of 2007, the changes have made the trademark consistent with the indications of the new ISO 14025:2006 (ISO 2006a) standard encouraging both the diffusion of the label around the world and the harmonisation of the different existing environmental trademarks for the products. In particular, the main changes concern: the organisational and valuation structure of the system; the logo; the definition and identification of the product categories; the harmonisation and the consulting phase on an international level of the Product Category Rules (PCR) (Fieschi and Filareti 2008); the EPD contents; the subdivision of the internal and external documentary verifications and the opportunity to elaborate EPDs based on a unique impact category (Fieschi et al. 2008).
Regarding this last aspect, the EPD information has been sometimes critised as being too generic, because it covers all the relevant aspects of the environmental performance of a product; one of the innovations introduced in 2008, was a specific declaration named Climate Change or Climate Declaration, connected with the specific contribution which a product or an activity has given for climatic change; in particular, this declaration describes the greenhouse gas emissions during each phase of the life cycle of a product, expressed in mass of CO_2 eq,(carbon footprint) (Lo Giudice and Clasadonte 2010).
The EPD system is valid for foods and other goods and, apart from Sweden, the countries which are testing and encouraging this system are Italy, Japan, Switzerland and Spain. As far as food and beverages are concerned (mineral water, extra virgin olive oil, milk, beer, biscuits, pasta, crackers, toasted bread, etc.) in July, 2012 there were 45 registrations:16 are Swedish products while 29 are Italian products (Swedish Environmental Management Council 2012).
These last data point out that the Environmental Product Declaration is fully used for the environmental communication linked to agricultural and food products.

- Earthsure
It's a multi-criteria environmental labelling system which was developed in 2000 by the Institute for Environmental Research and Education (IERE) USA in order to guarantee environmental communication regarding products which respect the environment, to sensitise consumers and encourage them to buy these products and promote sustainable economy in the agri-food sector (Schenck 2008; Schenck 2009).
The Institute for Environmental Research and Education is a non-profit organisation, founded in 1997, and it is headquartered near Seattle, Washington; it is the professional society for LCA in the US.
The Earthsure labelling system started to be developed in 2000, following ISO TR 14025, and the eco-label (the Product Category Standard for meat production) has undergone a public process which has involved producers, consumers and interested parties (over 300 reviewers were engaged).

Earthsure is a declaration for a product based on LCA principles which fully conforms to the ISO 14025 of 2006 (ISO 2006a) Standard and it can be applied to all agri- industrial production systems covering the entire life cycle of the products (Earthsure 2009) from the farming to the selling. The Earthsure eco-label name was trademarked with the US Patent office in 2006.
The products certified by Earthsure are grouped into large categories while the criteria necessary for their certification are pointed out by a Committee which involves the delegates of the organisation which has asked for the certification, the suppliers, environmentalist ONG and consumers. The criteria are specific for each of the examined group of products and they include the evaluation of the most important environmental impacts on water, air and soil, pointed out through the complete analysis of the life cycle (LCA). Other important criteria are: the observance of laws and of the set of environmental standards and the presence of an environmental management system.
A careful evaluation is also done for the definition of the Product Category Rules (PCR) in order to fix precise standards to develop the LCA for the same category of products thus making it possible to compare the LCA and EPD studies based on the same PCR.

- CarbonNZero
  It's a mono-criterion environmental communication which can be obtained for foods and other goods (coffee, honey, travel, tourism, household goods, freight, etc.).
  The organisations certified by CarboNZero have requested the measurement of the greenhouse gas (GHG) emissions in the environment in order to quantify their impact on the global climate (Measurement and Reduction Scheme 2012).
  The CarboNZero programme was born in New Zealand and it has become the first greenhouse gas certification scheme which is internationally reliable and recognised by the International Accreditation Forum (IAF). International accreditation has been awarded by the Joint Accreditation System—Australia and New Zealand (JAS-ANZ), an international body established following a treaty drawn up by the governments of New Zealand and Australia.
  The certifications are issued following two independent steps: the ISO 14065:2007 (ISO 2007) specifies principles and requirements for the organisations which verify GHG emissions and the Cemars certification (CEMARS 2012) which is dedicated to the measurement and the management of greenhouse gas emissions; CEMARS points out and proposes plans for the reduction of greenhouse gas emissions issuing independent certifications for both actions.
  In order to obtain the CarboNZero certification organisations have to demonstrate that they have taken action in order to check greenhouse gas production, for example, by using renewable energy sources or by carrying out energy-efficiency rating projects or supporting reforestation.

- Carbon Reduction Label
  The Carbon Label Company was developed in 2007 by the Carbon Trust in partnership with the UK Department for the Environment, Food and Rural Affairs (Defra) and BSI British Standards (Carbon trust certification 2012).
  In 2009 the company became the Carbon Trust Footprinting Company whose aim was to provide fair and independent certification services, based on the measurement of the quantity of carbon and CO_2, contained in the products.
  The company supports the firms which have made a request to measure, reduce and inform about the life cycle of the greenhouse gas of their products and services including foods and beverages. The mono criterion issued label which clearly highlights the carbon mark, helps consumers to make more conscious choices oriented towards the reduction of carbon dioxide. It also informs consumers so that they can make a better use of the purchased products thus reducing their carbon mark.
  Carbon Trust has collaborated with the Department for Environmental Food and Rural Affairs, of the United Kingdom (Defra) in drawing up the PAS 2050 (BSI 2008) Standard which identifies in the ISO 14040 Standard the most effective and coherent instrument to determine the Life Cycle of greenhouse gas emissions of goods and services. Contemporaneously, the Code of Good Practice on GHG emissions and reductions claims (the Code) (Carbon Trust 2008), provides guidance on developing and making GHG emissions claims.
  The process to obtain the Carbon Reduction Label for a product is divided in different steps:

  – the entire chain involved in the realisation and supply of the product and its boundary thresholds are detected;
  – all the data connected with the entire chain are identified and collected, evaluating the carefulness and any cases of uncertainty;
  – with the help of a comprehensive toolkit a coherent carbon mark is built in conformity with PAS 2050 (BSI 2008);
  – then the certification which authorised the "Carbon Reduction" label is issued (PE International Sustainability Performance 2012).

- CarbonCounted
  The environmental CarbonCounted is a mono-criterion label and it has been proposed by the non-profit organisation CarbonCounted Carbon Footprint Solutions Canada; it can be issued for foods and other goods. (Carbon Counted 2012).
  Using a greenhouse gas stocktaking system based on PAS 2050 (BSI 2008), the company provides online consulting services for the firms which would like to calculate the carbon dioxide emissions related to the life cycle of their products; as a third party, the company also verifies the corporate data. Using the software, firms calculate the emissions and, following further verification, they can download and use the environmental label.
  According to Lewis et al. (2010) the methodology is not clear.

8.2.1.4 Other Labels

Even if Type IV Labels are considered as "environmental labels" because, indirectly, their adoption brings about environmental benefits, the main interest is often addressed to the biological quality of the foods, to the welfare of the animals, to fair trade, to the promotion of sustainable fishing, etc. Below is a report on a selection of the labels which are considered the most significant within this research.

- IFOAM Organic Production
  The International Federation of Organic Agricultural Movements' Standards is a global organisation, born in 1972, which develops, promotes and defends the principles of biological agriculture, facilitates its adoption and gives credence to all the worldwide organisms of biological certification (IFOAM 2009).
  The IFOAM crediting procedure is granted to the certification organisations which meet the criteria fixed by the IFOAM to guarantee fair trade in all countries. Certification by a third body is the formal procedure supported by documentary evidence which guarantees that the standards of biological production have been followed. Nowadays, some standards regarding biological production adhere to regulations fixed by over 60 governments and the foods sold as "biological" have to be produced following the European laws on the subject. These laws establish that these foods have to come from cultivators, workers and importers recognised by the organisations of biological certification, approved by IFOAM, or by a controlling body similar to the others present in the European Union.
  Biological production standards are based on a "best practice" set of criteria to differentiate the product from others coming from conventional agriculture. No evaluation of the life cycle is carried out to detect major environmental effects.

- Soil Association
  The Soil Association was set up in England in 1946 by a group of people concerned about the impacts that intensive agriculture might have on soil, foods, landscape, and so forth (Soil Association 2011). In 1967, the Soil Association drew up the first biological agriculture standards which were stricter than those established by national regulations, and in 1973 it elaborated the scheme for the related certification.
  Following this scheme primary production, foods, beverages, health and beauty products, textiles, ethical trade goods and so forth can be certified. The Standards cover all the aspects of biological product certification from production to packaging, the welfare of the animals, the preservation of wildlife and the ban on the use of food additives in transformed biological foods.
  The certification is issued by the Soil Association Certification Limited (SACL), an independent non-profit organisation affiliated to the Soil Association which also gives consulting services about all the aspects of biological certification. SACL is one of the ten bodies recognised in the United Kingdom which are authorised to issue biological certification.

Like other biological certification systems, the criteria used by the Soil Association to certificate agricultural products are not based on the evaluation of the impacts generated by the life cycle of the product but on best practice.

- Fair Trade Federation (FTF)
  The certification trademark "FairTrade Labelling" was born in 1988 on the initiative of Solidaridad, a Dutch development agency which promotes the sale of Mexican coffee produced without the exploitation of the pickers. In 1997, in Bonn—Germany, the International Fairtrade Labelling Organisations (FLO) was set up to join the initiatives of ethical labelling all over the world under a unique label, standardising the criteria and certification (Fairtrade labeling organisations international 2011). In 2009, the FLO along with the World Fair Trade Organisation adopted the Charter of Fair Trade Principles (Fairtrade labelling organisations international 2011) which became the only reference for fair trade.
  The Fairtrade system is presently managed both by the FLO, a non-profit organisation responsible for the strategic direction of fair trade and which establishes Fairtrade standards and supports producers, and the FLO-CERT, an independent certification society, which belongs to the FLO. The FLO-CERT inspects producers and traders to guarantee compliance with Fairtrade standards.
  Besides the international organisation, some national organisations are present in many countries and they work within the Fairtrade certification system; nowadays, in fact, worldwide there are 19 Fairtrade Labelling Initiatives which cover 23 countries in Europe, North America, Japan, Australia and New Zealand. Certifications concern foods, fibres and ornamental plants such as bananas, coffee, cocoa, cotton, flowers, fresh fruits, honey, fruit juices, sugar, tea and wine.
  From an environmental point of view, Fairtrade encourages eco-sustainable farm production and biological farming. Producers, in fact, have to protect the environment in which they live and work; they have to face the problems of soil erosion and of waste management; they have to follow national and international standards for the use of chemical products and they have to point out the impacts that their activities cause on the environment, and plan to reduce them and keep them under control.

- Stichting Milieukeur-SMK
  The SMK label is the Dutch State trademark for environmental quality which can be applied to foods and other products, and which was developed in 1992 by Stichting Milieukeuran, an independent organisation (CPI 2008; Liefferink 1996). The Eco-label Foundation (SMK), to which belong all the delegates of the parties concerned (environmental associations, consumers, industry and government officials) is the competent body which establishes the criteria for products and services. The criteria are developed for each of the products belonging to the same category.
  For agricultural and food products the criteria do not refer to precise environmental standards; they are based on the results of research studies which have

examined the entire productive chain and have pointed out the best agricultural practices. Generally, what is taken into account is the quality and quantity of fertilizers and pesticides which have been used, the watering techniques and the quantity of water and respect for the natural habitat; these data are updated on a yearly basis in order to take into consideration any new laws or the availability of new pesticides and/or of new technologies.

In the case of agricultural and food products, the environmental label SMK does not adopt the LCA approach; however, it provides a fair method to guarantee a good level of environmental quality given that the organisations which participate have to manage the productive cycle carefully and they have to satisfy a large number of criteria (Lewis et al. 2010).

With regard to non-food products, the environmental impacts of the single products/services are evaluated using the LCA approach; consequently, in this case, the SMK label is considered as a Type I label.

The certification is issued by certification bodies recognised by SMK and which conform to ISO 45011.

- Marine Stewardship Council (MSC)

  The Marine Stewardship Council is the communications label for sustainable fishing products. The MSC, an international non-profit independent body, based in the UK, was set up by the World Wide Fund for Nature (WWF) and Unilever to promote sustainable fishing. From 1997 to 1999 the MSC, in cooperation with a large group of interested international subjects, established and wrote a set of principles and of criteria to which all the companies and the organisations which want to obtain the certification and to use the logo have to refer (Deere 1999). The standard is based on fundamental principles such as the sustainability of the fish population, the minimisation of environmental impacts, the protection of ecosystems and the respect for local, national and international laws. The certification is issued by an independent third body, accredited by MSC and is subdivided in different phases in order to determine if fishing satisfies the MSC standard.

- Dolphin Friendly/Dolphin Safe/Salmon Safe

  These are eco-labels which can be used for foods, like tuna, which are produced using the techniques which protect dolphins and salmon (Sustainable Corporate Corporation 2001).

  "Dolphin Friendly/Dolphin Safe" promotes the protection of dolphins during the tuna fishing season; Salmon Safe certificates that the salmon comes from the drainage basins where the silt outflow of the farms, which is extremely toxic for these animals, is well controlled. Tuna fish with the label "Dolphin Friendly/Dolphin Safe" is sold in many countries all over the world; wine with the label "salmon-safe" is sold in America and is produced from vineyards which have adopted the controls on soil erosion to reduce the silt outflow.

8.2.2 Literature Review and Critical Analysis of Environmental Labels and Declarations in the Agri-Food Sector

Despite the fact that interest in environmental labelling of agri-food products is still lower than that in other productive sectors, in recent years it has certainly increased. This is demonstrated by the debate in the international scientific literature which tries to ascertain whether environmental concerns influence the attitude of consumers in their purchases and whether labels are an effective tool to induce real change both in consumers and in producers. Today, in fact, a great variety of environmental label schemes aim at guiding and promoting sustainable consumption. These product labels form part of a new environmental policy, which is market-based, consumer-driven, and jointly formulated and implemented by state and private associations. Environmental labels promote sustainability by giving the consumer information as to whether products meet or fail to meet certain environmental standards. However, especially in affluent societies, enabling the consumer to buy sustainable products by providing environmental labels is one important step towards increasing sustainability.

In order to analyse the effectiveness of this instrument of communication properly it is necessary to point out that its success is due to the activities of various subjects: producers/processors who should choose the appropriate label to communicate to the stakeholder their environmental commitment thus obtaining the right economic benefits; consumers who should be better informed about the value of the label to "re-push" the market towards eco-sustainable products; public and/or private bodies which should offer systems of stimulating, believable and effective visual communication based on instruments which measure the real improvements of the environmental performances of the product.

Many researchers have tried to study how "environmental labels and declarations in the agri-food sector" are perceived by producers and consumers and whether they influence their habits; above all, they have tried to highlight the points of strength and weakness of labels and declarations. A complete and comprehensive review on this subject nwas carried out by Defra (Defra 2010) within the "Effective approaches to environmental labelling of food products" project, and was published in November, 2010. The researchers who worked on the Report have examined more that 200 specialised scientific papers and more than 60 types of available labelling systems for foods and other products, analysing in detail: the scientific basis of the labelling; the effectiveness of its communication; the attitudes of the consumers and of the producers; they have also assessed the costs and benefits that the adoption of these systems require; the consequent environmental advantages.

In general, the literature review at first pointed out that the interest in environmental labelling was high worldwide, but it also remarked that the labelling dedicated to foods was limited, even if it was growing, and this was due to such factors as the peculiarity of the food products, the difference of the productive systems and the difficulties, especially for the multicriteria labels, in determining and communicating exactly the environmental impacts in the involved areas (air, soil, water, bio-diversity, landscape, non renewable resources, waste materials, etc.). Moreover most of the labels for agri-food products were based on best-practice; they did not quantify the impacts and as a consequence, they did not give information about the damages and/or the achieved environmental benefits.

From the survey carried out some significant information has emerged about the effectiveness of this instrument; to give a full picture of the analysis, reference is made below to the most important aspects relative to the relevant actors who are differently involved in the agri-food chain: the consumers and the producers.

With regard to the first ones the analysis of the literature has pointed out that there are several variables which influence the purchase of food products, because consumers are guided by some important factors such as: price, distribution, availability, promotion, health and security, social, moral, economic and cultural differences (Defra 2010).

In particular, in relation to environmental labels, from the surveys carried out in Europe, it has emerged that the labelling weight on the purchase decisions remarkably change from country to country and that the more sensitive subjects are the better educated people, young people and women.

As far as the relationship between food and the environment is concerned, it has been noticed that the environment is not considered fundamental, except for the more sensitive subjects who consider the health of foods, the welfare of the animals, waste management and recycling important (Defra 2010; Eurobarometer 2009; Goedkoop et al. 2009; White et al. 2009).

The research has pointed out that consumers, during their purchases, seldom read and correctly understand all the information available on an environmental label, so it is necessary for the communication to be simple and readable; from this point of view, multi-criteria labels should speed up the decisional process of the consumers, changing their mentality towards agri-food sustainability.

In order to increase the interest of the consumers in environmental labelling, it is necessary to start a marketing and educational campaign based on environmental awareness and which should guide the market towards eco-sustainable and labelled food products. In this context an important role should be played by the governments, producers and resellers who should operate to make it easier for the consumers to make their sustainable choices (Defra 2010).

Despite the fact that producers have not yet been discussed in detail, (Nilsson et al. 2004), research has pointed out that the environmental labelling of agri-food products is not widespread both because it is not easy to determine the environmental impacts in such a varied sector and because the producers find it hard to communicate the attainable environmental benefits (Bruce and Laroiya 2007). However, this situation is changing: producers, in fact, are urged to use environmental communication labels according to the needs of the market which ask for a better security and quality of the production methods of the foods. For the producers, one of the reasons for choosing environmental labels, and which has been widely analysed by the literature, is the costs/benefit analysis (UNEP 2005). A lot of producers, in fact, consider the costs of carrying out the logo procedure too high; moreover, the introduction into the markets of the labelled products takes too long and it becomes difficult to plan the return charges. The literature also highlights the mark up of prices for the consumer who cannot always justify its increase, especially in a period of worldwide economic recession. Economic incentives to the producers should become the regulating instruments to promote voluntary environmental improvements (Defra 2010).

The adoption of the trademark of ecological quality should give producers a competitive advantage helping them to gradually eliminate the products which do not respect the environment; this should contribute both to the sales and incomes growth and it should promote the change inside the supply chain improving the company reputation and creating a positive impact of the brand (Defra 2010).

In relation to the effectiveness that these systems have on the environment, from the analysis of the literature examined by Defra, it appears clear that the reliable data in literature are not so many, so it becomes necessary to collect further scientific data to have more information about their environmental effects (UNEP 2005; Defra 2010).

The uncertainty of the data is due to the fact that many labelling systems used today are of type IV; it means that they are based on “best practice” criteria and they do not enable experts to quantify exactly the environmental impacts on the different eco-systems; to collect more precise information productive sites should be better known, using the appropriate instruments of analysis. But this does not demonstrate that the labelling systems are inefficient; it only demonstrates that the research carried out so far is doubtful also because there are a lot of variables which influence the environment (Defra 2010).

More recent studies (Czarnezki 2011) point out that society is more aware of the fact that the agri-food sector greatly contributes towards environmental decay and the choices of foods can contribute to the climate crisis, can cause the loss of bio-diversity and of water, can endanger the quality of the air and quicken the decay of the soil. These studies confirm the importance of environmental labels as an instrument to promote a sustainable food system. Czarnezki also thinks that act the labelling system of agri-food products should be improved.

It has to be underlined that studies have been carried out also regarding the role of labels for the protection of the climate (Czarnezki 2011; Gadema and Oglethorpe 2011; Bonnedahl and Eriksson 2011; Zhao et al. 2012) and for the safeguard of water (Ridoutt et al. 2010; Ridoutt et al. 2012), sectors which seem to sensitise the public opinion.

Thus, buying labelled goods might well be a functional equivalent to other forms of sustainable consumption spurred and institutionalised by differing market and retailing conditions. In the future, more research is needed to take into account different patterns of sustainable consumption, the organisational varieties of environmental labelling arrangements, as well as differing market structures. This would help to further understand the complex dynamics and path-dependent developments that have shaped the markets for sustainable goods (Koos 2011).

8.3 Conclusions

Food choices contribute to the climate crisis, cause the loss of some species, damage water and air quality, and accelerate land use degradation. In particular, the large production and distribution systems of modern agriculture and commercial processing are powered by fossil fuels (Edwards and Laurance 2012). A lot of life-cycles of food products only have significant carbon footprints; these are some of the most important pollution impacts, but of course not the only ones, and in any case they have to be considered together and as interacting with all the other factors. However, quality eco-labelling of food requires accurate and verifiable information, and it must provide life-cycle information on production, processing, and distribution. Consumers must have access to aggregated information that takes into consideration the chemical additives, land stewardship practices, and fossil fuel consumption required to introduce any food into the market (Czarnezki 2011).

As shown in the preceding paragraphs, the aims of labels and of environmental declarations in the agri-food sector are: to help consumers distinguish among the products on the market those which respect the environment most; to induce consumers to buy this type of products giving, at the same time, to the more sensitive producers a competitive advantage in comparison with their competitors. Labels and environmental declarations can, therefore, been seen as instruments of environmental policy; starting from the concept of the responsibility of the producer, they are the drivers to promote the change in the production and consumption of foods in order to reduce the negative environmental impacts along the chain of this sector.

The review of the relevant literature has collected some knowledge concerning the labels and the environmental communications which delve into the highlights and shadows of these systems. The general context suggests that labelling can influence the behaviour of some consumers and it can encourage producers to reduce their environmental impact; it will certainly continue to play a role along with other initiatives, to improve the sustainability of food production and consumption. However there are many actions to take before making it credible, solid, practical and effective. Some criticism is related to the difficulties of determining, unambiguously and constantly in all productive sectors, the environmental impacts which occur in the different areas of the ecosystem. This is probably due to the fact that there are a lot of sectors to consider (air, water, soil, bio-diversity, landscape, natural resources, etc.) and that each method has its characteristics to investigate and its observed impacts to quantify. For this reason and to make labelling more believable, clear and fair towards the analysed products, labelling systems should envisage the possibility of having only one instrument to analyse and quantify the impacts. The LCA studies seem to be the most significant in that they give thorough information on the impacts and on the actions to be taken to reduce them, and they make it possible to compare the environmental performances of two or more products. Besides, it seems to be necessary to go through a phase of standardisation and normalisation of the methodology whereby impacts can be evaluated and the whole system made more effective. In this perspective, a wider use of some existing harmonisation approaches such as the methods recommended by LCIA (Procter and Gamble 2012) should be welcome.

Another important aspect to point out is that labels have to communicate the message in a clear and easy way, allowing a fast comparison between the "best" or the "worse" products. The multi-criteria labels should be preferred to the mono-criterion ones, because they give information about different impact areas; the mono-criterion labels, in fact, show what happens in only one area, but they say little or nothing about other types of environmental pollution caused by the product. An effective environmental life-cycle eco-labeling system for food would inform consumers about the environmental costs of their food purchases and provide a baseline comparison for food in different production categories (Ridoutt et al. 2010). Consequently, it would be a good idea to establish reliable life-cycle environmental assessment methodologies for foods, and to determine the best way of supplying information to consumers to enable them to make informed choices (Roheim et al. 2011).

Of course, some very interesting actions in this direction have already been developed and are presently being discussed. Among these labels we have "The European Food Sustainable Consumption and Production Round Table" in which scientifically reliable and uniform environmental assessment methodologies are identified for food and drink products (European Food Sustainable Council and Production Round Table 2012).

For future studies, water is a critical resource supporting the health of humans and the ecosystem; the use of water is the most significant environmental burden in some product systems, so the development of methods of channeling water use is an important innovation occurring in life cycle assessment (Humbert 2010), but one must not forget that a single impact category is not an indicator of the overall environmental impact (Ridoutt et al. 2012).

Another consideration is that a list of relevant impact categories for the environmental assessment of food and drink products has to be outlined as a minimum requirement, with the option of additional impacts whose inclusion should be relevant, feasible and appropriate (Tlusty 2011; FoodDrinkEurope 2012).

To achieve that success, market benefits are necessary for environmental label and declaration programmes to influence production and management practices in any industry. To achieve these objectives, scientifically reliable and uniform environmental assessment methodologies should be identified for food and drink products; product category specifications should be included where relevant, considering their significant impacts throughout the entire life-cycle of the product. Moreover, it is necessary to identify suitable communication tools for consumers and other stakeholders and draw up some guide-lines as to the use of these tools, taking all channels and means of communication into due consideration. Finally, it is fundamental to promote and report on continuous environmental improvement along the entire food supply chain and engage in an open dialog with its stakeholders (European Food Sustainable Council and Production Round Table 2012). To achieve these purposes, we have proposed some guidelines, an innovative instrument suitable for evaluating the characteristics and the environmental impacts of a product/service and for assisting the firms which are willing to apply an environmental label to their own outputs by choosing a communication system close to their activities through the evaluation of their objectives.

Improved labelling, schemes to support environment-friendly food consumption, and the market of available food products must be improved. Legal and marketing policies should support even further local, low-input, and nonindustrial unprocessed food markets through streamlined organic certification for small farmers, low-carbon diets, community-supported agriculture, farmers' markets, and increased consumer access to sustainable food products. The industrial conventional food market will continue to shift to organic production (to such an extent that perhaps, in the future, organic food will rival the conventional food market). Following these trends, improved labelling regimes will enhance consumer awareness by stating the environmental costs of consumer purchases; they will also create shifts in consumer choice and, consequently, will modify the norms of food production and distribution for farmers and companies (Czarnezki 2011).

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Chapter 9
Guidelines for Environmental Labels in the Agri-Food SMEs

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9.1 Introduction

The sustainability of the productive processes is a factor of great competitiveness for the companies especially for those which intend to answer to the increasing request of social and environmental responsibility by the consumer. For this reason the research of procedures able to guarantee the respect of the environmental resources is growing in all areas. The energy theme, the climatic changes, the water consumption, the exploitation of the soil, are just some of the examples which will deeply bear on the productive processes in years to come. This trend will be more definitive for the agro food sector both for its specific exposure to some risk factors (e.g. the climatic one), and for the importance of the relationship between the producers and the consumers about the quality and health of the agro food productions.

Today, the production of quality foods using eco sustainable processes not only is a need for the consumers, but it is important also for the organisations involved into the productive processes (from the single farmer to the great sector company), aware that a great attention on the environmental problems and on the improvement of the environmental performances of their own products can produce considerable energy savings of resources and materials, converting them into economic benefits (Defra 2010).

In the last years it has been thought about the more suitable instruments to direct the efforts of the firms towards the renewal of the productive processes to

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involve the environmental performance, and to give the products an objective environmental value, recognisable and saleable on the market. In this context, as it has already discussed in the preceding paragraphs, the use of trademarks and environmental declarations should appear both functional to demonstrate the responsibilities of the companies towards the use and the management of the sustainable environmental resources and a way to communicate this commitment to the consumers and the stakeholders (Coldiretti 2011).

However, the firms wonder which is the more incisive and suitable instrument of environmental communication for the characteristics of the products and for the distinctive features of the sector to which they belong. This becomes particularly important in the agro food productive context where the characteristics of the products are the result of the interaction among very different subsystems, from the farming to the transformation and marketing processes.

With the passing of time, in this sector occurred the springing up of voluntary environmental labelling systems used as instruments of environmental communication and useful to obtain a commercial feed-back of the eco sustainable management which, as it has been described in the preceding section, can be on a single criterion (e.g. the carbon footprint) or on multiple criteria. The result is a varied survey and it becomes extremely difficult and complex for the operators to choose the more effective label which explains the values of their environmental involvement and the application of the operating modes of the chosen labelling system. Hence, it follows the need to carry out some guidelines which, considering the peculiarities of the soil, the specificness of the products, the characteristics of the supply chain, of the company operative context and of the final reference markets, give the firms a way to choose the more adequate environmental label for their agricultural and food products and which allow to bring out their communication strategies and the visibility on the market.

These guidelines should represent an innovative instrument suitable to evaluate the characteristics and the environmental impacts of a product/service and suitable to assist the firms which want to apply an environmental label to their own outputs, choosing a communication system close to their realities through the evaluation of objective, comparable and believable information (Lo Giudice and Clasadonte 2010).

The outlined and written guidelines are the result of an exhaustive study which has highlighted the more common problems among the operators who intend to implement an environmental communication instruments into their productive chain. The starting point is both the respect of the laws applicable to the compartment and the European, national and local rules in force or those deriving from voluntary agreements signed by the organisation and by the codes of good conducts (Schau and Fet 2008).

Moreover, they have been realised to obtain an environmental labelling system which constantly updates the “profile of the green consumer”: it refers to the buyer who takes into account not only the qualities and the price of the product but also the quality of the environmental performances of the same product.

9.2 A Framework of Guidelines for Environmental Labels and Declarations for the Agri-Food SMEs

The proposed guidelines are presented in the following index, where each paragraph is divided in some sub-paragraphs which go into further detail (Table 9.1); the first two paragraphs have introductory features, while the others refer to the procedure needed for the process of environmental labels and declarations.

Below the paragraphs and the subparagraphs will be described in detail following the numbering reported in Table 9.1.

9.2.1 Structure of the Guidelines

9.2.1.1 Introduction

In the last decades, the communication of the values, actions and environmental performance has become the principal activity of organisations considering the growing interest of the stakeholders in the environmental themes. Through environmental communication, organisations are able to show the environmental implications of their activities, outputs and services, meeting the requests of more information from the workers, investors and the other parties concerned.

The presented guide lines are coherent with ISO 14020:2000 (*Environmental labels and declarations—General principles*) and the ISO 14063:2010 (*Environmental management—Environmental communication—guidelines and examples*) set of standards which, in the literature, are the reference international regulations.

They reflect the aim of a continuous improvement supported by the Deming Cycle (Plan-Do-Check-Act) taking into account the peculiarities and the environmental and managerial problems of agri-food chains; their general features can be applied by all organisations in the agri-food sector, regardless of their size, position in the productive chain and location; it is a structure based on iterative procedural steps which suitably supports the decision processes necessary for choosing the label and is linked to the product-driven environmental management system (POEMS). Finally, the guidelines provide a precise analysis of the technical, operational and managerial aspects of the single company so that users can be aware of the effectiveness and the feasibility of environmental labelling of food products.

A correct and coherent use of the suggested guidelines gives the management the opportunity to provide distributors and consumers with the necessary information to choose eco-compatible products consciously: the information refers to the different steps of the realisation of the product, the product itself, the environmental impacts of its performances, product conservation and re-use and/or disposal of the packages at the end of the life-cycle of the product.

Table 9.1 Structure of the guidelines

Section	Subsection
1. Structure of the guidelines	1.1 Introduction
	1.2 Aim of the guidelines
	1.3 Advantages of the guidelines
2. Aims and purpose of environment labelling	2.1 Terms and definitions
	2.2 Principles of environmental communication
	2.3 Environmental Labels and declarations
3. Starting assessment of the company	3.1 Analysis of the general and environmental characteristics of the company
	3.2 Environmental aims of the company
	3.3 System boundaries
	3.4 Lawgiving references
	3.5 Company voluntary certifications
	3.8 Company knowledge of labels and of environmental declarations
4. Environmental Communication Policy	4.1 Commitment of the management
	4.2 Planning of the communication activities
	4.3 Individualisation the company resources involved
5. Company strategies of environmental communication	5.1 Contents of the communication
	5.2 Reasons for company communication
	5.3 Communication Techniques
	5.4 Operating time
	5.5 Specification of the target group
6. Characterisation of the labelling system/ environmental declaration	6.1 Identification of the company environmental impacts
	6.2 Indicators of the company environmental performance
	6.3 Decision Support Tables
	6.4 Choice of the most appropriate labelling system
7. Reporting	7.1 Drafting of the required documents
	7.2 The team of the environmental communication
	7.3 Logo
	7.4 Supports for environmental communication and channels to be used
8. Valuation of environmental communication	8.1 Evaluation of environmental communication
	8.2 Periodical Audit
	8.3 Cost analysis
	8.4 Advantages of labels and environmental declarations
	8.5 Potential integration with other firm management instruments
	8.6 Final recommendations and continuous improvement

To define this model it was important to consider all the environmental, social and economic aspects, which were often in contrast with each other, due to the different actors which operate along the entire chain.

9.2.1.2 Aim of the Guidelines

This document is useful for the companies belonging to the agri-food, product, regardless of their size and location; it will help them to decide and adopt the voluntary environmental labelling system which is in accordance with the company needs and characteristics. In order to give detailed information about the labelling, it is necessary to consider some specific information about the interested organisation, such as the managerial, organisational, environmental and structural aspects.

The guidelines also provide a complete analysis of the impacts along the entire productive chain using instruments conceived to implement the company policies for the prevention of the impacts and for the improvement of the environmental performances.

9.2.1.3 Advantages of the Guidelines

The proposed guidelines are derived from objective environmental assessments, so during the application phase they could make the management more aware of a higher control of the productive processes and of a more responsible management of all the company activities thus making sure production improves continuously in terms of environmental performance.

Being divided in iterative procedural steps, the guidelines support the company management in their choice of the environmental label suitable for the company's productive reality. The management will, therefore, be able to communicate (to distributors and consumers) objective environmental information on the products and services which are, consequently, comparable and believable. The guidelines can also be adopted by companies which want to acquire a real competitive advantage and hope to enhance the value of their product within the framework of a general improvement in terms of economic, ecological and social performance.

This document has been drawn up to help companies which can thus easily implement a policy of environmental communication; moreover, through the quantification of the different environmental impacts along the entire life cycle, it is possible to transform them into commercial advantages, attracting the groups of consumers who are more sensitive to eco-sustainability themes.

9.2.2 Aims and Purpose of Environmental Labelling

9.2.2.1 Terms and Definitions

In order to facilitate the reading of this document, the following definitions have been reported:

- **aim**: definition of the performances which the organisation intends to achieve within a determined period of time; this definition has to be fixed by the top management;
- **audit**: systematic verification process to determine if the activities and the respective results conform to the planned activities, if the activities have been really performed and if they are suitable to reach the aims and the policy of the organisation;
- **best available techniques**: most effective and advanced stage in the development of an activity and its methods of operation, which indicate the practical suitability of particular techniques for providing, in principle, the basis for emission limit values designed to prevent or eliminate or, where that is not practicable, generally to reduce an emission and its impact on the environment as a whole (Sect. 5 of Environmental Protection Agency Acts, 1992 and 2003, and Sect. 5(2) of the Waste Management Acts 1996–2005);
- **continuous improvement**: improvement path which constantly goes on and which involves the entire company structure and which can be reached through the application of the Deming cycle PDCA: "Plan"- resources management; "Do"—processes management; "Check"—control data analysis; "Act"—measurement, analysis and improvement;
- **education**: an educational process which transfers to workers and other subjects who work in the prevention and the environmental protection sectors useful knowledge and procedures for them to acquire the abilities to do their own work safely by identifying, reducing and managing risks;
- **environmental communication objective**: the environmental communication goals consistent with the environmental communication policy which an organisation sets up as part of its environmental communication strategy;
- **environmental communication policy**: the intentions and directions of an organisation related to its environmental communication as formally expressed by top management; the environmental communication policy can be a separate policy or part of other policies within the organisation;
- **environmental communication strategy**: organisation framework for implementing its environmental communication policy and for the setting of environmental communication objectives and targets;
- **environmental communication target**: detailed performance requirement, applicable to the organisation, which arises from the environmental communication objectives and which needs to be set and met in order to achieve those objectives;

- **environmental communication**: process that an organisation conducts to provide and obtain information, and to communicate with internal and external concerned parties in order to encourage a shared understanding on environmental issues, aspects and performance;
- **environmental impact**: the elements of an activity, of a product and/or a service done by the organisation and which can interact with the environment and which can be important to establish the company aims; the environmental impacts to be considered can be divided in direct (emissions in the atmosphere, water waste, management waste, the contamination of the soil and of the subsoil, the use of natural resources, energy and raw materials, noise, vibrations, smell and fumes, visual impact) and indirect (design, packaging, transport, use, waste, recycling, disposal, catering and innovation of the products);
- **environmental indicators**: numerical data and qualitative information which help evaluate the performance and efficiency of a company or collective system activities which aim at safeguarding the environment;
- **external communication**: procedures to communicate to the stakeholders data and information about their own services concerning the environment, including the results of the management review and of the monitoring system;
- **green marketing**: instruments based on strategic incentive and on competitiveness, which are extremely important for the firms which base their communications on the strong and concrete improvement of their own environmental performances and which try to meet the increasing sensitivity of the consumer to environmental defence;
- **information**: the set of activities necessary to identify, reduce and manage the risks in the work environment;
- **interested party**: person or group concerned with or affected by the environmental performance of an organisation;
- **internal communication**: an indispensable aspect to motivate the staff to carry out, vertically and horizontally, the policy and aims of the organisation, responsibilities, the results of internal verifications and the voluntary and legally binding prerequisites;
- **LCA (Life Cycle Assessment)**: systematic analysis which assesses potential associated impacts, quantifying the energy and material flows of the entire life cycle of the product (Society Environmental Toxicology and Chemestry—SETAC, 1993);
- **leadership**: commitment and involvement of the high management, fundamental for the development and the maintenance of a voluntary management system to achieve the aims of the organisation;
- **organisation**: company, corporation, firm, enterprise, authority or institution, or part or combination thereof, whether incorporated or not, public or private, that has its own functions and administration; for organisations with more than one operating unit, a single operating unit may be defined as an organisation;
- **performance**: measurable results related to the control and the quantification of environmental impacts on the different sectors of the productive activities of the organisation;

- **procedure**: a specific way to carry out an activity or a process; it is supported by some documents, if they exist, and which describe the ways, responsibilities, time, input and output data used by the organisation carry out particular activities or processes;
- **sub-suppliers**: economic body of the supply chain which, directly or indirectly, provides the supplier with goods and/or services necessary for the production of the goods and/or the services for the organisation;
- **suppliers**: commercial body which supplies the organisation with goods and/or services used for the production of goods and/or services for the organisation itself;
- **system boundaries**: set of criteria specifying which unit processes are part of a product system;
- **target group**: interested party or parties selected as the focus of an organisation's environmental communication activity;
- **training**: a complex of the activities necessary to teach the workers the correct use of equipment, machines, plants, substances, devices and working procedures;
- **voluntary management systems**: part of the general company system associated with the activities of the organisation which include: organisational structure, activity planning, responsibilities, praxis, procedures and resources. The aim of these systems is to elaborate, implement, achieve, re-examine and enhance the company policy by going beyond the legally binding sector standards.

9.2.2.2 Principles of Environmental Communication

For the drafting of the guidelines the use of a suitable language which has the following characteristics is required:

- **appropriateness**: make information provided in environmental communication relevant to interested parties, using formats, language and media that meet their interests and needs, enabling them to participate fully;
- **clarity**: ensure that the environmental communication approaches and language are understandable by the concerned parties to minimise ambiguity thanks to a strict scientific base but easy to read;
- **coherence**: the label has to provide information coherent both with the context in which the product is made, distributed and consumed and with the aim and the category to which it belongs;
- **comparability**: if the environmental performances of a product are a criterion of choice for the consumer, it is necessary to compare them with the clear and unambiguous data of the competitive products, using temporal reference, environmental parameters and comparative terms;

- **comprehension**: environmental communication has to be clear, immediate, comprehensible, precise and not misleading regarding the real environmental impacts of the organisation;
- **credibility**: conduct environmental communication in an honest and fair manner, and provide information that is truthful, accurate, substantive and not misleading to interested parties. Develop information and data using recognised and reproducible methods and indicators;
- **easy understanding for the users**: environmental communication has to be easy to read and understand by the users-consumers in order to lay down the conditions to make more conscious choices;
- **effectiveness**: capacity of the communication to achieve the goals that the company has fixed to reach using a stated trademark;
- **readability**: the information reported in the label has to be incisive and essential in the context and readable from a graphic point of view;
- **reliability**: characteristic which underlines the necessity of truthful and verifiable information;
- **responsiveness**: ensure that environmental communication is open to the needs of interested parties: it should answer the queries and concerns of the interested parties in a full and timely manner and make interested parties aware of how their queries and concerns have been addressed;
- **transparency**: the processes, procedures, methods, data sources and assumptions used in environmental communication available to the parties concerned, taking into account the confidentiality of the information as required. Inform interested parties of their role in environmental communication;
- **truthfulness, accuracy and deceiving communication**: a strategy based on technical and detailed information given through the label of a product which is correct but not effective if language and the style do not suit the knowledge of the average consumer;
- **visibility**: a fundamental role is played by the position of the label on the product; the label must be easily traceable and recognisable on the different packages—boxes or tins- it must contain and highlight environmental information; its ultimate aim is to standardise the formats in which the trademark is presented, thus making the information clearer for the consumer.

9.2.2.3 Environmental Labels and Declarations

Type I "LCA Eco-labels (ISO 14024)": these labels are generally voluntary, multi-criteria based, third-party verified schemes that award a licence to use the scheme label/logo for specific products or services that meet prescribed standards based on a life cycle assessment approach including, for example, energy and water consumption, emissions, disposal, etc. The standards and scheme criteria are usually developed through the involvement of stakeholders and awarded after an independent process of verification.

Type II "Self-declared environmental claims (ISO 14021)": this type of label is the most widely used to provide environmental information to consumers and other stakeholders. According to the official ISO definition, these labels are not awarded or verified by an independent authority but usually developed internally by companies and tend to take the form of a declaration, a logo, a commercial, etc. For example: "made from x % Recycled materials", "Biodegradable", "Recyclable" or "Free from chlorine".

Type III "Environmental impact labels (ISO 14025)": these labels are one of the most detailed forms of providing environmental information and, like Type I, are based on life cycle impacts. These types of labels are dedicated to specific products and do not normally assess or weight the environmental performance of the products that they describe but only provide raw data, such as the quantity of emissions. Their evaluation is left to the consumer. Many of the carbon labels fall into this category whereby the amount of CO_2 eq. emitted (as g/unit) is provided on the label.

Type IV "Environmental impact labels (No ISO standard)": these go beyond the definition of ISO Type II and they are submitted to an independent verification by a third party but do not rely on a life cycle assessment approach or actual measurements. These labels are generally based on a set of "best practice" criteria or standards which are used to differentiate the single product from the main stream products, usually on the basis of the reputation of the organisation issuing the label. For example, the Forest Stewardship Council certifies that labelled products are from forests which are managed following a specific set of protocols. An auditing process is undertaken to verify compliance and add credibility but a life cycle assessment of practices and their environmental impact is not undertaken.

9.2.3 Starting Assessment of the Company

The starting point to implement a voluntary environmental labelling system is a "starting assessment" which verifies the knowledge and the sensitivity of the organisation to environmental themes and helps to identify all the environmental impacts along the productive process. Moreover, it highlights the organisational, managerial and processing needs of the company which are the starting points to choose the type of environmental labelling system path.

This evaluation is the first and most important phase for the fulfilment of this project: evaluation and development cover the strengths and weaknesses of the company, its opportunities and its difficulties, the existing procedures, the available resources and the position of the company regarding the legally binding and voluntary prerequisites with a view to verifying the feasibility of the company's course of action.

9.2.3.1 Analysis of the General and Environmental Characteristics of the Company

In order to facilitate the monitoring of the company performance some check lists were made. They are easy to understand and useful for companies when they want to make a preliminary evaluation of the requisites of environmental labelling and any possible drawbacks.

The management has to answer some specific questions which verify both the general data connected with the internal organisation of the company and the main environmental aspects with a view to pointing out the most important problems.

This helps to set the productive site in its territorial context and to acquire complete information on the different environmental impacts of the company's productive activity related to the atmosphere, hydrosphere, soil, etc. This is the simplest way to fix the aims and programmes of improvement, intervening on the most critical areas and pointing out the resources necessary to achieve the target.

The correct use of the guidelines can help companies which want to check their environmental policy with the aim of carrying out an eco-sustainable and responsible management of the natural resources; moreover, the guidelines can also facilitate the inspection and control activities thus ensuring the correct use of the undertaken precautionary measures.

- Company general data
  - company name;
  - sector of business;
  - number of company units and branches if there are any;
  - number of employees;
  - market research done regarding Quality and Security;
  - economic and human resources intended for R&S activities;
  - presence of external consultants in the course of the planning and development of the productive process;
  - request of certified products (e.g.: PDO) from customers/consumers or customers/producers;
  - according to the company's experience, the sensitivity shown to environmental themes by Italian/European consumers.
- Analysis of the productive process and innovations
  - considering the entire life cycle of the product/service, indicate the steps of the productive cycle (Es.: Wheat farming, grapes, olives, transport of the raw materials, processing-production, packaging, shipment-transport of the finished products);
  - for each step of the productive process point out the main associated environmental impacts;
  - identify the area where the environmental impacts generated during the different steps are more concentrated (atmosphere, water, soil);

– specify the farm production used by the company or by the suppliers (conventional, integrated, biological);
– if used, indicate the dressing, fertilizer, pesticides directly involved in the productive process/indirectly by the suppliers;
– transformation processes of the raw materials before putting them into the productive process and any possible environmental impact;
– use of renewable energy source during the entire productive cycle;
– indicate any transformation processes (cooking, drying, sterilisation, etc.) of the input during the production phase;
– types of packages (wood, plastic, carton, metal, glass, etc.) used by the company;
– use of eco-compatible materials for the packages (biodegradable or recyclable, etc.);
– waste management system (urban and dangerous waste);
– internal or external company distribution network for the finished products;
– type of transport for the finished products;
– type of label on the finished products;
– type of product/process innovations in the last years;
– innovations and results achieved as a result of these innovations.

9.2.3.2 Environmental Aims of the Company

The aim of eco-sustainability is to generate the environmental policy of organisations, which is at the heart of environmental communication and offers the opportunity to the company to fix the starting point of its improvement process.

These aims have to conform to the nature and size of the structure; they have to respect the laws, environmental standards and other signed commitments, consider the results of internal checks and offer inputs for planning interventions and company activities. Moreover, they have to be reachable, measurable, documentable, suitable, modifiable and communicated to all the externally and internally involved subjects. To define these aims it is necessary to consider also the legal prescriptions, significant environmental aspects, any available technological options, resources, staff and the necessary know-how, means, plants, structures, premises and commercial and operative aspects.

Some of the aims which should be defined by the company are:

- development of more sustainable farming systems;
- information and education of the consumers about eco-compatible agriculture;
- prevention or reduction of the environmental impacts caused by the productive cycle on water, air and soil;
- respect for legal requisites;

- encourage the suppliers/customers to use Environmental Management Systems (EMS);
- modify the attitude of the consumers and of the industry towards environmental themes.

9.2.3.3 System Boundaries

The system boundaries define the unitary processes which have to be included into the system and the input and output factors of the productive process.

They change according to the aims to be reached: first of all, it is necessary to verify the means in use, the time and the availability of the necessary data; moreover, the analysis interfaces with the environment and with the other products which can be defined through a careful description of the examined system and the realisation of a flowchart of the productive cycle in order to plan the collection of the data and information outlining the range (Fig. 9.1).

A first delimitation of the boundaries is done considering the organisational, managerial and technological criteria and understanding the quantification of the environmental impacts and the productive processes which have to be checked for this analysis. The time boundaries are also a constraint for the analysis because they point out the gap in which the potential impacts of the product are evaluated and how certain parameters evolve.

The company has to fix exactly the products, the phases and the processes which will be treated by the chosen labelling system. The internal and external phases of the organisation should be the following: the acquisition of the raw materials, the

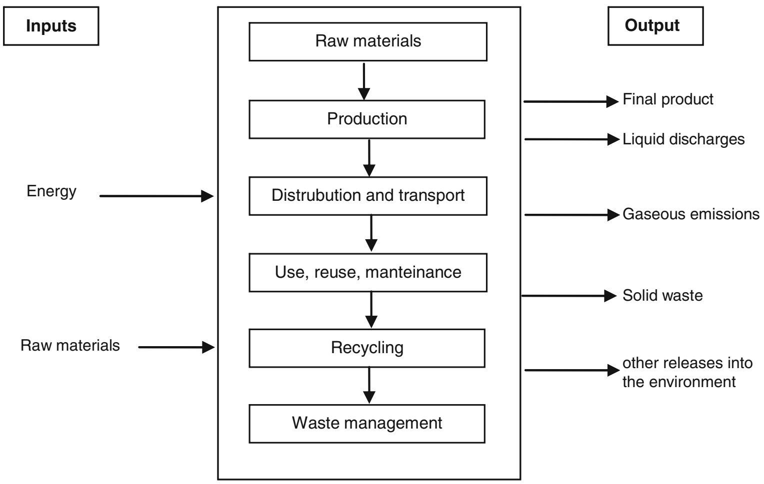

Fig. 9.1 Environmental input–output flow-chart

inputs and outputs in the main sequence of the production, distribution/transport, use of fuel, electricity and heat, product maintenance, waste, product and process disposal and further activities such as lighting and heating.

9.2.3.4 Lawgiving References

An organisation which aims at a voluntary labelling system has to start a procedure so that it can identify the official instructions applicable to its own reality, at the same time respecting national laws and the signed standards which refer to the operating sector and other laws connected with its own activity.

The organisation has to have a book with all the official instructions indicating the updating status in order to control their constant application and observance looking at constant improvement rather than the imposed limits. This book should contain information about the title, the reference number and the date of the law; the body which has enacted the document; the voluntary standard; the commitments met by the organisation.

A voluntary labelling system must first and foremost respect all the laws relating to the environment and products and/or services provided by the organisation.

By identifying the laws and standards connected with the activity, the organisation is able to verify the respect for official instructions, prevent any possible sanctions on the part of the Public Administration and verify conformity with the fixed aims.

In order to facilitate the self-evaluation process regarding the legally binding standards applied to the agri-food sector, also in this case, a check list has been prepared:

- difficulties found in carrying out the legally binding standards concerning the agri-food sector;
- difficulties found in monitoring the entire chain of the productive process;
- critical points in putting into effect the standard related to the traceability of the product and of the chain (Reg. CE 178/02);
- considering the legally binding standard, any possible faults found in the labelling system of the products;
- influence of the standard to indicate the presence of OMG (for example, Reg. (CE) 1880/03) mandatory in the raw materials to buy and to indicate the presence of allergenic substances and of their by-products (es.: gluten, Directive 89/2003/CE).

9.2.3.5 Company Voluntary Certifications

To verify the presence in the company of voluntary certifications of product/ process the following check list has been prepared:

- regulated Voluntary Certifications of the product (es.: PDO "Protected Designation of Origin", PGI "Protected Geographical Indication", Biological, CDO "Controlled Designation of Origin", CGDO "Controlled and Guaranteed Designation of Origin", Ecolabel "Quality Ecological Trademark of the European Union");
- regulated Voluntary Certifications of the company process (es.: UNI EN ISO 14001:2004 "Environmental Management System"; UNI EN ISO 22000:2005 "Management System for the Food Safety"; ISO 22005:2008 "Agricultural Food Chain Traceability"; Reg. (CE) n. 1221/09 "EMAS Eco-Management and audit scheme";
- possible LCA study already used in the company;
- reasons why the company has chosen to agree to these standards;
- any possible aims and obtained results due to the choice of these standards;
- any possible problems during the certification procedure;
- any possible changes in the company organisation due to the adoption of the new standards;
- any possible certifications of product/process which the company intends to adopt in the middle term.

9.2.3.6 Company Knowledge of the Labels and of the Environmental Declarations

Considering the aim of these guidelines, this section is dedicated to the knowledge that the company management has about the labelling systems and the voluntary environmental declarations and their possible presence in the company. The relative check list follows:

- possible knowledge and/or adoption in the company of the voluntary system of Environmental Labelling of type I ISO 14024:2000 "Ecological labels which consider the life cycle of a product and are checked by an independent body of certification";
- possible knowledge and/or adoption in the company of the voluntary system of Environmental Labelling of type II ISO 14021:2002 "Ecological labels which report "self declarations" about the ecological characteristics of the product";
- possible knowledge and/or adoption in the company of the voluntary system of Environmental Labelling of type III ISO 14025:2006 "Ecological labels which report environmental information of a product according to pre established parameters and checked by an independent body of certification";
- possible system of environmental labelling which the company intends to adopt in the middle term.

9.2.4 Environmental Communication Policy

The policy of environmental communication is, within the methodical formulation of these guidelines, the starting point and the basic reference for the company to put into practice the outlined needs. It has to contain not only the aims and the principles of action which inspire the organisation, the moral commitment and the assumed responsibilities, the accordance with all the reference and the laws about the environment, but also the commitments dedicated to a constant and reasonable improvement of environmental efficiency. Moreover, in order to develop this policy, the environmental management inside the organisation should interact with the people responsible for environmental communication to make sure that the policy is coherent with the other company principles, policies and values. As a consequence, the management should implement this policy giving a few hints on how to formulate and modify it.

9.2.4.1 Commitment of the Management

The top management has to periodically check the adequacy, fairness and continuous effectiveness of the policy of the environmental communication inside the company, the procedures and the results of the environmental performances obtained following the signed requisites. Any possible system adjustments and necessary improvements have to be implemented within the previously described framework in order to guarantee the continuous improvement within the company. Moreover, the top management has to guarantee that, if possible, the environmental communication policy respects the cultural local, regional and/or national characteristics, and this policy has to be documented, implemented, kept active, communicated and made comprehensible for all the employees including the administrators, managerial staff, management, supervisors and operative staff.

The top management should promote a policy of environmental policy based on a continuous relationship with the stakeholders, on the information related to the environmental performances and on the critical points which have to be underlined. The commitment of the management implies the definition of the resources and of any useful means with a view to achieving the pre-arranged aims, the analysis and definition of the solutions for any environmental problems and the time and methods necessary to put corrective measures into practice.

The top manager can carry out this activity directly or through one of his or her representatives to whom all the necessary documentation is given. Programmed meetings should be foreseen both to verify the fairness and the effectiveness of the resources available for the environmental communication and to give each sector manager the opportunity to state their own activity.

9.2.4.2 Planning of the communication activities

In order to implement their policy of environmental communication, companies have to carry out some processes and activities which affect all the aspects connected with company communication. The aims and strategies of environmental communication need specific actions to be achieved, taking into account the environmental aspects, the geographical borders and the parties concerned. The planning which reflects the starting point of the Deming cycle, “PLAN”, consists in establishing and developing one or more procedures to point out the environmental aspects of the actives, products and services which, being a priority, as the environmental analysis of Sect. 9.2.3.1 showed, can be controlled and influenced to reduce their impacts. The organisation has to quantify and carefully evaluate the most significant environmental aspects, compare them with the limits fixed by the law and decide on other targets using alternative technologies and trying to improve them.

When planning environmental communication activities, a company should consider the following aspects:

- coherence of the communication activity with the principles reported in Sect. 9.2.2.2 and with the company policy;
- presence of environmental monitoring techniques;
- promoting consensus among the different parties involved;
- consideration of the, different key aspects of the organisation;
- how easy it is to implement environmental communication inside the organisation;
- definition of the times and of the ways necessary to achieve the aims;
- clarity in sharing responsibilities and authority;
- consultation and involvement of all the company sectors;
- clarity and competence in training the employees and in giving them information;
- efficiency in implementing communication activities inside other branches of the organisation;
- efficiency in updating the communication activities in accordance with the changed company requirements;
- fairness of the economic and financial resources for the prefixed aims;
- fairness of the competitive productive capacity to support the productive and market choices;
- control of the fairness and measurability of the prefixed aims;
- attention to be dedicated to the procedures connected with the purchase process in order to guarantee that the suppliers abide by the laws and the criteria signed by the organisation and its environmental policy.

9.2.4.3 Individualisation of the Company Resources Involved

This step should be identified by the "DO" of the Deming cycle.

The company should allocate the right resources to carry out its policies of environmental communication necessary to reach the prefixed aims. For this reason some initiatives should be taken in order to survey the necessary economic, human and technical-structural resources and any other related sources. A treatment of three different types of resources distinguished in their respective categories follows.

- Financial resources

In order to achieve an effective and efficient communication, it is necessary to manage suitably the financial resources which compare the resources engaged, the pre-arranged plans and the beginning of the consequent actions. Also the allocation of funds has to be completed with a view to setting up programmes of technological development such as those concerning the improvement of the effectiveness and efficiency of the productive processes or those necessary to put the legislative measures into practice (IPPC). Moreover, the completion of the financial reports help to verify the ineffectiveness or the inadequacy of the processes applied to the adopted systems, thus pointing out any necessary corrective actions.

During the evaluation of environmental communication activity, it is also important to consider the potential costs and consequences of "non-communication"; these can be tangible and, for a long period of time, they can be higher than those used for environmental communication in that they can burden the organisation with further costs such as damage to the image and reputation of the company. The company should assign proportionate financial resources to put its environmental communication policies into practice thus achieving the pre-arranged aims; for this reason the resources should be chosen after a detailed analysis of the involved resources, the pre-fixed plans and connected sources. It is fundamental to plan financial resources, which have to be part and parcel of the budgets and be under constant control; there might also be the necessity to assign financial resources to technological development programmes. Finally, the company should have a system of costs survey in order to measure and monitor the effectiveness and efficiency of the systems adopted within the company itself.

- Human resources

The human factor represents an indispensable resource for the company communication system because, to have good results, the top management has to demand that all the employees have acquired some appropriate training in terms of experience and competence; the organisation has to make sure that the employees have the right competence (acquired, for instance through their education, work, training or training courses) and awareness of the importance of their work. In order to do this, the organisation should insist on the necessity of training and refresher courses. The company should make sure that through training and the refreher courses all the employees are aware of the environmental policies.

Moreover, the experience of the employees is a key aspect which influences directly and indirectly the conformity of the product performance to the requisites fixed by voluntary labelling.

Finally, the responsibilities given to human resources should not be relegated within environmental limits; they can also be found in other areas of the company organisation. From the organisational point of view, the management should plan an organisation chart which shows the structure of the organisation and its tasks, standards, responsibilities and duties to fulfil.

- Technical-structural resources

In order to implement correctly a policy of environmental communication, the organisation should define the technical infrastructures necessary (e.g. buildings and workplaces, transport, computing science and communication system, skilled workers) to guarantee both the product/service standards and also to satisfy the expectations and the necessities of all the parties concerned.

9.2.5 Company Strategies of Environmental Communication

The company management should develop a strategy to define its environmental communication policy; this strategy should include the aims of environmental communication, the identification of the stakeholders, when and how the company management has planned to communicate and the commitment of assigning the right resources.

A company, in fact, has to explain what it intends to achieve, taking into account its resources in order to meet the expectations of the stakeholders. Environmental communication is a part of the general environmental company activities and it should be coherent with the other elements of the management system, policies, strategies or other important activities. When the strategy has been defined, it has to be approved by the top management and then it can be used as the starting point of the environmental communication activities. A correct communication strategy has to be written and accepted by all the people who are involved in the communication activities, that is both internal and external subjects; it has to guarantee continuity; it has to be clear and realistic; it has to be in line both with the human, economic and technical resources of the company and with the market; it also has to be coherent with the company aims, the budget and the choice of the communication tools; it is to be understood and understandable by the final consumers and by all the stakeholders. So, it is necessary to point out the recipient and the aims that the company tries to reach, to identify the content of the message and the way to transmit it, considering the type of people to whom it is destined (type and thorough examination of the information, language to be adopted, statement, etc.).

An effective strategy of communication should be built as follows:

- definition of the contents of the communication regarding sustainability (what has to be communicated)—the content;
- focusing the communication aims on the different stakeholder (why it has to be communicated)—motivations;
- selection of the instruments and planning of a Communication Plan (how it has to be communicated)—techniques of communication;
- identification and characterisation of the stakeholder (to whom it has to be communicated)—target groups.

9.2.5.1 Contents of the Communication

The message and the contents of the communication are a crucial point for the definition of a strategy because what has to be taken into account is not only what has to be communicated but also what can be communicated, that is the actions carried out and the results achieved by the company and which can be appreciated by the stakeholder; also what is better not to communicate is to be taken into consideration. This is particularly true for the environmental implications of the activities carried out by an organisation which can have environmental impacts on the territory; but it is also important to understand what the stakeholders expect to know through environmental labelling and how much they really understand what has been transmitted to them. The label has to focus on the most significant environmental aspects of the product; so the firm can promote the environmental aspects of the product using data which increase its value, for example, by giving further information and inviting the reader to consult the website of the agri-food firm.

9.2.5.2 Reasons for Company Communication

The company must have clear objectives in their communication to customers and stakeholders, which can only be achieved by adopting different strategies; the aims of environmental communication, in fact, change in accordance with the type of stakeholder and the context in which the communication flows develop. The system of voluntary environmental labelling has to meet the needs of the consumers who consider environmental performance as part and parcel of the productive process; therefore, the real challenge is to make environmental improvement associated with product consumption concrete and perceptible in order to persuade the customer-consumer of the real utility of the labelling as a means to safeguard the environment. For this reason the label has to show the market, in an effective way, the company's commitments to safeguard the environment and/or the concrete results in terms of the ecological performance of its products.

9.2.5.3 Communication Techniques

What is important is not only what has to be communicated but, above all, how to communicate it, choosing the most effective and correct method at the same time taking into account the recipient and the content of the messages: each category of stakeholders, in fact, has specific characteristics which can make communication useless or self-defeating if it is not well-planned in terms both of content and of the language used. For example, a label which reports environmental parameters in an excessively detailed and complex way cannot be appreciated by a consumer who does not have the skills to appreciate it.

Information should consider the behavioural, social, cultural, educational, economic and political interests of the target groups; an appropriate language register has to be used; the use of images and electronic media has to be coherent with the chosen approach and, in case it is relevant, with any other information on environmental aspects previously communicated by the firm. An organisation should test its own communication procedures before actually addressing its public; for this reason market research should focus on the customers' expected needs. Any communication about environmental impacts has to be based on data which have been aggregated in a believable and clear way; a label is, and will always be, a simplified way of communicating something which is much more complex. Communication contents can include:

- impact areas and environmental aspects because if the label refers to just one of the environmental aspects, it will not be clear;
- the system, to which the impacts refer and which has to be clearly defined;
- the functional unit of each impact which should be clearly expressed;
- the labelling scheme which has to complete other initiatives concerning the same aspects inside the organisation.

9.2.5.4 Operating Time

An implementation strategy of an environmental labelling system has to consider the important time variable. External circumstances and events might make it necessary to synchronise environmental communication; sometimes specific communication activities have to be anticipated or postponed by internal conditions of the firm. It is important to define the most appropriate actions in order to achieve the set target and to be able to make sure that the actions make effective progress; so it is possible to work out an agenda which organises a set of activities and events taking into consideration the interrelations among the various actions, thus monitoring progress and optimising time and work procedures.

9.2.5.5 Specification of the *Target Group*

The company approach to environmental communication has to take into account its relation with the target groups; it is important to underline that environmental communication is a dynamic process and the relationship between the target groups and the organisation changes continuously. When choosing the approach for the most appropriate communication the needs and interests of the target groups involved in the communication, have to be taken into consideration. There are different communication approaches depending on whether the organisation and the target groups are active or passive. The aims of the environmental communication of the company, the target groups and the company resources available for the communication, can also condition the approach to be adopted. Identifying the recipients of voluntary environmental labelling means understanding all the categories of subjects which, for different reasons, have an interest in the environmental performances of the same firm; each category has specific characteristics in terms of values, interests and expectations but also in terms of reception, understanding and appreciation of the messages reported on the label.

It is important to underline that changes in consumers' attitudes and in industrial behaviour require different approaches; for example, a detailed report on environmental impacts and the use of environmental declarations for the product are maybe more suitable for the company's internal communication while simpler labels are more suitable to be addressed to the consumer. In any case it all depends also on the aim of the labelling system. For example, more detailed information is necessary when addressing consumers who are particularly sensitive to environmental themes and who already know about the environmental impacts of foods. In particular, in order to identify the recipients of the label, it is worth analysing some peculiarities of the organisation such as:

- the sector it belongs to;
- reference markets;
- total market share;
- market share which should be characterised by the consumers sensitive to environmental performance;
- analysis of its competitors;
- composition of the products portfolio;
- analysis of the needs of its own interlocutors;
- understanding of the environmental perception of the customers-consumers;
- environmental attention of the customers-consumers.

For this reason the interlocutors the company interacts with in the market and the variables which can condition their purchase choices should be compared. This leads to a precise assessment of the importance that each interlocutor gives to the variables considered.

Among the recipients of environmental labelling, one can find:

- final consumers classifiable according to their high or low sensitivity to environmental problems;
- average consumers or transformation industries which operate in the business to business market and which differ according to their grade of maturity and sensitivity to environmental problems;
- distributors who have different marketing and environmental needs depending on whether they fall into the large-scale distribution or the retail categories.

The following are just a few examples of the different methodologies and instruments of analysis of the target group:

- *desk research*: research, evaluation and revision of collected information available for a third party; the information comes from external sources of the firm such as public institutions, statistical sources, specialised press, research institutes, the internet;
- *market research*: it is done on the spot; it cannot be previously detected and can only be carried out following a direct research programme; it generally analyses the behaviour, characteristics and attitudes of the consumers;
- *interviews or personal contacts with the stakeholders*: these include meetings organised inside the firm or in neutral places in order to exchange honest and open information about specific aspects. This consolidates the trust among interlocutors. It might be difficult to identify all the concerned parties due to the time limit and the low preparation of the third bodies involved. In this case the role played by the skilled representatives of the parties concerned is fundamental in that they have to carry out a specific job;
- *focus group:* meetings with small groups of stakeholders, who have similar backgrounds, to discuss specific matters: in this case a free exchange of ideas is possible because the participants feel at ease among people who have the same opinions. Therefore, agreements are often reached even about important aspects; in any case these are long-term procedures because they involve the concerned parties.

However, it is essential for the enterprise to compare the analysis of the consumer with an evaluation of the market dynamics in order to identify and evaluate the different factors which justify the purchase of ecological products and which is linked both to the trends of the demand and to the characteristics of the offer of these products.

9.2.6 Characterisation of the Labelling System/ Environmental Declaration

This section is dedicated to the identification of the most suitable voluntary environmental labelling system for firms and connected with the different technical–economic parameters analysed using the check lists, the starting evaluations and the choices of the company strategies, already treated in Sects. 9.2.3–9.2.5.

9.2.6.1 Identification of the Company Environmental Impacts

As regards the exposure of the data related to environmental aspects and impacts, just for illustrative purposes the company can use synthesis matrix, like the one reported in Table 9.2 which is related to a generic productive process of a company belonging to any agri-food sector.

9.2.6.2 Indicators of the Company Environmental Performance

This phase corresponds to the “CHECK” of the Deming cycle and, to carry it out, it is necessary to identify and quantify the right environmental indicators.

The organisation has to analyse and quantify their own significant environmental aspects, mentioned in the environmental policy dealt with in Sect. 9.2.4, working out some sort of timetable whereby periodically environmental aspects are quantified, evaluated and compared to relative laws; new environmental objectives can be set, and, in this case, a new process begins.

In the literature and, above all, in the company practice, environmental indicators are divided into two categories: environmental performance and environmental impact.

The first indicator points to those quantitative and qualitative values which help to evaluate the effectiveness and the efficiency of the use of the environmental resource by an enterprise or an entire productive sector.

The second indicator is useful in the evaluation of the impact of enterprise activities on the natural environment. This impact can be calculated with the help of physical and monetary indicators.

Table 9.2 Environmental aspect and damage related to each productive process step

Productive process step	Environmental aspect	Environmental impact
Raw material (R.M.)delivery	Emissions in the atmosphere Noise	Possible air pollution Possible damages to the operators’ health
R.M. Verification	Waste	Possible soil contamination pollution
Cold storage room	Use of energy resource	Possible air pollution Greenhouse effect
R.M. Washing	Use of water resource	Impoverishment of unconfined ground water
	Waste Water	Possible pollution of hydric body water receptor
Grading	Use of energy resource	Possible air pollution
Packing	Use of energy resource Waste	Possible air pollution Possible soil contamination
Shipment by road	Use of energy resource Emissions in the atmosphere	Possible air pollution Possible damages to people’s health Noise

Physical indicators measure the contribution of enterprise activities to the change in environmental conditions, locally and globally; they are an auxiliary measurement of the efficiency of the enterprise in managing natural resources and refer to the consumption of raw materials and energy, to the emissions of the productive processes and to the characteristics of the products.

Following the measurements of the quantities of natural resources taken from and/or discharged into the environment, the effects can be assessed.

Monetary indicators allow the enterprise to transform the changes caused in the natural environment into economic terms and so to integrate the environmental variable into the decision-making processes, which are traditionally based on economic considerations. The main requisites are reported below; no measure of the performance would be meaningful without them:

- *objectivity*: the evaluations on environmental problems carried out by companies are today too subjective;
- *demonstrability*: it is necessary to identify the action of the phenomena which have to be analysed;
- *significance*: clear and concise indexes can be elaborated but they do not really interest the management or the public.

Table 9.3 illustrates some indicators related to the impact categories of the company productive processes which can be applied to all agri-food firms with their related units of measurement.

For agri-food firms which, within the framework of their productive processes also carry out primary activity, it is necessary to quantify specific environmental indicators to measure the impacts deriving from the use of the Earth and of Biodiversity; the recommended indicators are:

- area of the habitat that is physically protected;
- area of the habitat which is not farmed but is identified as being environmentally important;
- total length of aquatic habitat that is physically protected compared with the total area managed;
- in environmentally protected areas the density off non-native vegetation;
- road length per unit area;
- areas dominated by native species compared with the total area managed;

Table 9.3 Examples of significant "Environmental Impact Categories" and their units of measurement

Impact category	Unit of measurement	Impact category	Unit of measurement
Climate change	kg CO_2 eq	Ecotoxicity	m^3—yrs
Stratospheric ozone	kg CFC-11 eq	Water use	l Water
Acidification	H^+ moles eq	Mineral resource	gm minerals
Eutrophication	kg N eq	Fossil fuel depletion	MJ eq
Photochemical smo	kg NOx eq	Land use/biodiversity	m^2 land occupied
Soil depletion	gm soil	–	–

- in environmentally protected areas the density of non-native vegetation;
- road length per unit area;
- area dominated by native species compared with the total area managed.

9.2.6.3 Decision Support Tables

Regarding the set of instruments able to support firms in choosing the most adaptive system of environmental labelling, a set of tables has been drawn up. Each table takes into account different aspects of the managing system, each of which is independent of the others; therefore, the firm will be able to choose one of the following aspects, obviously the one which satisfies its needs best:

- economic;
- environmental;
- need of the target group;
- content of the environmental communication.

At the end of this deliberate process, the firms will have all the necessary elements useful to make a discriminative choice among a labelling system of types I, II, III, and IV. When the typology has been pointed out, the firm will move towards the most useful and convenient label.

The idea of suggesting a way to identify the most suitable labelling typology, rather than just the label is due to the continuous evolution of the environmental communication instruments which are difficult to follow and predict.

- Economic aspects

With regard to the company commitment related to the estimate and amount of economic resources which can be used as a voluntary environmental communication instrument, different options are pointed out in Table 9.4, using an analogical presentation of costs.

Considering that, as has been said previously, type I environmental labels require the company to demonstrate label conformity to predefined parameters, the costs connected with the adoption of the trademark essentially depend on the type of laboratory analysis and on the internal procedures which the company has to develop to provide these guarantees; sometimes the payment of a royalty has to be added for the trademark used. Even though structural investments are not envisaged, this instrument turns out to be really expensive for the company which aspires to obtain the certification.

The environmental statements of type II are not all subjected to a certification system; at the moment, in case it is necessary, costs are not high and they generally refer to the demonstration of the truthfulness of what is communicated to the customer. In certain cases, such as the Carbon Footprint, it is necessary to make an LCA study and the costs are similar to the ones for type III labels.

Table 9.4 Levels of total costs of different environmental labels and declarations

Economic aspects			
$	$$	$$$	$$$$
Type I	Type II	Type IV	Type III

The costs related to type III labels refer to the necessity of making use of an external consultant who conducts an LCA study on the product or on the service, using a software and database available on the market; moreover, the costs increase because it is necessary to submit the study to a third body, attaching an environmental declaration of the product/service.

Finally, as far as type IV labels are concerned, the costs which have to be paid to the organisation which issues this certification have to be taken into account. For this reason, even if they are not ruled by ISO, sometimes these labels are more expensive than type II labels.

- Environmental aspects

If the productive process of a firm, which includes also the primary activity, can quantify some of the following criteria:

– total quantity of pesticide,
– plans for use of water,
– use of irrigation planners,
– pesticides and fertilisers periodically inspected,
– cultural practices,
– fertilizer and pesticide use,
– water consumption,
– fuel and electricity use,
– soil nutrient status,

the firm can then implement:

– Food eco-label Type I: SMK,
– Food eco-label Type III: Earthsure,
– Food eco-label Type IV: IFOAM Organic Production; LEAF Marque.

If the firm has already done an LCA study of its global productive process, or of a part of it, it can move towards these labelling systems:

– Food eco-label Type II: Casino Carbon Index (CCI);
– Food eco-label Type III: Environmental Product Declaration (EPD), carbon Reduction label, Earthsure.

If the firm wants to focus just on one of the criteria of the labelling system, e.g. the quantification of the greenhouse gas expressed in terms of emission of CO_2 eq/ 100 g of product, during the life cycle steps from raw material production to the consumer home (production—including agricultural processes; manufacture;

transport; packaging; distribution and point of sale), it can move towards the following labelling systems:

– Food eco-label Type II: Casino Carbon Index (CCI);
– Food eco-label Type III: CarbonNZero;
– Food eco-label Type III: Carbon Reduction Label;
– Food eco-label Type III: CarbonCounted.

Finally, if the firm has already implemented an Environmental Management System (ISO 14001:2006), it should implement:

– Food eco-label Type III: Earthsure.

• Necessity of the target group

The company can select the labelling system which best suits the different targets of the market, according to the features that each of them assume as regards the expected contents and the key messages which the company itself considers important in order to to fulfil its expectations (Table 9.5).

• Contents of the environmental communication

Table 9.6 offers an easy way to choose the labelling system and it is based on the key message decided by the firm and on the variables that it decides to insert in its environmental declaration and which can influence the choices of the purchase/consumption of its consumers/customers.

9.2.6.4 Choice of the Most Appropriate Labelling System

This phase corresponds to the "ACT" of the Deming cycle.

When the preferred criteria have been chosen, the company implements the voluntary environmental labelling system which best suits its organisational, environmental and economic features.

9.2.7 Reporting

During this phase it is possible to define the documents necessary to communicate the roles, the responsibilities and the authority needed to make the use of environmental labelling effective; the organisation has to decide and keep any paper or format documentation in order to describe the main elements of the labelling system and their interactions; these documents have to be kept under control. The documents have to be functional for the organisation which has to have a clear and exhaustive view of the procedures and of the internal activities necessary to implement the selected labelling system and to communicate it clearly to the

Table 9.5 Features of the company recipients and related environmental communication

Target group							
End user		Middle customer		Public Administration	Distribution		Government body of the territory
Uninterested	Proactive	Certificated firm	Not Certificated firm	Firm of services	Retail shop	GDO	
Type II	Type I/III	Type II/III	Type I	Type I/III	Type II/III	Type I/II/III	Type I/II/III

Table 9.6 Contents of the environmental declaration

Guarantees and certification forms	Environmental information	Environmental effects product/service as regards the consumer/customer	Competitiveness as regards the non-environmental performances	Benefits of the health/security of the consumers/customers
Type I	Type II/III	Type II/III	Type I	Type I

different people involved. The details of the documents should be sufficient to describe the main characteristics of the labelling system; the details and the quality of the documents will depend on the chosen labelling system and, of course, on the size and complexity of the organisation.

9.2.7.1 Drafting of the Required Documents

The data used to build up the system of the labelling/environmental declaration should be collected in order to be easily organised, kept and used by those who are interested in using them. The documentation should be managed in such a way as to have a fast access to all the information, especially, to the part which can become fundamental in critical situations and environmental emergencies.

The data evaluation should involve checks on accuracy, compatibility, reliability and applicability. The presentation of the collected data should mirror both the aim set and the target group.

9.2.7.2 The Team of Environmental Communication

The management should come to a decision regarding the procedures which define the responsibilities, times and ways of passing on the external communication to the different parties concerned; on the other hand, from them the organisation should expect to get some significant feedback so that it can give adequate answers. First of all it has to insist that the people responsible for the communication should transmit not controversial or vague but true information; the communication technique must not distort the message but, given that there are different interlocutors, information has to be as clear as possible and also define the times of the external communication. In order to verify the effectiveness of the communication it is possible to quantify some indicators such as: the number of the participants in the information meetings/number of invited people; number of cases of non-conformity due to ineffective messages/number of total non-conformity; increase in percentage of sales after the acquisition of the trademark; number of the external requests concerning the communicated environmental aspects, etc.

9.2.7.3 Logo

The logo can be put on the top of the package of the product.

It can also be put in the point of sale of the material; in the websites belonging to the product manufacturer or service provider; online reseller product catalogues (products) and online directories (service); advertising, product brochures, catalogues and other sales materials; in product manuals.

The aspect of the labels can be either a simple trademark which indicates that certain standards have been reached or in the form of a list of the emissions and of the impacts on different environmental areas. In both cases, labels are the result of the aggregation of data and information. It is important to make sure that this aggregation has been obtained in a believable and unambiguous way and within technically acceptable limits. The way of communicating the impacts on the label has to be as simple as possible; the label chosen has to be "suitable for the aim"; there are different ways to communicate environmental impacts on the label: for example, a single label should be used to communicate that the product respects a set of standards; other labels reflect the connected impact on a range of categories of impacts. In any case, when it comes to choosing the approach, the company has to bear in mind the aim and purpose of the label, which means that the aim can influence the related way of carrying out the communication.

9.2.7.4 Supports for Environmental Communication and Channels to be Used

When the company has obtained the environmental trademark which reflects its reality, it becomes fundamental to let the outside world know about the company's efforts to respect the environment. For this reason, the choice of the most suitable instruments and channels to transmit the message and its contents to potential recipients is extremely important; as the firm can use a range of channels; this choice is neither simple nor immediate. Information, in fact, has to be effective, readable, understandable and accessible to the interlocutors that the company has identified as its target.

The company can either opt to concentrate on limited publicity by preparing documents meant for the interested people, or it can decide to appeal to a large number of users. In the latter case it can prefer instruments such as the Internet and websites. Instruments are divided into two categories: *written communication channels and oral communication channels.*

Among the first:

- *websites*: an electronic means of communication, user-friendly for all concerned parties, internal and external. Thank to websites users can download reports, educational material, and links to sites where they can give feedback to the firm. The strength of websites is that they enable the firm to reach a large number of users and thus give the right information. Moreover this means of communication can be easily updated. However, websites have a weakness too: often firms underestimate interactivity with the users; moreover, the data should be uploaded using a format which can be read also by the not updated computers; finally, websites must not be expensive and a telephone number dedicated to the requests of the customers is an important asset;

- *e-mail*: an electronic means of communication to exchange information, messages and paper material. It has got many strong points: it is cheap and simple to use; it can exchange messages and information very fast and can reach a large number of people quickly and at the same moment. However, it must be pointed out that many people have no access to the computer or to the e-mail and, moreover, messages can be deleted before being read if the content is considered unimportant;
- *environmental or sustainability reports*: these instruments give full evidence of the company commitments and performance regarding a certain number of extremely critical environmental aspects; excerpts or summaries of these reports can be included in other forms of communication of the company such as financial reports. The strong point of these reports is that they help the company to delve into the different environmental aspects and to guarantee a high internal transparency concerning its most relevant environmental aspects. The only drawback of these reports is that they are expensive and difficult to update frequently. They can also give information which cannot be compared with similar companies;
- *printed material* (*reports, brochures and newsletters*): reports and brochures contain a summary of the services, specific interests, key points and participation methodologies of the stakeholder. The strong points in this case are that they can single out and analyse, if necessary, just one of the environmental aspects; they are not expensive and quick to draw up; they can reach a great number people at the same time. The weak points are: they can be misunderstood and they provide just basic information; moreover they cannot get direct feedback. Newsletters contain a periodical update of the work activities. It is advisable to use a simple and objective language register, photos, maps and a reference telephone number;
- *posters*: put in the appropriate public places, they describe the project pointing out its main aspects. They give general information; their costs are low and they can also reach those people who maybe do not know anything about the project. The weak points are: they give information without receiving any; they have to be placed in visible places; they can use photos and they have to be periodically updated especially when it comes to names and telephone numbers;
- *magazine articles*: they describe the characteristics of a project or of a service, are addressed to a large audience and they are also a good means of general information;
- *advertisements*: advertising relies on the use of newspapers and sponsorship; it can reach a large audience but it can be expensive and, in any case, it offers limited possibilities to describe all the environmental aspects.

Oral communication channels:

- *public meetings*: they are a way of exchanging information and opinions. They are based on presentations and sections where the interested participants can have all their queries answered; their costs are minimal and they can reach a large number of people. The interaction among the participants should be limited and not all the points of view expressed can be taken into account. The presence of a chairman is advisable;
- *target group visits*: visits to the organisation area are organised in order to establish a direct contact with the company involved, showing the environmental actives that it is carrying out; the main disadvantages in this case are the limit of the number of participants and the use that has to be made of the working time of the human resources in order to organise the guided tour of the firm; it is advisable to organise tours just for those productive processes directly involved in the business strategies;
- *conferences and workshops*: these are an opportunity to exchange views with the parties concerned with a view to involving the company in high priority goals; they can be expensive from in terms of time and money.

9.2.8 Valuation of Environmental Communication

9.2.8.1 Evaluation of Environmental Communication

An organisation should take its time before the labelling system can actually be adopted. This time depends on the type of the chosen communication, the number of the parties concerned and their interests and the chosen communication channel. The organisation should review and evaluate the effectiveness of its environmental communication taking into consideration the following aspects:

- its policy of environmental communication;
- how the principles of environmental communication have been applied;
- if the set goals have been reached;
- the quality and appropriateness of the information given to the target group and the environmental communication itself;
- the procedure followed prior to the environmental communication;
- the feedback of the stakeholders;
- whether the environmental communication programme has favoured a relevant and effective dialogue with the target groups;
- whether the approach and the procedure followed have been clear;
- whether the environmental communication satisfies the needs of the target groups;
- whether the target groups have understood the aim and contents of the environmental communication.

The results of this evaluation process should be the basis for the top management's review of the company's policy in terms of environmental communication.

9.2.8.2 Periodical Audit

The organisation has to adopt the right methods to monitor and measure, in an objective and fair way, the performance of the system processes of the environmental labelling system; by so doing it can show the capacities of the actions taken to achieve the objectives set; if the results hoped for have not been reached, corrective actions have to be taken bearing the company targets in mind.

Each company should plan and programme the right internal control modes for the entire site and its activities concerning the environment in order to reach a sufficient starting level of environmental performance and to monitor efficiently the results produced by the virtuous circle of continuous improvement. Therefore, the internal environmental audit is in itself a kind of self-evaluation which is organised and managed in all its phases by the firm itself.

The auditors interested in this evaluation either belong to the company or are consultants or experts who act on behalf of the company management. For this reason it is important to identify the control and internal inspection criteria in order to facilitate the control activities, correction, audit and review of the environmental aims and to respond to any changes in the productive and market circumstances. Moreover, if some non-compliances occur, in order to intervene in appropriate ways, companies will have to make an effort to identify the causes and make sure that such situations do not recur, using the right procedures whereby the right corrective and precautionary actions can be taken. Through periodical audits the organisation can verify if the voluntary labelling system conforms to the planned actions and if it is being properly applied and kept active. In particular, it is better to control the procedures connected with purchases and contracts to make sure that the suppliers and contractors follow the environmental policy of the company; these periodical audits have to monitor the following: reduction in environmental emissions; reduction in the discharge; treatment and reclaim of wastewater; reduction in waste production; the use of a higher quantity of re-used, recovered and reclaimed products; preventive measures regarding soil contamination; rational and lower use of natural resources; energy saving measures using renewable non-polluting or low polluting sources,; reduction of noise, vibration, etc.

To this purpose test criteria should be identified; so should be internal checks using, for example, specific environmental communication indicators which have to be chosen or identified carefully in that they help the company trace any critical points and bear the interests of the parties concerned in mind. The indicators used by the organisation to evaluate communication have to be simple, precise, easy to understand and relevant to the process to which they refer.

Below are some of the possible indicators:

- number of letters/telephone calls/e-mail per unit time received by the concerned parties and connected with environmental aspects (e.g. number of e-mails in a month) and analysis of the content (positive or negative);
- number of complaints about some aspects, activities, environmental problems;
- number of awards received;
- number of articles published through the media;
- number of visitors (e.g. every month) looking for environmental information in the pages of the company website;
- number of outreach activities carried out and analysis, by means of surveys/questionnaires, of the most effective ones according to the target groups.

Considering the results obtained using the above-mentioned indicators, the company can organise a revision of its environmental policy or of the other policies and strategies.

To determine the need of a revision an organisation should:

- evaluate the suitability of the resources involved in the completion of environmental communication;
- evaluate the process of collecting data;
- distinguish between any necessary improvement in the information given to the parties concerned (including the information development process) and the communication process (including the approach adopted).

Before deciding to make any change in environmental communication policy, strategy or activity, the company should take into account the parties concerned, whether they can understand the change and how the firm can explain the reasons for this change.

9.2.8.3 Cost Analysis

There are a lot of costs linked to the implementation of the labelling system. Among them, the organisation should foresee:

- Labelling costs
  - cost of the external communication of the results achieved;
  - costs entailed by the definition of the technical characteristics that a product should have to conform to the chosen labelling system;
  - costs of the methodological determination and of the working cycle;
  - inspection and internal audit costs;
  - cost of the external communication of the results achieved;
  - cost of the audits carried out by the body which issues the trademark, if required;

- cost of the internal personnel to be assigned the voluntary labelling system;
- costs of the preparation of the logo, if required.

- Preventive evaluation costs
  - costs of the necessary market research to find out about the sensitivity of actual and potential customers to the environment;
  - R&D costs to create products which satisfy the requisites of the labelling system chosen;
  - costs of design and development of green eco-compatible products, which often require reports integrated by suppliers and customers;
  - costs of design to transfer the ideas and the principles put into practice during the research and development of the products.

- Costs of the best technologies available
  - costs of the introduction of clean technologies which reduce environmental impact;
  - cost of sewage recycling;
  - cost of production waste reclamation;
  - cost to install Renewable Energy Sources (RES);
  - cost of packaging change;
  - cost entailed by the use of re-used packages;
  - cost of the replacement of non-toxic impacting material;
  - cost of the new market opportunities for the re-use of raw materials;
  - costs entailed by the definition of the technical characteristics that a product should have to conform to the labelling system chosen;
  - costs for the determination of the methods and of the working cycles.

9.2.8.4 Advantages of Labels and Environmental Declarations

Environmental labels are a valid instrument as regards producers, consumers and distributors because they bring about different direct (financial) and indirect/external advantages.

There are three different categories of direct advantages:

- competitive advantages: environmental labels strengthen the relationship with the different actors of the chain defining the environmental position of the product, guiding the firm in the improvement processes and communicating the results to the consumers; they improve the relationship with the company stakeholders; they increase competitiveness and enhance the company image; they are a fundamental factor for the careful consumer; they indicate the continuous commitment to environmental issues; they open new markets where labelling is a prerequisite, for example the exportation of agri-food products into countries where these systems are well-established. The reduction of multiple labelling may be done through the self-evaluation of the company;

- economic advantages: environmental labels help point out any possible waste and save resources thanks to environmental efficiency improving environmental performance; they reduce the costs of energy consumption, waste management, water consumption, the flowing back treatment, raw materials and packages; they improve the evaluation of structural investments;
- managerial advantages: environmental labels improve the participation of the employees; they define exactly the skills and responsibilities of the single person; they help manage coherently the voluntary instruments already in the company; they improve legislative compliance, competitiveness and productive capability; they optimise company resources.
- Among the indirect advantages related to the introduction of environmental labels the following are worth mentioning:
- reduction of production costs due to the better technologies available which protect the environment, are run by more efficient management procedures and control the activities related to the environmental aspects of the productive process; this helps the company economise in terms of costs of energy, waste management (collection, transport, processing and disposal), water consumption, cleaning and discharge of the effluents, purchase of the raw materials and packages;
- improvement of the relationship with banks, capital market and insurance companies thanks to the higher attention of the firm dedicated to analysing environmental risk;
- reduction of the costs of administrative sanctions and detentions of activity of the plants due to the violations of the law regarding the environment;
- reduction in the costs of environmental consulting services and of the necessary equipment in order to re-establish the compliance with the violated environmental standard.

Labelling makes the community more aware of the impacts caused by convenience goods and promotes sustainable life styles by sensitising people to environmental issues.

Labelling also meets the needs of the distributors, that is the main actors of the large-scale retail trade who are fully aware of environmental problems and who demand stronger commitments from their suppliers. Therefore, labelling is not just meant for the final product but it can also be used within the supplier-customer relationship in the Business to Business area.

Finally labels, which give easy and understandable information about the environmental impact of the product, promote responsible consumption, help consumers choose the products which respect the environment and at the same time improve consumers' knowledge of environmental issues.

As a consequence, labels are not only a means of communication but also the result of the commitment of the company to manage the critical state of the environment, combining the efforts of both firms and consumers to put into practice a sustainable model of production and consumption.

Some of the risks that may have to be faced:

- lack of common standards and a consequent decay of competitiveness because of the behaviours of the more unscrupulous competitors;
- a constant lack of respect for implicit and defined standard;
- the adoption of a labelling system which does not comply with the type of organisation;
- the non-involvement of the personnel in environmental policy and strategies of environmental communication;
- the lack of adequacy of the actions taken with a view to the continuous improvement.

9.2.8.5 Potential Integration with Other Firm Management Instruments

The System of Environmental Management in accordance with ISO 14001:2004 or EMAS standards is not a prerequisite for a voluntary environmental labelling system to be set up; anyway, the presence of one of these standards should facilitate some necessary steps such as the identification and quantification of environmental impacts and the implementation of flowcharts which support the choice, as has been described in the Sects. 9.2.6.1, 9.2.6.2, 9.2.6.4 of these guidelines.

A traceability system, set up following the voluntary ISO 22005:2008 standard, should also be a valid support; it establishes the principles and prerequisites for a food and food chain traceability system whereby companies can follow the course of the materials, identify the necessary documentation for each step of the production and guarantee the coordination and information among insiders.

Finally, within the framework of the modular structure of the POEMS model, here proposed, the guidelines for the specific needs of the organisations and for the aims that they plan to reach, can be easily integrated with one or more company managing systems such as those related to quality (ISO 9001:2008), on-the-job safety (OHSAS, *Occupational Health and Safety Assessment Series,* 18001:2007), ethics (SA, *Social Accountability*, 8000:2008) or food safety (ISO 22000:2005).

If the adoption of the company policy is shared and supported by all the components of the organisation, the starting evaluation of the company, proposed in Sect. 9.2.3, can be done in an integrated way using the managing approach certifications which help view the company from different point of views also including the quality and the safety of the products. The definition of the environmental policy and the idea of adopting a voluntary labelling system can influence the decisions of the management which can then channel all the human, technical and economic resources to build up the common company programmes.

Since the ultimate aim of a voluntary labelling system is to favour the application of all the standards, including legislative obligations, it is possible to integrate the chosen labelling system with other voluntary instruments of environmental policy already existing within the firm and avoid duplications and overlapping. This can reduce the quantity of paper documents thanks to the adoption of schemes and; consequently, the time need for the internal check by the certification bodies in case this is envisaged. As a consequence, all this leads to the rationalisation of the company behaviour and to the adoption of common policies which optimise the activities and the human resources of the company with the aim of preventing environmental damages within the framework of a synergic vision.

9.2.8.6 Final Recommendations and Constant Improvement

Environmental communication is one of the most important issues that every organisation has to face, with or without an ongoing environmental management system. Environmental communication refers not only the managerial issues but also to the values put into practice by the organisation. In order to guarantee the success of the communication processes, it is important for the organisation to consider itself as a responsible partner inside society and to meet the environmental expectations of the parties concerned.

Since the advantages of the voluntary labelling system are constant, it is important to take a proactive attitude towards environmental problems in order to manage the information more rationally and to tackle the environmental problems which involve the entire community. The community, in fact, is aware of the importance of ecology and it is also aware of the necessity for companies to invest in it to improve their performance. For this reason, internal audits or other monitoring systems which can point out immediately any non-compliances and areas of improvement, should be planned. Moreover, through standard communication channels, it is advisable for the company to disseminate the results achieved, giving information about its environmental performance thus consolidating the awareness of customers and suppliers.

Improvement concerns the achievement of the programmed aims, the satisfaction of the customers and of the other parties concerned, legislative compliance and the assessment of the performance of the products and processes.

9.3 Conclusions

The proposed guidelines have been divided in iterative procedural steps and they adequately support the management in choosing the most suitable environmental labelling for its productive reality. They can communicate to distributors and consumers objective, comparative and believable information about the products and the services which subject the environment to little stress. They can also be adopted by all agri-food companies which can thus obtain a real and competitive advantage, and enhance their continuous improvement of the economic, ecological and social performance.

These guidelines help firms to choose the type of voluntary labelling system among those already existing (which can cause uncertainty and confusion in the markets). They are, at the same time, a valid support for consumers in their attempts to understand better the contents of the messages relating to environmental impacts. Moreover, these guidelines enrich the cultural change process regarding eco-sustainability and the sensitivity of the stakeholders involved in different ways.

As a consequence of these guidelines implemented by the company, a green marketing approach in the product area could promote the integration of environmental issues with all aspects of the corporation's activities, including strategy formulation, planning, construction through production and relations with consumers. Corporations will have to find solutions to environmental challenges opting for the right marketing strategies, products and services in order to remain competitive. Examples of such challenges are: new technologies for handling waste, sewage and air pollution; product standardisation to ensure environmentally safe products; genuine products which help conserve resources; more health protection for workers.

During the evaluation stage this approach encourages manufactures to check suppliers' environmental programmes, require minimal packaging of input and consider sources of material that could be easily replenished or recycled.

During the production stage, SMEs are encouraged to reduce emissions, toxicity and waste and to preserve water and energy. Companies are also encouraged to seek and develop alternative uses for waste products, to revise the manufacturing processes to minimise waste generation, to minimise energy use, and to attempt to find alternatives sources of energy.

During the consumption-usage stage, minimisation of packaging, conservation of energy and minimisation of waste from product maintenance and service are strongly urged; the final stage of a product is its disposal and the label introduces the concepts of re-use and recyclability, in addition to the concept of waste reduction.

The guidelines developed are applicable to all products, in any sector and in the course of any agri-food chain step; they could be useful to develop a framework assessment methodology for food and drink products and to identify suitable voluntary communication tools; they also could be considered the starting point to identify the practical implications of various environmental assessment and information systems because they take into consideration the various environmental aspects and impacts of production and consumption at different stages.

Moreover, these guidelines bear in mind any possible variations in the production approach, the sensivity of the local environment, the type of cultivation and the different environmental labels available to communicate environmental impact.

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Chapter 10
The Implementation of the Guidelines for Environmental Labels and Declarations in Agri-Food SMEs

Maria Teresa Clasadonte, Agata Lo Giudice and Agata Matarazzo

10.1 Introduction

In order to test the applicability of the guidelines, a firm which operates in the pasta chain was chosen as it was considered representative of the Sicilian economic system because of its size and market; this organisation could be a good SME example of. After a brief description of the sector and production chain, the path followed by the firm towards the choice of a voluntary environmental labelling system which suited its peculiarities will be reported.

10.2 Implementation of the Guidelines for Environmental Labels and Declarations in a Pilot Firm in the Pasta Production Sector

The industry of pasta in Sicily is characterised by two different types of companies: the industrially organised ones which generally produce dry pasta and those which are organised as micro-small productive units scattered all over the urban areas and which directly produce and market fresh pasta.

At the moment in Sicily there are 16 factories which industrially produce dry pasta spread all over the region; however, more than half of the overall capacity is concentrated in the area of Trapani and Palermo areas.

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This sector has shown, during these last years, clear signs of a concentration process, with the closing down of small-sized enterprises and increase of the overall regional working capabilities. The medium-large enterprises with a fairly good organisation of their productive activity, maintain their position in the regional market because they are able to produce pasta at middle-low costs and, thanks to their territorial location, supply shops having to face limited distribution costs.

These types of enterprises are based on a company system and they are mainly limited companies (11 units), followed by joint-stock companies (3 units) and co-partnerships (2 units).

The enterprises which are only orientated towards the production of pasta are 4 whereas the ones in which pasta is integrated with other mill activities are 10. The integration with milling in the initial stages allows the pasta industries, as has already been said, to plan their distribution policy and exert a higher control on the quality of wheat.

Next to the industrial pasta factories there are also firms of micro dimensions, which sell pasta on the local market inside the urban core.

The various phases of the pasta productive chain will be described in detail (Fig. 10.1):

10.2.1 Wheat Production

During the durum wheat manufacturing process, all the modern agronomical technologies of mechanised working fields are used. The phases foresee an intensive exploitation of the soil. The analysed activities are: plowing, trimming, dressing, seeding, top dressing, picking, transport. The result of these phases is hard wheat and straw.

The wheat harvest in Italy starts at the end of May- at the beginning of June in the South of Italy- and it ends at the beginning of July in the North of Italy. The wheat is reaped by reaper-threshers during the ripening or the death phases, when the humidity of the grains is lower than 14 %. The reaping consists in the cutting of the wheat stems using the reaping machine. After the cutting, the sheafing phase follows; it consists of tying the wheat in sheaves: it can be done also mechanically using reaper-binders which reap and tie the sheaves.

Threshing is the action carried out to separate the grain kernels from the cods (in which they are contained), and from the straw and the rachises of the ears. In the past threshing was handmade, then the reaper-binders were introduced. In time these were replaced by modern reaper-threshers which are used both for reaping and threshing.

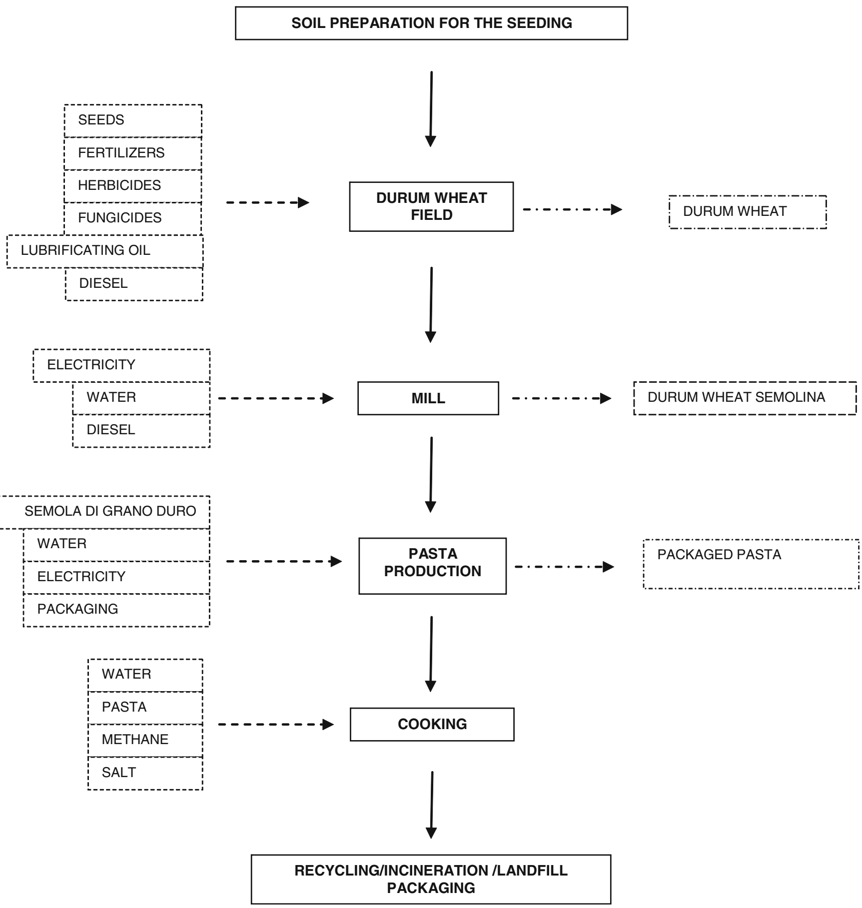

Fig. 10.1 Flow chart of the chain from the durum wheat to the packaged pasta

10.2.2 Storage

Storage is an essential phase to improve the product. In the past it was directly done by the small and medium companies but nowadays corporate storage is difficult because of the expensive necessary structures and the set of standards to follow. Before being stored, the grains have to be precleaned by suction and screening; then, if their humidity is lower than 13.5–14 %, they can be stocked.

Storage can be done in horizontal or vertical silos which have to satisfy the following prerequisites:

- separation from other company buildings around the silos;
- insulation and protection of the external environment to avoid access to birds, rodents and insects;

- smooth walls, easy to clean and disinfect;
- waterproofing roof to prevent water infiltrations;
- a good ventilation system;
- a monitoring system to control the presence of insects in the foodstuffs.

Modern conserving methods provide forced refrigeration and the conservation in a controlled atmosphere.

The incoming stocks of grains have to be stocked separately according to their characteristics; in order to increase the value of the product, homogeneous stocks are put together satisfying the demands of the transformation industry. Moreover, it is necessary to certify in written form the lack of contaminations (chemical residues, mycotoxins, GMO) in order to guarantee the traceability and security food requested by the end-consumer and by the regulations.

10.2.3 Milling

The semolina is extracted from the grain produced by the durum wheat; it is the raw material for the preparation of pasta itself and is formed by more or less big, sharp-edged and not floury endosperm fragments.

Durum wheat milling is carried out using a different system from the one adopted for soft wheat because it is meant to produce both semolina (and not flour) and also some other by-products such as bran and fine bran, small flour and broken grains of wheat for zootechnical use and cleaning scraps formed by particles, blades of straw and foreign material.

The most important qualitative fact for the semolina industry is the milling yield (sifting rate) which corresponds to the kg of semolina obtainable from 100 kg of grains. This value depends on the weight per hectolitre, the degree of whiteness and in particular the ash content; the law, in fact (Presidente della Repubblica 1967, 2001; Ministero del Lavoro e delle Politiche Sociali 2004), decrees that the semolina ash content must not be higher than 0.85 and in order not to overcome this limit sometimes the miller has to lower the milling yield.

The prerequisites required for durum wheat acceptability are:

- acceptable minimum hectolitre weight: 76 kg/hl;
- maximum percentage of white grains: 50, which wheat grains: 4 %;
- tolerance relating to whitness is 20 %.

The high quality of durum wheat is typical of the regions in the South of Italy, thanks to the edaphic and climatic conditions which are decisive characteristics to obtain an excellent quality of pasta.

The prevalent use of durum wheat for the preparation of pasta was defined by law (Presidente della Repubblica 2001) and it states as follows: by the names “durum wheat semolina pasta” and “refined durum wheat pasta” are meant the products obtained from the drawing, rolling and following drying of doughs specially prepared with:

- durum wheat semolina and water;
- refined durum wheat and water.

The different milling phases are:

Preliminary cleaning

It consists of two steps: the corn is taken from the silos and washed; all the impurities from the coarse ones (e.g. stones, rocks, straw) to the thin ones are removed.

Conditioning

During this phase the corn is stored at a particular temperature and humidity (through the "dampening" process with water, poured in a percentage between 1.5 and 2), an operation which makes milling easier and the flour obtained is good to knead.

Milling

This is done by using metal rolls which rotate in the opposite direction to each other: they have cross stripes which break the grains. There are three types of equidistant rolls with decreasing grooves: the first is used for sorting the bran while the second and third ones are used for the fine bran groats. The cylinder for the milling is smooth and it is used for refining rough- ground corns. Bran and fine bran are 20–22 of the vegetable waste and they are rich in fibre. Semolina (a rough flour with sharp corners) is obtained the milling of durum wheat. This product is useful for the production of pasta, that is semolina. From the milling of the semolina re-ground semolina is obtained; this is also called refined semolina or durum wheat flour, which is used in the production of durum wheat bread.

10.2.4 Dry Pasta Production

Dough and extrusion

The semolina then is taken out of the silos and is sent to the kneading machine where the doughing, extrusion, design and pasta cutting phases are carried out.

Pasta drying

During the drying phase the water quantity in the pasta must be reduced gradually until the 12.5 % imposed by the law is reached.

For the drying pasta phase heat is fundamental and, in particular, in the form of the overheated water which passes through the coils and radiators into the grain dryer, releasing the needed heat. Here electric operation fans blow on the radiators generating currents of hot air which dry the pasta.

Packing

In the packing rooms, the pasta is taken from the silos where it is stocked and is transferred to the wrapping machines by means of conveyors and electric hoists.

10.2.5 Consumption

To cook pasta you need a litre of water for 100 g of pasta and 10 g of common salt (NaCl) for each litre of water. Heat energy is necessary during the cooking phase and it can be generated from different sources of energy.

10.2.6 Final Discharge

This phase refers to the procedures to be followed for the packing waste discharge (cardboard or plastic boxes, etc.). As a matter of fact, the environmental impact is important and a method for treating the waste should be adopted; it means: re-use, recycling/resource recovery, disposal of solid waste in the landfills, etc. (Lo Giudice et al. 2011).

In the following box there is a brief description of the pilot firm—the subject of the study case—which was the first to implement the guidelines proposed in the previous chapter.

Pasta Faraci

The Faraci trademark was born in 1930. The present state of this enterprise is the result of experience and tradition which have been handed down from generation to generation for over 70 years. Faraci have always produced durum-wheat semolina pasta. The plant is located in Sicily in the Syracuse province and covers an area of about 30,000 m^2, 2,000 m^2 of which is covered. Today the farmhold is managed by the third generation and the traditional methods adopted by the grandfather have been improved by new productive systems which respect both the environment and the consumer. For this reason, the drying process is carried out at a medium–high temperature to conserve the natural characteristics and unique taste of the pasta. The grains are strictly Sicilian and selected by production managers who are able to offer the consumer a product of a constant good standard thanks to the company milling apparatus. The productive chain meets all the law requirements, respects all health and hygiene standards including the internal control standards for food companies (HACCP) and the recent standard

relating to chain traceability. In these last years, thanks to the Faraci trademark, the farmhold has consolidated the Sicilian market and it has been planning to expand abroad, looking at the international market.
Products

- Short Pasta
- Long Pasta
- Small Past
- Special Pasta
- Biological Pasta
- Biological whole-wheat
- Bronze-drawn pasta
- Condiments and typical sauces

"PASTA FARACI" factory has the following certifications:

- BRC (British Retail Consortium)
- IFS (International Food Standard)
- HALAL

The company has drawn up the check lists reported in the different sections of Sect. 9.2.3 of the guidelines, "Starting evaluation of the firm", with the aim of furthering their knowledge and the sensitivity of the organisation to environmental issues and of identifying the environmental impacts produced during the various phases of the productive process.

In particular in Table 10.1 reports on the main information collected by the firm.

As far as the environmental policy (Sect. 9.2.3.2 in the guidelines) of the firm is concerned, from discussions with the management, it emerged that the foremost objectives of the company should be: to encourage suppliers to adopt more sustainable farming production systems; to enrich the knowledge of its consumers regarding eco-compatible reduction; to prevent and reduct environmental impacts connected with the company productive cycle; to implement a system of integrated medium-term management.

Regarding the environmental communication policy described in Sect. 9.2.4, the management has decided to control periodically the procedures and the results of the company's environmental performance in accordance with the legally binding requisites; it has also decided to make all the necessary improvements in order to reach the environmental aims described above, thus ensuring the continuous improvement of the company at large.

Moreover, to promote this policy, the management pointed out the appropriate financial, human, technical and structural resources (Sect. 9.2.4.3 of the guidelines) with a view to putting into practice programmes of technological development within the company and monitoring the effectiveness of the communication

Table 10.1 Company check list process

Data	Answers	Data	Answers
Name	M.I.A. s.r.l.	Label	In accordance with the law
Legal form	Limited company	Distribution net	Own means (within the region) Wholesalers (other)
Sector	Pasta	Types of packages	PP Carton
Site	Floridia (SR), Italy	Difficulties to carry out the legally binding standard in the agri-food sector	NO
Employees	20	LCA study	YES
R&S in QES	YES	Voluntary certifications	BRC IFS HALAL
Request for certified products	YES	Knowledge of voluntary environmental labels	Type I, II, III, IV
Customers' environmental sensitività	YES	Renewable energy sources	NO
Steps of the productive cycle (internal)	Reception of raw materials; Dough, compaction, extrusion; Drying process; Wrapping; Storage; Distribution;	Steps of the productive cycle (external)	First activity: conventional
Main environmental impacts	Materuak waste packaging Energy consumption		

system set up. As regards Sect. 9.2.5 of the guidelines, the management decided that the company strategy of environmental communication had to include the identification and quantification of the different environmental impacts connected with the different steps of the productive process; moreover, from the analysis of the specially carried out market research, it emerged that the reference target group for the company seemed to be mainly composed of the current end-consumers, who were more or less sensitive to environmental issues, distribution operators of the pasta product and other consumers, including foreign ones, who would remain loyal to the firm if it adopted proper environmental communication systems (Salomone et al. 2011, 2012).

The main company environmental impacts have been pointed out, analysing the life cycle of the entire productive chain (from the farming to the final consumption by the end-user and the disposal of the packages): in particular, as far as emissions in the air were concerned, ammonia emissions (NH_3), and nitrogen oxide and dioxide (N_2O and NO_2) were detected; in water instead, nitrate ion (NO^{3-}) and phosphate ion ($PO_4{}^{3-}$) were detected besides the high energy and thermal consumption during the entire production process.

The most important indicators of the environmental performance detected during the company's environmental evaluation were: Human Resources, Health and Climate Change.

The information collected by the firm, subject of this case study, was integrated with the decision support tables given in Sect. 9.2.6.3 of the guidelines: it emerged that the voluntary labelling system most in line with the organisational, environmental and economic characteristics of the company was Type III.

In particular, considering that the company had already done an LCA study and that in the literature the "Grain Mill Products" Product Category Rules (PCR) Basic Module and the PCR "Uncooked pasta, not stuffed or otherwise prepared" and "Pasta, cooked, stuffed or otherwise prepared; couscous" existed already, the management decided to orientate itself towards the "EPD label" (Swedish Environmental Management Council 2012).

Currently in Italy only two companies, leaders in the pasta sector, have achieved this labelling while in Sicily no company can be proud of this award. The pilot firm has all the instruments to implement this ambitious project and it could be the first Sicilian firm in the sector to obtain the EPD label with all the competitive advantages, market share, etc. that would ensue.

10.3 Conclusions

The experience resulting from the application of the guidelines proposed to the pilot firm has shown how it is possible to choose the voluntary communication system, closer to the business reality, by starting from the analysis of the company activities and of the expectations of the management, the stakeholders and their environmental awareness. Moreover, the lack of difficulty of applying and implementing the guidelines has been pointed out. Following the iterative procedural steps and making use of decision support instruments, the organisation has achieved the aim of giving to its distributors and consumers the necessary information for a conscious choice of eco-compatible products; it has also given the relevant information connected with the phases of the productive process, the product itself and the performance in terms of environmental impact.

By choosing the most suitable environmental label, the pilot firm can improve its production chain drive within the limits of sustainability, also because the success of any environmental label mostly depends on the level of consumer awareness.

For food and drink products, however, it is very important to establish standard environmental assessment methodologies and to identify suitable tools for the communication of the environmental credentials of labelled products to consumers and other stakeholders, who look for clear information regarding the environmental impacts of the product so that they can make conscious purchasing decisions.

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Part V
Product-Oriented Environmental Management Systems (POEMS)

Chapter 11
Product-Oriented Environmental Management Systems: Methodologies and Experiences

Roberta Salomone, Giuseppe Ioppolo and Giuseppe Saija

11.1 Introduction

In the last few years, many environment-related challenges linked to market and regulatory pressures have increasingly been impacting European companies, often with significant consequences in terms of competitiveness.

With reference to regulatory pressure, various EU policies and directives can be cited as they have increased the legal, financial and market-related pressure to develop more sustainable products especially on manufacturing industries, forcing them to become more sustainable, expanding their responsibility from the production site to the whole product supply chain (Maxwell and van der Vorst 2003; Jørgensen 2008). This is highlighted, for example by: the Integrated Product Policy (IPP) Green Paper that aims to strengthen product-focused environmental policies and assist the growth of a market for greener products; the End of Life Vehicles (ELV) Directive focused on the automotive sector; the WEEE Directive that promotes separate collection, treatment and recycling of Waste Electrical and Electronic Equipment (W-EEE); the RoSH Directive for the restriction of the use of certain hazardous substances in EEE; the EuP Directive on the eco-design of energy-using products (EC 2000, 2001b, 2003a, b, 2009).

Similarly, market pressures also influence companies' behaviour. Nowadays, companies are considered responsible for the impacts of their operations in each phase of the life cycle of the products they make: from the extraction of raw materials, on through distribution, up to consumption and final disposal of the

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product, thereby leading to the so-called "extended liability of producers" (Koudate and Samaritani 2004) and they face a much wider range of problems associated with the total impacts of their products or activities over the lifetime of their products (Sinding 2000). Indeed, while firms were once concerned mainly with quality and productivity and their environmental liability was restricted to what occurred solely in the manufacturing phase, this is now no longer the case. This is because a new scenario is emerging in which the customer seeks a product that is able to satisfy not only expectations in terms of function, quality and cost, but also expectations demanding products that save energy, are eco-compatible, recyclable, etc. The attention paid to product characteristics is broadening: environmental characteristics of products and the way they have been produced, transported and disposed of, are gaining importance (de Bakker and Nijhof 2002). Firms therefore need to be able to take charge of a process that extends beyond the confines of their factories, starting from design and continuing throughout the life cycle of a product, right up to its final disposal.

This means that, in pursuing competitive strategies, the boundaries that separate firms from other actors in the economy and those between process management and product/service management have turned out to be borders that firms can step over any time they decide to make a real commitment to improving their environmental performance. This different perspective in the consideration of environmental issues is bringing about the need for more sophisticated management tools that allow firms to control and properly manage emissions and waste originating from different life cycle stages of products, and firms will have to develop suitable ways to organise themselves in response to this environmental product demand (de Bakker 2002). "The number of firms working on the environmental performance of their products is becoming higher, and more firms have begun directing their environmental efforts earlier in the product chain" (de Bakker et al. 2002).

In order to manage these challenges, new strategies should be designed and, in this context, *Product-Oriented Environmental Management Systems* (POEMS) could play a key role in defining them.

11.2 State-of-the-Art and Literature Review of POEMS: Methods and Experiences

The concept of *Product-Oriented Environmental Management System* (POEMS) has been introduced quite recently in order to respond to the strong need for integration between standards for EMS (ISO 14001 and/or EMAS) and standards for products (mainly Eco-Design and Life Cycle Assessment), but it still lacks a standardised methodological structure.

The international debate on the subject began more than ten years ago,[1] gradually enriching literature with both methodological research and practical experiences. Indeed, nowadays there are different POEMS models and applications available in literature, but this tool is still in its infancy and further improvements are needed to adapt it to the requirements of different firms, which vary greatly depending on their size, sector and/or market characteristics.

In order to bring order and clarity to the main issues concerning POEMS, a literature review of previous methodological and applicative studies was performed. The review method employed, consisted of classifying and separately analysing the collected material on three different levels of document content:

- Level 1—projects and programmes concerning POEMS application;
- Level 2—technical standards suitable for the POEMS structure;
- Level 3—methodological research on POEMS framework.

The state-of-the-art and literature review was organised in order to cover the most relevant articles on the specific field of POEMS, although documents and manuscripts reporting detailed descriptions of other product-oriented environmental management approaches[2] were also sometimes considered, whenever they could be a useful input for the definition of key features of a POEMS model.

In some cases there is an overlap between levels (especially 1 and 3) when articles report both on methodological aspects and project results: in these cases the article was inserted in the level that mainly represents the research content or in both categories if significant inputs were detected for both applicative and methodological purposes.

The final goal of the state-of-the-art and literature review is to identify models and case studies on POEMS from which to extrapolate key topics for designing a complete theoretical framework of the tool. These *key topics* will be useful starting points to drive future research and developments and successful implementation of POEMS.

11.2.1 Projects and Programmes Concerning POEMS Application

There have been various examples of projects aimed at POEMS implementation since the 1990s, and in literature it is possible to find articles containing reviews of these international experiences with varying levels of detail (e.g. Ammenberg and Sundin 2005a; Andriola et al. 2003a; EC 2001a; Luciani et al. 2003). A brief

[1] The first applicative experiences of POEMS certainly date back to the period 1996–1998 and are related to the Dutch Environment Ministry's PMZ programme—VROM (see Sect. 11.2.1.1).

[2] See Sect. 1.2 for an overview of different product-oriented environmental management approaches.

examination of the most interesting projects, organised with a country-application method, is reported below.

11.2.1.1 The Dutch Experience

In the Netherlands, in the 1996–1998 period, the Dutch Environment Ministry (Ministry of Housing, Spatial Planning and the Environment—VROM) developed a POEMS policy, in close cooperation with Dutch industry, sector organisations and intermediaries. In particular, the "Stimulating Product Oriented Environmental Management" Incentive Programme (in Dutch, Product en MilieuZorg—PMZ Programme) aimed to introduce and support a process of continual product improvement and systematic product environmental innovation, through the development of POEMS (participants in the project could obtain a subsidy of up to 50 % of the costs), mainly intended for the introduction of Eco-Design activities into EMS routines. This experience can be seen as a starting point for the diffusion of POEMS concepts and application as a consequence of the introduction of a mandatory scheme into government product policy (VROM 1998).

The monitoring activities on the Dutch companies involved in the PMZ Programme pointed out that (Brezet et al. 2000; Collignon 2003; Luciani et al. 2003; von Henk 2000; VROM 1998):

- the reasons for implementing a POEM System varied depending on the size of organisations (for larger firms it is a strategic challenge, for smaller ones it is a way of anticipating government measures); in any case, the main reason was better knowledge of the environmental impacts of their products and of the product chain in order to structure environmental policy;
- the greatest problems for firms are often related to the collection of the necessary information by suppliers, due to their poor familiarity with the gathering and management of environmental data; difficulties were also encountered in setting up regular contacts;
- SMEs were generally not able to collect complex information from different partners in the production supply chain and most of them were not able to develop feasible improvement options on the basis of the eco-profile obtained;
- the companies involved became aware of the strategic importance of environmental actions and of the need for every part of the organisation (marketing, product design, production and environmental affairs) to work together;
- the presence of a Quality Management System (e.g. ISO 9001) encouraged the step towards POEM System implementation;
- companies already operating with an Environmental Management System ISO 14001 found little added value with POEM System implementation;
- companies integrated POEM more quickly when management clearly declared that the environment is strategic for the company's success;
- the main characteristics that a POEM System should satisfy are: it can easily be incorporated into business operation; it is closely related to R&D, purchasing,

production, sales and marketing; it can be used to compare a company's own product situation with the environmental performance of the products of other companies.

Collignon (2003) reports the main results of an investigative study into the implementation of POEMS in Dutch companies, as a consequence of the PMZ Programme developed by VROM: almost 900 companies were contacted by telephone plus 20 more detailed interviews. The most interesting result of the survey was that companies which are experienced in implementing POEMS report greater effects on environmental improvements than others, but that real environmental improvement options are limited by the context in which companies operate (e.g. demand for green products, legislation/fiscal stimulus, pressure from environmental movements, etc.): "POEMSs have an accelerating effect on reduction of environmental effect of products, but the pace in which progress is made also depends on the 'environmental context' in which companies operate" (Collignon 2003).

The programme was mainly applied in the construction and industrial sector, but the agriculture, service and transport sectors were also involved in implementation. Some interesting examples of product-oriented environmental management activities and experiences deriving from the PMZ programme can be found:

- in the Dutch Plastic Recycling Industry (Baas 2002);
- in the Dutch Furniture Industry (Pinkse and de Graaf 2002; Vuijk et al. 2002)—in this case a website containing useful information for companies was also developed in order to support them in the implementation of POEM systems;
- among Tour Operators (van der Duim and van Marwijk 2006).

The Dutch experience is of particular relevance for POEMS diffusion, but it should be considered that it was a mandatory scheme, not voluntary, so government pressure certainly caused an acceleration in the diffusion of product-oriented environmental management experiences; furthermore, in general, the PMZ programme had little success in SMEs, so a specific POEM tool needs to be designed for these firms (de Graaf 2002).

11.2.1.2 The French Experiences

In France, two different experiences of POEMS implementation can be identified: a study conducted by the French Environmental Ministry on the Integrated Product Policy (IPP) and, particularly, on POEMS implementation in French companies, and the EDIT (Eco-Design Interactive Tools) project, financed by the European Union with the LIFE Programme (Ardente et al. 2006; Luciani et al. 2003).

The study on POEMS undertaken by Arthur Andersen Consulting for the French Environmental Ministry identified the main requisites a POEMS should satisfy as being the following:

- it should be implemented on a voluntary basis;
- it should be separate from EMAS or ISO 14001 regulations, but potentially certifiable;
- it has to be simple to understand and easy to implement;
- it is necessary to consider the whole product life cycle for each product covered by the POEMS. This means describing the life stages and considering interactions among them;
- at least three environmental aspects should be chosen and continually improved, for each product covered by the POEMS;
- relevant quantifiable targets should be defined regarding all of these aspects and involving each level of company management (these should be set both in terms of total amount per product unit and by quantification of environmental benefits gained at the company level).

The other French experience was with the EDIT project; a project aimed at the development of product oriented environmental management in the automotive sector, involving about 250 SMEs. The conceptual input to the project was provided by the "End of Life Vehicles (ELV)" Directive (EC 2000), with the purpose of increasing the recyclability of scrapped vehicles and reducing the remaining waste going to landfill to 16 % by 2005 and to 5 % by 2015.

This experience demonstrated that POEMS are compatible with the first steps of ISO 14001 and EMAS; furthermore, it was highlighted that POEMS differ from traditional EMS in the requirement to involve the whole life cycle product chain, both upstream and downstream (this requires the sharing of information among different actors within the supply chain).

11.2.1.3 The Danish Experiences

In the mid-1990s, the Danish Government launched a programme to stimulate the development of product-oriented EMS; following this programme a great number of firms, only a few of which were small and medium-sized ones, implemented a POEMS. To reach SMEs the Danish Ministry of Environment also decided to develop another programme specifically designed to support them in the early stages of the implementation of a POEMS; the programme was launched in 2002.

Still on the theme of the Danish experiences, a particularly successful case that is often cited in literature is that of Gabriel A/S, a niche company that develops, produces and sells furnishings products. In order to anticipate future environmental regulations, the company began to analyse the environmental impacts associated with its products and established improvement goals in an product oriented EMS (POEMS). The project was developed in collaboration with two consulting companies: COWI Consultant Engineers A/S and Dansk Kvalitets Rådgivning. The basic idea of this collaboration was firstly to perform the LCA of some of the firm's products and then to expand the existing EMS with more product-oriented environmental management in order to define a 3rd generation EMS. During its experience, Gabriel A/S adopted new product oriented policies, defined objectives and programmes, established a new procedure for product LCA and integrated the new procedures for environmental communication, environmental improvement, product development, supplier selection, purchasing policy and production with the existing ones (Andriola et al. 2003a).

This experience also showed that an LCA project can be very useful for the enhancement of cooperation between customer and supplier; in particular, meetings with suppliers allowed the gathering of better quality environmental data.

11.2.1.4 The Italian Experiences

Interesting experiences dealing with POEMS have also been registered in Italy, although complete POEMS applications are not reported (Luciani et al. 2003).

The best known experience is that of ABB Group. ABB was among the first companies in Italy and Europe to work in the field of environmental management by adopting the early British standard BS7750 and, subsequently, ISO 14001. ABB was also active in the field of the product management from the beginning by performing Life Cycle Assessment (LCA) studies and including LCA and Environmental Product Declarations (EPD) among its environmental policy targets. In Italy, ABB conducted a feasibility study (in collaboration with the Italian National Agency for New Technologies, Energy and the Environment—ENEA—and UPPER) on the possible integration between management and product tools (based on LCA), highlighting the possible areas of integration.

Another Italian case study was developed by ENEA, which carried out a project in the wood and furniture industry for the gradual introduction of product issues into Environmental Management Systems. In this case, a POEMS model was applied in an Italian industrial furniture cluster (Distretto del Mobile di Pesaro), within the EU LIFE LAIPP project “Dissemination of IPP tools in the wood furniture district of Marche Region” (funded by the European Commission on the basis of a proposal from the Marche Region—Italy). The project involved five firms operating in the wood-furniture chain in the industrial district of Pesaro (Italy) which performed LCA studies of different products and defined guidelines for Green Public Procurement (GPP) and technical guides for IPP tool implementation. Three of these firms also implemented an experimental POEMS model in order to define product-oriented environmental improvement programmes (Cariani 2010). The applicative cases demonstrated that POEMS could be an efficient IPP tool for the promotion of greener products and that a screening LCA is a useful tool to support POEMS implementation (Masoni et al. 2007).

The different procedural steps of the POEMS model designed within the LAIPP project are the following (Masoni et al. 2007; LAIPP 2012; UNI 2009):

- a screening LCA of the selected product;
- identification of the significant environmental impacts of the product and of a set of environmental performance indicators;

- selection of the aspects on which improvement actions are possible (considering the firm's capabilities);
- definition of environmental improvement targets and how to achieve them;
- definition of control procedures;
- release of a Product Environmental Report (PER).

The PER represents an innovative feature compared to the POEMS models of other experiences (some of which used EPD for the communication process); it is a public document containing the most significant environmental aspects of the product life cycle and the related environmental targets that the firm wishes to achieve.

11.2.1.5 Other Experiences

There are also some pilot and demonstration projects exploring the POEMS concept in Portugal; these projects aim to incorporate product aspects into companies' environmental management systems and involve several industrial sectors, without any strategic interest or funding from the Portuguese government, and in cooperation with Delft University of Technology, The Netherlands (Tukker and Eder 2000). In these cases the main focus is also on the integration of Eco-Design approaches in EMS.

In the Basque Country, interesting experiences of systemic approaches to Eco-Design have been organised. In particular, the IHOBE (a Public Corporation whose aim is to support the Basque Government Department for the Environment, Spatial Planning, Agriculture and Fisheries) prepared a "Manual on Eco-design. 7 steps for implementation", which provides criteria and simple tools for the Basque industries to implement the environmental factor into their product design. The manual establishes seven steps for the implementation of Eco-Design methodology, resulting in low environmental impact products and services (IHBO 2000).

11.2.2 Technical Standard Suitable for the POEMS Structure

There are no specific technical standards on POEMS, although there are two documents that could be useful as reference points for its methodological structure:

- ISO 14006:2006 "Environmental management systems—Guidelines for incorporating eco-design";
- UNI/TR 11334:2009 "Product environmental management: state-of-the-art and significant experiences within environmental management systems".

The international standard ISO 14006:2011 provides a guide to organisations that aim to incorporate eco-design into an environmental management system (or similar systems). ISO 14006 was prepared using the previous Spanish standard UNE 150.301:2003 as a base reference point, but a difference exists between the two: the UNE standard is certifiable, while the ISO is a guideline not intended for certification (International Organization for Standardization 2011). In particular, the International Standard provides guidelines to assist organisations in establishing a systematic and structured approach to the incorporation of eco-design process in an EMS (even if it is also of value for organisations that only have a quality management system or no management system). It can be practically suitable as a guideline for POEMS implementation, in the event that POEMS is intended as an EMS with a broader scope that includes Eco-Design activities aimed at reducing the adverse environmental impacts of products. The correlation of ISO 14006 with the other international standards is particularly useful; indeed the relationship among ISO 14006, ISO 9001:2008 "Quality Management Systems—Requirements", and ISO/TR 14062:2002 "Environmental Management—Integrating environmental aspects into product design and development" are highlighted in Annex B. The main weak point of this guideline is that, even if it can be applicable to all organisations, regardless of type, size and product provided, it refers only to Eco-Design activities and organisations that do not perform design activities cannot use it as a reference.

The Italian technical report UNI/TR 11334:2009 contains a description of documents, norms and research on product management in EMS at international level and a description of approaches and methods implemented in some Italian experiences (e.g. the LAIPP project described in Sect. 11.2.1.4). The technical report is not to be interpreted as UNI approval of the cited experiences (and therefore does not provide any methodological standardisation), but it is particularly useful for firms wishing to learn more about the various ways of integrating product-related issues into "traditional" environmental management. Furthermore, there is a stronger emphasis on the role of Life Cycle Assessment and product communication activities that could be of greater utility for firms not engaged in design processes.

11.2.3 Literature Review of Methodological Approaches

In Table 11.1 a brief literature review is presented, organised according to a chronological method, in which references with an explicit mention of methodological POEMS issues (or POEM activities if considered useful input for the definition of key features of a POEMS model) are cited.[3] The table highlights denomination and tools/approaches involved/integrated in the model (plus any case studies). In order to identify the main characteristics that a POEMS model

[3] Articles reporting case studies and literature reviews were also included, if containing significant inputs on methodological aspects.

Table 11.1 Literature review on POEMS: summary of key findings

Literature reference	Denomination	PDCA	QMS	EMS	Eco-design or DfE	LCA	Product labelling	Other tools	Case study
PricewaterhouseCooper (1999)	PEC	✔	I	I		I		Eight different ad-hoc tools	
Klinkers et al. (1999)	PEC in EMS	✔	✔	✔		✔		Supply chain analysis	
van Berkel et al. (1999)	P-EMS	✔		✔	✔	✔			Experiences in various segments of Dutch industry (retail, manufacturing, food processing, building sector)
Rocha and Brezet (1999) Brezet and Rocha (2001) Rocha and Silvester (2001)	POEMS	✔		✔	✔	I		eLCC or other tools for product environmental impact assessment	A truck manufacturer Evaluation of the experience of ten companies that joined the first phase of the PMZ Programme
Baas (2002)	POEM-system							SWOT	
De Graaf (2002)	POEM in SMEs							AIDA	
de Bakker and Nijohof (2002)	POEMS				I	I		Capability cycle	
Andriola et al. (2003a) Andriola et al. (2003b)	POEMS			✔		✔			A firm in the wood-furniture sector
Granchi and Granchi (2004)	POEMS			✔		✔	✔		

(continued)

Table 11.1 (continued)

Literature reference	Denomination	PDCA	QMS	EMS	Eco-design or DfE	LCA	Product labelling	Other tools	Case study
Donnelly et al. (2004) Donnelly et al. (2006)	PBEMS	✔	✔	✔	✔	✔			A multi site company producing wireless hardware products
Ammenberg and Sundin (2005a) Ammenberg and Sundin (2005b)	POEMS	✔		✔	✔				
Ardente et al. (2006)	POEMS	✔		✔		✔		Deming Cycle and Capability cycle	A wine-producing firm
Luciani et al. (2006) Masoni et al. (2007)	POEMS			✔		✔	✔		Three leading firms in the wood furniture sector
Kim (2008)	C-POEMS	✔	✔	✔				An ad-hoc diagnosis template	Three companies mainly producing IT and telecommuni-cations equipment
Salomone and Greco (2009) Salomone and Saija (2010)	POEMS	✔	✔	✔		✔	✔		

✔ Tool integrated in the methodological approach
I Tool potentially insertable in the methodological approach (if specifically mentioned by the author)

should possess, the general procedure of the model, its principal requirements, main obstacles and benefits are also outlined in the discussion, when these are clearly described in the reviewed articles.

A brochure published by PricewaterhouseCoopers in 1999 describes an 8-step plan for Product-oriented Environmental Care (PEC) implementation. The plan has a PDCA structure and links up with both the ISO 14001 and/or ISO 9001 systems (even though the plan is designed for companies with or without management systems); for this reason, this work was inserted into Level 3 of the literature review of interest for POEMS model definition (PricewaterhouseCoopers 1999). The eight steps are supported by eight ad-hoc developed instruments, summarised as follows:

Step 1. taking a management decision on the introduction of product-oriented environmental care;
Step 2. selecting a product to be used for a pilot project—for the selection process six instruments, specifically developed mainly in the form of matrixes, are suggested [(1) a method for producing a short-list from a long-list of products; (2) a scoring method for selecting three products from the short-list; (3) a method for mapping the product chain; (4) a method for making a qualitative assessment of the environmental impact of the product chain—alternatively, an LCA analysis is suggested; (5) a method for estimating the interests of product chain partners; (6) a method for gaining insight into existing relationships];
Step 3. taking a decision on the choice of a pilot project;
Step 4. determining improvement projects for the product with partners in the chain;
Step 5. choosing an improvement project with partners in the product chain—for this step another specifically developed instrument is suggested [(7) a tool that allows comparison among projects, giving a score based on pre-defined criteria];
Step 6. executing the improvement project and measuring its results;
Step 7. evaluating the success of the improvement project;
Step 8. taking a management decision as to whether product-oriented environmental care is of importance to the company—a further instrument developed to help take this decision is suggested [(8) a list of questions that require yes/no answers regarding the importance of PEC for the company].

In Klinkers et al. (1999) the introduction of PEC in EMS is described, highlighting that "Product-oriented environmental care (PEC) links up with the ISO 14001 system… a link with LCA can also be established… the aspects of PEC can be also linked to the ISO 9000 series…". The authors suggest that "companies do not begin reducing the environmental effects of a product or service until their internal environmental care is in order" (Klinkers et al. 1999). This means that it is probable that product-orientation is a natural evolution of the environmental commitment implemented with an EMS: in pursuing the continual improvement of environmental performances, once internal affairs are put in order, further improvements may begin to be achieved by considering the chain as a whole.

van Berkel et al. (1999) summarise examples of Product-Oriented Environmental Management Systems (P-EMS) projects in the retail and manufacturing industry in the Netherlands and briefly refer to tools facilitating P-EMS applied in two industries operating in the food processing and in the building sector. The analysis conducted by the authors highlighted a few success factors, such as:

- P-EMS needs strong collaboration and data exchange among actors in the product chain, so efforts to establish collaboration should be concentrated on partners that have a strong incentive to act;
- screening type LCAs and user-shells for LCAs should be used in order to balance between comprehensiveness of LCA and necessary resources;
- early successes are necessary to motivate organisations to establish and maintain P-EMS.

The authors also highlighted that SMEs face problems in the implementation of P-EMS because the collection and processing of environmental product information is a bottleneck particularly for these kinds of firms; indeed, gathering environmental information requires time and resources that they may not possess and their power position in the product chain is often limited, so they are not able to influence the other actors in the supply chain. According to a customised approach for P-EMS, developed and tested in SMEs, cited by the authors,[4] in order to face these problems, a P-EMS should:

- suit the day-to-day practices in SMEs;
- be built on the existing process-oriented management systems;
- be result-oriented (improvement options for the firm's products developed and carried out in the early phase of P-EMS implementation);
- be carried out by firms themselves.

Brezet and Rocha (Rocha and Brezet 1999; Brezet and Rocha 2001) present a POEMS model based on the integration of EMS and Eco-Design activities and describe the results of its implementation in a truck manufacturing company, highlighting how the POEMS model might play a strategic role in the systematic implementation of Eco-Design and the consequent product innovation opportunities and that "existing EMS standards (ISO 14001 and EMAS) could provide a structure for a product-oriented environmental management system (POEMS)". The authors explore the role that EMS might play in attaining objectives of improvement of product environmental performances, identifying the following reasons:

[4] Lafleur et al. (1998) Towards a feasible model for product-oriented environmental management systems in small and medium sized enterprises. (in Dutch) IVAM Environmental Research, Amsterdam, The Netherlands.

- standardised EMSs are useful structures to implement a company's environmental strategy (so this usefulness might also be translated into product strategy);
- Eco-Design can be seen as a continual improvement process to be inserted in the EMS;
- companies active in the field of Eco-Design had often already implemented an EMS and these were inclined to establish a link between their EMS and Eco-Design activities.[5]

The proposed model follows the PDCA and LCA or other tools are suggested for use in product environmental impact assessment, combined with environmental costs across the lifecycle (eLCC); furthermore, the model combines an operational cycle (oriented to the improvement of product features through Eco-Design) with a managerial cycle (oriented to provide managerial support for Eco-Design). The authors also give a precise definition of POEMS "an environmental management system with a special focus on the continuous improvement of a product's eco-efficiency (ecological and economic) along the life cycle, through the systematic integration of eco-design in the company's strategies and practices" and identify its core elements:

- the eco-efficiency (ecological and economic) of products is strategic for a company, so an environmental product policy is defined;
- the life cycle environmental performances of products are regularly evaluated;
- the product development process also includes environmental criteria;
- goals are set for continual improvement of product environmental performances, in cooperation with other actors of the product chain.

In Rocha and Silvester (2001), the authors studied 10 companies that participated in a Dutch programme aimed at stimulating the implementation of POEMS (the PMZ Programme[6]), and present a theoretical model for POEMS developed by the Delft University of Technology. They mention four different categories of activities included in their POEMS model, which are of a general character:

1. activities that lead to the concrete definition of environmental objectives and performance criteria for the product, as well as activities aimed at tracking progress;
2. operational activities for the improvement of product eco-efficiency and innovation;
3. activities to ensure the necessary capabilities;
4. activities to establish control and routinisation of Eco-Design.

The POEMS activities performed by companies were organised at three different levels:

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[5] In order to support this statement the authors cite a study conducted in 77 SMEs (van Hemel 1998).

[6] See Sect. 11.2.1.1.

- activities at a strategic level (e.g.: definition of environmental strategy and evaluation of market expectations);
- activities at a managerial level (e.g.: definition of managerial objectives and allocation of financial resources);
- activities at an operational level (e.g.: consultation of partners in the product chain and definition of environmental performance indicators for the products).

The results of the analysis demonstrated that the PMZ programme introduced a significant number of activities, but those that started as part of the project and then continued after the end of the project is very low.

In general, companies started with organisational activities and the baseline study (LCA) and then evolved to operational activities leading to potentially improved products. The main problems encountered were related to the fact that it was not clear which of the POEMS activities started as part of the project were continuous activities or were destined to be eliminated at the end of the project. This means that it is not clear to what extent companies spontaneously implement POEMS (i.e. without participation in a particular project).

In Baas (2002) a POEM-system method specifically designed for the Dutch plastics recycling industry (mainly SMEs) is presented. The POEM-system presented is a five-step-model, including:

1. establishment of project objectives and teams;
2. preliminary investigation of the company by tailoring the general SWOT (Strengths-Weaknesses-Opportunities-Threats) tool and product profile;
3. finding additional information on environment or market related issues, and setup of a programme of requirements for new product development;
4. checking and improvement of alternatives with necessary R&D work;
5. embedding of a timeframe for further action, preparation for production and marketing, and evaluation of the project or potential integration of the requirements from the project into other management systems.

The particular structure of this model is determined by the inclusion of SWOT analysis in order to discover a company's interest or capability for POEMS implementation and by a double operational level of the model: the sector and company levels. Indeed, after the first step of defining and establishing project objectives and team, the preliminary investigation is performed using SWOT analysis applied to several firms operating in the specific productive sector. The aim is to identify the sector's environmental problems and opportunities and, consequently, to decide on which aspect the sector needs to focus on; in addition to this knowledge, information on new markets and competitiveness in the market should also be explored. Then, the opportunities derived and developed from the previous investigation, analysis and interpretation at sector level are translated and applied at company level. During this process, companies can implement a POEMS project by using the sector information. The interesting aspect of this POEMS model is that the sector specific environmental information could easily be used by SMEs, making the product-orientation of their environmental management systems easier (the practical implementation of this is not sufficiently clearly explained in the article), but the system should first be established with a wide level of cooperation and coalition among a group of companies and this seems very difficult to apply in many productive sectors.

De Graaf (2002) reports another example of preliminary investigation supported by the AIDA (Attention-Interest-Desire-Action) model. Recognising the difficulties for SMEs in understanding the concept of POEM and in utilising it for business practices, the author (reporting the result of a research project conducted by BECO group) describes the four-step model that is intended to prepare all stages of POEMS process for its successful implementation: *Attention* (communication with participant companies in order to introduce POEM), *Interest* (the companies express which areas of POEM are of interest), *Desire* (the companies' particular expectations, such as potential benefits through implementation of POEM, are identified), and *Action* (the required activities of POEM are identified for their insertion in the management system). The AIDA model was developed and tested in eight volunteer companies and then the tested AIDA model was incorporated into a POEMS.

de Bakker and Nijohof (2002) are the first to describe a "capability cycle" framework aimed at defining the capabilities necessary to build responsible chain management. The capability cycle consists of four stages: *interpretation* (stakeholders' interests are interpreted and translated into organisational plans); *integration* (plans are translated into actions); *monitoring* (the actions undertaken are evaluated and reported upon); *communication* (the results of monitoring are discussed with relevant stakeholders). This conceptual framework is then applied in three different initiatives, among which the POEMS case is also described. Working on POEMS means developing new routines and new working capabilities: internal capabilities to interpret issues of responsible chain management are often supported by performing LCA studies and applying eco-design principles; on the contrary, external capabilities are not always as well developed because discussing organisational responsibilities with the other actors in the supply chain is difficult.

Andriola et al. (2003a, b), in the first study, present a brief review of the previous experiences of POEMS, highlighting the main requirements that it should satisfy:

- it is a voluntary system;
- it is not necessarily linked to EMAS registration or ISO 14001 certification, but should be potentially certifiable;
- it should be simple to comprehend and implement;
- it should consider the whole life cycle of a product, with at least three environmental aspects to improve continually.

The authors also arrive at the conclusion that "some firms already active in the field of EMS demonstrate perception of the environmental management of product as a natural and inevitable extension of their management system beyond the bounds of their factory" (Andriola et al. 2003a).

In the second study (Andriola et al. 2003b) the authors present a case study experimentation, conducted in an Italian firm operating in the wood-furniture sector, in order to verify the coherence between the EMS compliant with ISO 14001 and the LCA on a standard product of the firm (according to ISO 14040). The model consists in the following fundamental steps:

- Environmental review;
- Data collection LCA;
- Environmental Policy;
- Environmental Programme;
- Environmental Management System.

The first applicative experiences demonstrated that tools for process and product perfectly integrate with synergic results, but the effectiveness of POEMS should be guaranteed by the simplification of the procedures and the simplification of LCA analysis, together with an enhancement of the promotion and marketing of the product, maybe using the guideline on environmental communication contained in ISO 14063 (Andriola et al. 2003b).

Granchi and Granchi (2004) describe a POEMS as an EMS with a broader scope, in which the initial environmental analysis is widened using the Life Cycle Assessment methodology and in which two main aspects are considered highly important and tricky:

- the involvement of external actors who will provide information about their internal processes;
- a communication process involving a system of environmental labelling, which appears to be the best tool to transmit the organisation's environmental commitment to the market and other stakeholders.

The authors also conclude that "the approach to a POEMS is very close, if not equal, to the approach to be adopted in the case of a request for a third type of environmental labelling (EPD—Environmental Product Declaration)" (Granchi and Granchi 2004).

Donnelly et al. (2004, 2006) developed a model of Product-Based Environmental Management System (PBEMS) founded on DfE and LCA, and structured to facilitate interaction between business and environmental systems through the integration of sustainability considerations into strategic business decisions, product evolution planning and product development. The authors also report the results of implementing the model in a multi site company producing wireless hardware products (Lucent Technologies), which successfully aligned the product realisation process to the elements of ISO 14001 and TL 9001 (the quality system requirement standard for the telecommunications sector), obtaining different benefits in terms of product strategy focus, supplier partnership and increased efficiency in terms of costs, speed to market and customer satisfaction. "Benefits of the PBEMS have proven to be numerous and unconventional… 'what gets measured gets done'. By using the PBEMS to establish a recognised structure for the application of sustainability inputs and reporting achievements and opportunities for improvement to top management, awareness of eco-issues is heightened and resolution of eco-challenges is made possible" (Donnelly et al. 2004, 2006). This experience is mainly developed on processes connected to product design and development, product materials and manufacturing services (hazardous materials, recycling, reuse, etc.) and, being primarily built on Design for Environment (DfE), is not suited for companies that do not have design processes in their core activities, but nonetheless need product orientation of their environmental management activities.

Ammenberg and Sundin (2005a) present the main characteristics of POEMS using the existing models and project experiences reported in literature and identifying four general steps of POEMS:

1. product-specific environmental review—a review of the product portfolio from a lifecycle perspective is carried out in order to identify the significant aspects. A review of the organisational aspects of DfE relevance should also be conducted in order to identify the capabilities and weaknesses of the organisation. These two review phases should also gather information on the existing and future market (e.g. information on future customers' needs);
2. responsibilities and procedures—responsibilities and resources should be allocated and environmentally related procedures for the product development process should be written. Based on the initial reviews and relevant policies, product-related environmental objectives and targets should be established;
3. DfE projects—DfE projects should be implemented, following the information gained in the first step and the procedures established in the second step;
4. audit/evaluation—the POEMS activities must be evaluated/audited in order to determine continual improvement measures of product-related environmental performance.

The model integrates EMS and DfE with a PDCA approach, in particular "POEMS might include several parallel Deming cycles, as one concerns the overall EMS and others are focused on single product projects" (Ammenberg and Sundin 2005a).

In a later paper the authors (Ammenberg and Sundin 2005b) describe how external environmental auditors interpret product-related requirements of ISO 14001 in manufacturing companies in Sweden, identifying different concluding remarks, including the following summary suggestions:

- in the opinion of the interviewed auditors, product issues should be regarded as environmental aspects to be included in the environmental initial analysis, but some companies are reluctant to assess product aspects as significant;
- they saw signs of product-related issues in some companies, but in these cases commonly mentioned bottlenecks are complicated tools, difficulties in collecting useful information and lack of resources in terms of staff and competence;
- the interviewed auditors disagree regarding the link between the commitment to continual improvement and products (e.g. for some of them improvements are of an operational nature, for others of management type) and this divergence

suggests that the EMS standard should be clearer on the meaning of environmental performance;
- external factors influencing EMS and Design for Environment (e.g. market demands, legislation, availability of useful tools and information) should be emphasised by governments, authorities, researchers and society in order to incentivise the implementation of POEMS.

Ardente et al. (2006) identify two possible approaches for the implementation of POEMS:

- a firm can start from an EMS and then pay greater attention to the product, focusing on specific product-oriented elements;
- a firm can directly apply an LCA in order to enhance the environmental performance of a product by evaluating the product life cycle environmental impacts and insert this into an improvement programme.

Authors stress the issue that "inter-organisational environmental management requires active engagement beyond the boundaries of the single firm to environmental and sustainable development networks" and also present a case study of an LCA implementation in an Italian wine-producing firm, as a first attempt at a POEMS programme definition (Ardente et al. 2006).

In Luciani et al. (2006) and in Masoni et al. (2007) results of the EU LIFE LAIPP project[7] in the wood furniture sector are presented. In the former article, the role of Environmental Product Declaration (EPD) in POEMS is highlighted; in the latter the innovative POEMS model, used within the project, connected to a simplified LCA (in particular the eVerdee tool) and to a label on the product is presented. This is a case in which POEMS is not observed as a broadening of a traditional EMS, but as a model that "has significant simplifications with regard to ISO 14001 both from the technical and operational point of view" (Luciani et al. 2006; Masoni et al. 2007).

In Kim (2008) the author presents a model of C-POEMS—Component-based Product-Oriented Environmental Management System—(based on EMS and Eco-Design) and a diagnosis template (that allows SMEs to identify relevant environmental elements without necessitating the full effort involving in going through a variety of environment-related issues in the first place) which can be used together in a component-based structure. The research work is mainly focused on the "drivers review" (one of the categories of the model) and on the application of the diagnosis template in three different companies operating in the information technology and telecommunication equipment sector.

Salomone and Greco (2009) and Salomone and Saija (2010) propose a POEMS model that adds an LCA, as a basis for the product-orientation, to an integrated quality and environmental management system. The LCA addition in the "conventional" evaluation of significant environmental aspects and evaluation of customers' requisites allows useful information to be gathered in order to assess

[7] See Sect. 11.2.1.4.

changes aimed at improving the environmental performances of products. The proposed model is also enriched by the inclusion of LCEM strategies in order to improve the decision making process with the aim of pursuing the sustainability of the firm and allowing adequate methodological information support for the preparation of an Environmental Product Declaration (EPD) on the product (or products) under LCA analysis.

11.2.4 Main Findings from the Review

The analysis of the state-of-the-art on POEMS experiences and the literature review of the main methodological issues highlighted benefits and limitations of this tool and several inputs were recorded in the articles by the various authors who have dealt with this topic over a period of almost 15 years. On many key characteristics of POEMS there is broad consensus and consistency of opinion (e.g. the inter-organisational approach; the pursuit of continual improvement of environmental performances of products; etc.), while on others, different solutions and points of view still persist (e.g. its conception and structure; the tools and approaches to be integrated; etc.); these are clear signals of the need for further research efforts aimed at unifying and improving the methodological framework of this tool.

Summing up, in conclusion, five *key topics* on POEMS were extrapolated from the literature review findings, so as to identify useful drivers for the improvement of this tool:

1. The *first key topic* to focus on is the origin and conception of POEMS. Indeed, there are different conceptions of POEMS ranging from those who consider it as an evolution and development of "traditional" EMSs and those who consider it to be a tool in its own right.

   Those who consider it an extension of EMS, strongly link the product-orientation work with the already existing environmental management procedures in a firm with an EMS and this conception is mainly caused by the following motivations:

   - if product-oriented activities are not integrated into strategic management and daily operation, within a continual environmental improvement process, they will be limited and they could be abandoned (Brezet and Rocha 2001), so the integration of POEM activities into an EMS is a winning solution that assures continuity and stability in product-oriented activities;
   - product-orientation can be observed as a "natural" evolution of the process of continual improvement in EMS; indeed, in the initial phases of EMS implementation, top management introduces internal process improvement measures aimed at reducing the environmental impacts of the organisation; as time goes on, more difficulties in applying additional process improvements arise (unless major investments are sustained due to the increasing marginal

costs of reduced pollution) and, consequently, it is necessary to identify new areas for improvement in environmental performances—such as product performance (Luciani et al. 2003).

- On the contrary, those who consider POEMS a stand-alone tool, generally refer to a systemic approach to POEM activities designed and potentially applicable independently by the presence of management systems, even though, in most of these cases, it was recognised that companies with an EMS (and/or QMS) may show greater willingness and ease in POEM System implementation.
- Considering that even in this latter conception, the important role of pre-existing management system structure is recognised, it may therefore be concluded that *POEMS could be intended as an EMS with a broader scope that includes environmental product-related activities*.

2. The *second key topic* to consider is the effective role that standardised management systems play in successful POEMS implementation. Indeed, EMSs present several limitations to product-orientation work,[8] mainly represented by their internal orientation, process focus and lack of customer orientation; thus, in some of reviewed models presented in this chapter (about one third of level 3), the quality management system has been integrated (or suggested for integration) into the model framework, presenting "major advantages in taking a structured approach to product-oriented environmental management" (Brezet et al. 2000).
   The strategic role of quality management and quality management systems (QMS) for POEM activities, can be motivated as follows:

- interesting analogies exist between Total Quality Management (TQM) and POEM (such as customer focus, continual improvement and teamwork) (de Bakker 2002);
- in order to strongly link POEMS with market opportunity, it has to have a customer focus: organisational structures and processes should support the business needs and product requirements of customers. Processes for meeting legal and customer requirements are traditionally well organised in a Quality Management System in line with ISO 9001 and ISO 9004 standards;
- ISO 9001 (with its focus on customers' need) and ISO 9004 (which mentions the more environmentally and socially aware stakeholders) pay greater attention to the product chain than ISO 14001 and EMAS do. However, this attention is not focused on the environment and sustainability, so an Integrated Quality and Environmental Management System can satisfy both these needs;

8 See Sect. 1.2.1.

- many of the POEMS models presented in literature are based on the Deming cycle, which is the management cycle that forms the basis for ISO 14001 and ISO 9001. The PDCA cycle assures orientation to continual improvement (of stakeholders' satisfaction; of environmental performance; of the framework itself); indeed, amongst the POEMS models reviewed here, more than half are based on the PDCA model.

These motivations could therefore be considered as an implicit suggestion to an *integrated use of QMS and EMS as a basis for POEMS activities*. Integrated Quality and Environmental Management System is a suitable basis for evaluating and controlling the continual improvement of the environmental performance of products, but how ambitious the objectives are and how deeply they are diffused throughout the product chain depends on the company's strategic decisions (Rocha and Brezet 1999).

3. The *third key topic* to consider is how to integrate product-orientation into the chosen management structure. In almost all the models and experiences reviewed here, product-orientation is obtained through the use of Eco-Design or Life Cycle Assessment; in some cases the use of both methodologies was suggested. In the opinion of the authors of this chapter, LCA may ensure wider diffusion of the POEMS model, giving it a more general and flexible structure, for the following reasons:

- if POEMS is considered as an integration of Eco-Design activities into the EMS structure (e.g. van Berkel et al. 1999; Rocha and Silvester 2001; Donnelly et al. 2004), this means practically targeting the use of the tool only on businesses that have product development processes in their core business; on the other hand, a POEMS model that is not uniquely tied to Eco-Design and in which product-orientation is mainly practiced through the introduction of the LCA methodology, is also applicable in businesses that do not deal with product design;
- benefits deriving from the integration of EMS and LCA can be seen as reciprocal: LCA could enrich EMS with a life cycle perspective, covering a broader scope; at the same time, EMS could ensure that LCA, and the deriving product-focused activities, be incorporated into the firm's strategy, into system procedures and into the continual improvement process; furthermore, such a system could be easier to extend to Eco-Design, because design activities could be added, if necessary, for the implementation of the environmental improvement options identified through the LCA analysis (e.g. substitution of processes and/or materials; development of new products, etc.).

4. The *fourth key topic* to consider is how to adapt the model to the particular needs of SMEs operating in different productive sectors. Indeed, the previous experiences of POEMS implementation mainly involved companies operating in the manufacturing sector (e.g. wood furniture) or in productive sectors with higher regulatory pressure (e.g. electronic and electrical equipment or the

automotive industry) and mainly larger companies (having more specialised knowledge and more financial resources) (Klinkers et al. 1999). In any case, the introduction of POEM in SMEs was investigated by different authors (e.g. van Berkel et al. 1999; de Graaf 2002), highlighting that POEMS implementation can encounter specific problems in these kind of firms, varying from lack of know-how, time or money, resistance to change and difficulty in integrating the new approach into the strategic mission.

This led to the necessity of methodological solutions specifically tailored for SMEs operating in various production sectors, such as the use of ad-hoc or simplified assessment tools and a gradual approach towards sustainability (without any predefined criteria to achieve), for the following reasons:

- simplified approaches allow SMEs to overcome typical obstacles because they require limited time and financial resources and are easier to understand and implement;
- ad-hoc tools (such as guidelines, check-lists, supply chain analysis, etc.) provide a clear picture of the firm's situation and its collocation along the product chain. Indeed the placement of the company in the product chain can strongly influence POEMS success, because the "power position" may determine the extension of environmental improvement activities and the influence that the company may exercise over the other product chain actors cooperating and collaborating (van Berkel et al. 1999); furthermore, they can be useful to guide firms in the implementation of new approaches towards sustainability and provide an adjustable approach for firms' own needs.

5. The *fifth key topic* to focus on is which drivers can ensure successful implementation of a POEMS model. Several inputs were also detected on this topic through analysis of the state-of-the-art on POEMS experiences and the literature review on the main methodological issues, mainly oriented to increasing the competitiveness of the company though improvement of the product image on the market, better response to stakeholder pressure and compliance with increasing legal requirements. Thus, the drivers to implement POEMS "greatly depend on to what extent environmental problems and challenges can be transformed into business opportunities" (Ammenberg and Sundin 2005a) and this can be ensured by proper environmental product communication, for the following reasons:

- if POEMS is be considered as a suitable tool for product-oriented environmental activities, in line with IPP directives, it is necessary to connect POEMS to environmental labelling, indeed one of the most important goals of IPP is to stimulate the demand for greener products through easily understandable and credible information;
- environmental labelling is the best tool to transmit the organisation's environmental commitment to the market and other stakeholders (Granchi and Granchi 2004).

Analysis of the state-of-the-art on POEMS experiences and the literature review on the main methodological issues also highlighted the main descriptive elements of POEMS:

- *Definition*—the most widely cited definition is the one provided by Rocha and Brezet: “an environmental management system with a special focus on the continual improvement of a product’s eco-efficiency (ecological and economic) along the life cycle, through the systematic integration of eco-design in the company’s strategies and practices” (Rocha and Brezet 1999). But, another definition of POEMS, which is not unequivocally tied to Eco-Design and is, thus, also applicable to companies that do not deal with product design, is the one coined by de Bakker: “a systematic approach to organising a firm in such a way that improving the environmental performance of its products across their product life cycles becomes an integrated part of operations and strategy” (de Bakker et al. 2002);
- *Standard references*—currently, there are no prescriptive standards for POEMS, but some useful methodological references to be used as a starting point can be detected in ISO 14006 (relating to the insertion of Eco-Design in environmental management systems), and UNI/TR 11334:2009 “Product environmental management: state-of-the-art and significant experiences within environmental management systems”, which contains a description of documents, norms and research on product management in EMS at international level and a description of approaches and methods implemented in some Italian experiences;
- *Main characteristics*—the main characteristics that a POEM model should satisfy can be summarised as follows:

– it should be a voluntary tool;
– it should promote cooperation among firms in terms of exchange of information and of setting common improvement actions;
– it should apply transversal integration (integrating all the management tools available in the organisation);
– it should involve capabilities both in environmental management and in stakeholder management, aimed at pursuing “responsible chain management” (de Bakker and Nijhof 2002);
– it should help to pursue the continual improvement of the environmental performances of products, focusing on at least three environmental aspects;
– it should be simple to comprehend and implement;
– it should contemplate proper product environmental communication in order to transmit the organisation’s environmental commitment to the market and other stakeholders;
– it should involve a life cycle approach.

- *Obstacles and benefits*—the analysis also allowed identification of several obstacles and benefits in POEMS implementation. In order to better categorise and sort the most important factors affecting the application of POEMS, a

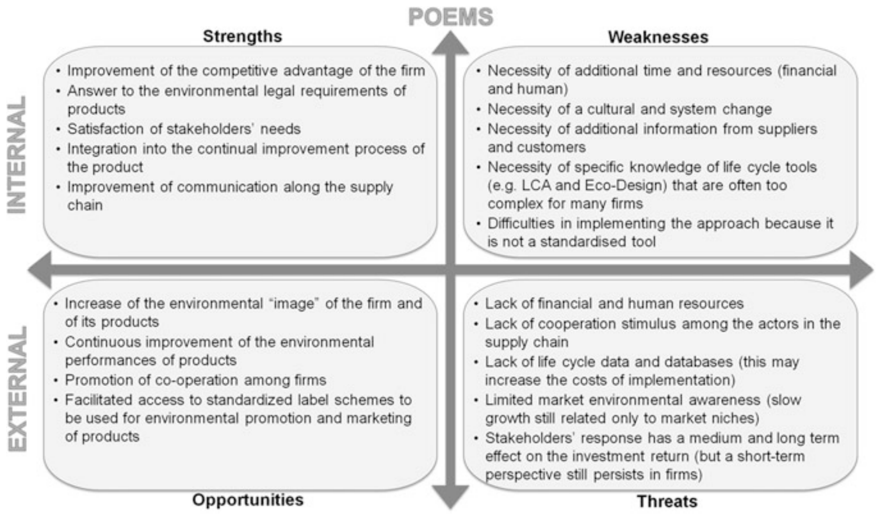

Fig. 11.1 A SWOT analysis for POEMS

SWOT (Strength, Weakness, Opportunities, Threats) Analysis was performed and is synthetically represented in Fig. 11.1. SWOT analysis is a strategic analysis tool that provides important information useful for the business strategy formulation process, but it can be applied to any planning purpose and not just in business. Thus, in this context it was used in order to focus on the key features of POEMS, and its findings were used as a basis for the planning of a POEMS model.

11.3 Conclusions

In conclusion, in order to move towards a sustainability management system, it is necessary to focus on the integration of different management standards (Jørgensen 2008) and product-related standards. Furthermore, there is wide acceptance nowadays of the concept that efficient environmental action requires not only adequate technology, but also an integrated approach to technological and managerial measures (Brezet and Rocha 2001).

Thus, a successful POEMS model should include an integrated quality and environmental management system, the life cycle perspective should be ensured by the implementation of Life Cycle Assessment, and market visibility should be ensured by a proper product environmental communication tool.

The outcomes confirm the importance of the critical success factors identified in the "path towards POEMS" described in Chap. 1 and they can be classified in two macro-drivers (internal and external), which should be given special attention in order to promote the application and dissemination of POEMS (simplification, general character, growing attention to environmental impacts, environmental information needs). The common base of these drivers is the focus on an evolutionary approach aimed at obtaining a holistic vision of process, product and supply-chain. Cultural and structural changes and continual improvement are the imperatives that should be properly managed in order to directly connect POEMS and its single components to the challenges of transforming sustained efforts into effective business opportunities (Salomone et al. 2012).

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Chapter 12
A Model of Product-Oriented Environmental Management System for Agri-Food SMEs

Roberta Salomone, Giuseppe Ioppolo and Giuseppe Saija

12.1 Introduction

Agri-food companies are faced with many environmental challenges, such as water consumption and wastewater discharge, air emissions, by-product disposal and utilisation, chemical residues, solid waste disposal and food packaging materials. In managing these issues, EMSs are very important because the implementation of a structured management system can ensure control of environmental hazards and pursuit of continual improvement of environmental objectives with the commitment of all employees (Arvanitoyannis 2008).

EMSs are a fundamental tool for the improvement of companies' environmental impacts, but the most important material and energy flows causing environmental impacts are closely linked to products, thus a management system encompassing the all product phases, and not only manufacturing, is essential (Ammenberg and Sundin 2005).

In this context, the definition of a Product-Oriented Environmental Management System (POEMS) model specifically studied to answering to the needs of organisations operating in the agri-food sector means defining a management structure to be used for steering these product chains towards sustainable production.

The development of this POEMS model will allow a shift of emphasis away from processes towards products in the environmental management of a firm. Indeed, from a green perspective, a product-based approach means going beyond the search for cleaner production processes, involving the whole life cycle of the product. It is, therefore, closer to the concept of sustainability of the product and of the whole food chain.

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The analysis of the literature review presented in Chap. 11, highlights that there is a lack of POEMS experiences specifically applied in the agri-food sector—there are only two references for this sector, reporting early attempts in the food processing industry (van Berkel et al. 1999) and in the winemaking industry (Ardente et al. 2006)—; indeed POEMS applications have dealt mainly with manufacturing industries (wood suppliers, metal products for ships, truck manufacturing, resin-makers, etc.) and the integration of Eco-design into the EMS, in some cases also by associating an Environmental Product Declaration—EPD (Tukker and Eder 2000).

In this context, a tailor-made approach specifically designed for SMEs in the agri-food sector, in accordance with these organisations' own needs, is of crucial importance, because this is a sector of a relative economic importance in the European Union, and it is associated with the use of considerable amounts of natural resources and release of environmental pollutants; indeed, the Environmental Impact of Products—EIPRO study (Tukker et al. 2006), conducted by the European Commission, showed that, among the products consumed in Europe, food and beverages are the ones which are associated with the greatest environmental impacts, in a life cycle perspective.

12.2 A Model of POEMS for Agri-Food SMEs

Starting from the main finding of the literature review presented in Chap. 11, and the considerations expressed in the definition of the path towards the final POEMS model presented in Chap. 1, the most appropriate methodological solutions for SMEs operating in the agri-food industry were identified and translated into the following POEMS model requirements:

- fundamental structure composed of an Environmental Management System (EMS) conforming to ISO 14001 (International Organization for Standardization 2004) or to the EMAS Regulation (European Commission 2009), integrated with a Quality Management System (QMS) ISO 9001 and other possible management systems of the agri-food sector—Integrated Management System (IMS);
- methodology approach based on the Deming Cycle (PDCA Cycle)—fully exploiting the iterative character of the cycle in order to pursue continual improvement of both the methodological structure and environmental and product performance—and the Capability Cycle—in order to develop and assess the organisational capabilities required to manage a POEMS;
- product orientation ensured by the integration of a simplified Life Cycle Assessment (LCA) methodology suitable for organisations in the agri-food production chain, which can be used to evaluate different cultivation methods, production technologies and alternative materials;
- translation of the environmental measures taken into commercial advantages, in the best possible way for the organisation, thanks to the use of guidelines that

can support organisations in their choice of the most suitable form of environmental message, closely linked to the product;
- simplification of certain operational aspects and reduction of "bureaucracy";
- general character, making it applicable to any type of activity in the agri-food sector, whatever the organisation's size, nature and position in the agri-food supply chain. The general character of the model makes it flexible and this is assured by the application of the PDCA cycle. This means defining an overall system level, while details have to be addressed in accordance with the particular conditions of each individual firm (Ammenberg and Sundin 2005);
- modular structure, as it is composed of a collection of management tools that can be applied, individually or as an integration of two or more elements, on the basis of organisations' specific requirements and of the objectives they aim to achieve.

The modular structure of the proposed model is illustrated in Fig. 12.1.

Moving from the base of the model to the top, the main focus of the environmental management activities becomes broader, progressively passing through a process, product and chain focus.

With the Integrated Management System the organisations' processes and their management are the main focus of attention: on the basis of measurements and knowledge of the processes, improvements are made.

With the implementation of product-related tools, such as LCA and product environmental labelling, the focus is on the environmental impacts of products and on the management of product environmental improvements.

Finally, complete application of the model ensures environmental activities with a broadened focus: not only internal processes are monitored and managed, but also processes that relate to other parties in the chain and that play an important role in the choices made by the company.

In such a situation, open communication and stakeholder involvement are essential to organise a winning system, and the firm has to demonstrate the organisational capabilities needed for managing internal and external issues along the product chain.

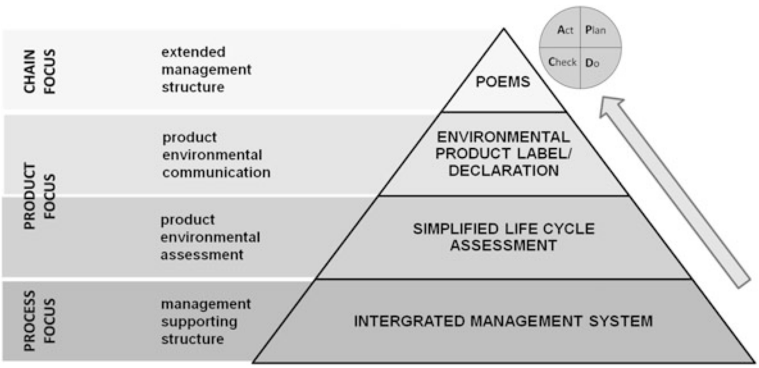

Fig. 12.1 The modular structure of POEMS (Salomone et al. 2011)

As stated in previous literature models, the POEMS framework proposed here was developed from a traditional EMS—ISO 14001 standard (International Organization for Standardization 2004)—integrated with a QMS—ISO 9001 and ISO 9004 standards (International Organization for Standardization 2008, 2009)—in order to allow the satisfaction of external customer and other stakeholder expectations concerning product requirements (a key issue in ISO 9001 but not in ISO 14001).

The main relations/differences among QMS, EMS and POEMS are summarised in Table 12.1.

The choice to develop the POEMS model starting from an IMS is mainly dictated by the need to find a route for the successful implementation in SMEs in the agri-food sector: firms already active in quality and environmental management are ready to tackle the transition to product-oriented environmental management and are more open to change in the search for continual improvement. The main obstacle firms will face in performing this transition is organising cooperation and close interaction between the different actors involved in the product chain: organisational capabilities will be needed. It is for this reason that the proposed POEMS model integrates the *Deming cycle* (Plan-Do-Check-Act—PDCA Cycle) (Deming 1986) and the *Capability cycle* (de Bakker and Nijhof 2002), in which capability is intended as *the ability to coordinate, deploy and legitimate resources to perform tasks* (de Bakker et al. 2002).

The integration of the two approaches is graphically summarised in Fig. 12.2.

The combined use of the Deming and the Capability cycle as a basis for POEMS implementation is not a new issue, as it was previously cited in literature (de Bakker and Nijhof 2002; Ardente et al. 2006). From an individual firm's perspective, in the organisation of POEMS, managers are the fundamental actors able to engage a capability building product-oriented process and competitive advantage is the main motive for them to start working on products (de Bakker et al. 2002). Considering that, in the model presented here, POEMS should be seen as an evolution of the Quality and Environmental Management System (Integrated Management System—IMS) already present in an organisation, top-management should first of all support the need to move from a process- to a product-centred organisational structure, and the competitive advantage potentially associated with the achievement of a product environmental labelling is the main motivation to start the product-orientation work.

This change inevitably entails the integration of new processes and tools and the modification of certain operating methods which should be translated into the form of written procedures in order to clearly define how to perform a specific task; each procedure defines responsibilities, objectives, methodologies, tools, registrations, etc.

The general model is graphically represented in Fig. 12.3.

Here below, the POEMS model is presented using the phases of the *PDCA cycle* and the *Capability cycle* as description method, but (considering that a complete IMS model is described in Chap. 3) only the relevant aspects connected with product-related integrations are highlighted, including: a general description

Table 12.1 Relation among quality management system, environmental management system and product-oriented environmental management system

Item	Quality management system	Environmental management system	Product-oriented environmental management system
Acronym	QMS	EMS	POEMS
Standard reference	ISO 9001:2008	ISO 14001:2004 EU Regulation No 1221/2009 EMAS	none
Field of analysis	Quality	Environment	Quality and environment
Main object of analysis	Products (customer requirements) and processes	Processes	Products (stakeholder requirements) and processes
Context of analysis	Organisation	Organisation	Product chain
Main target	Continual improvement of customer satisfaction Continual improvement of the management system	Continual improvement of organisation environmental performance Continual improvement of the management system	Continual improvement of stakeholder satisfaction Continual improvement of product environmental performance Continual improvement of the management system
Perspective of analysis	Internal and intra-company	Internal and intra-company	External and inter-company
Approach	Deming cycle	Deming cycle	Deming cycle and capability cycle
Main characteristics	Process orientation and structure potentially integrable with other management systems	Process orientation and structure potentially integrable with other management systems and product environmental management tools	Product and process orientation; strong integration of different systems and product environmental management tools (LCA, Eco-Design, EPD, etc.).
Communication of commitment/efforts	System certification (ISO 9001)	System certification (ISO 14001) System registration and\or Environmental Declaration (EMAS)	System certifications (ISO 9001 and ISO 14001 or EMAS) Product certification

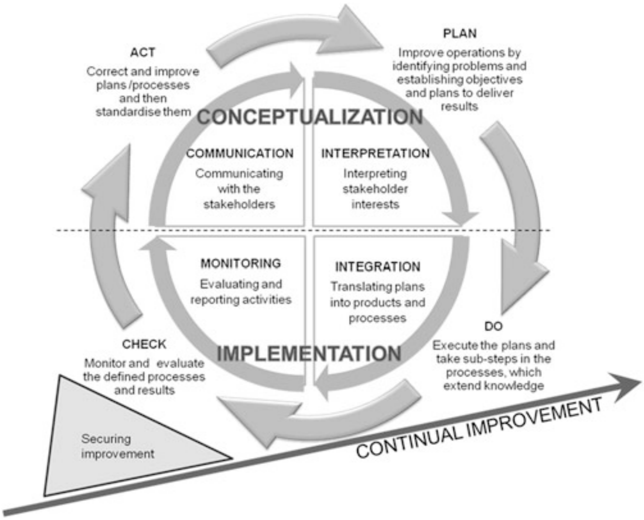

Fig. 12.2 The integration of PDCA cycle and capability cycle (adapted from: Deming 1986; de Bakker and Nijhof 2002)

of these "additions", where they are suggested for insertion into a pre-existing IMS, and what capabilities they require, both in the internal and external dimension.

12.2.1 Plan and Interpretation

The first step in the implementation of POEMS is the result of the combined application of the Plan step (Deming cycle) and the Interpretation step (Capability cycle). In this step, stakeholder interest and product environmental profile should be interpreted and the processes and the objectives necessary to achieve results should be established in accordance with stakeholder requirements and the organisation's policies.

When establishing the scope of POEMS the organisation should pay specific attention to the quality and environmental aspects of its processes and products. The pursuit of customer satisfaction (and other stakeholder needs, also considering the addition of ISO 9004), should be interpreted as the ability to consistently provide products that meet stakeholder, legal and regulatory requirements (including environmental issues) and the process of continual improvement should include the enhancement of stakeholder satisfaction, of the management system, and of performances related to the significant environmental aspects of its processes and products. The aim of a POEMS is to optimise the existing Quality and Environmental Management System (Integrated Management System—IMS) by introducing environmental product-related processes with a life cycle perspective,

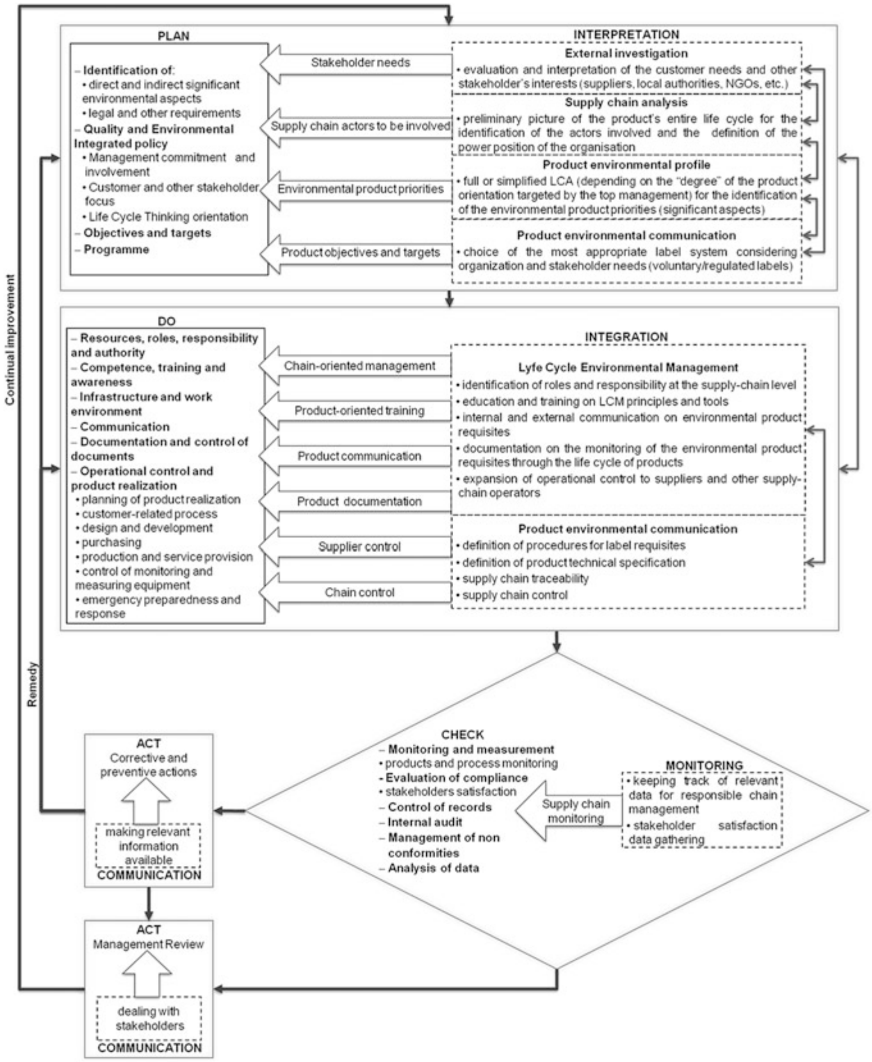

Fig. 12.3 The POEMS framework (EMAF 2012)

such as environmental product profiling (using Life Cycle Assessment methodology) and environmental product communication (using a proper product label or declaration).

External survey

Any organisation that wants to incorporate the product dimension should start by interpreting signals from stakeholders (customers, suppliers, local authorities, NGOs, etc.) and then translate external signals into internal actions. Indeed, the definition of external expectations concerning the organisation's products is strategic in deciding what environmental improvement objectives to set and what kind of environmental external communication to perform (feedbacks with the other processes in the *interpretation* step are necessary).

An organisation with a Quality Management System (conforming both to ISO 9001 and ISO 9004) already detects the expressed and implicit needs of customers and other stakeholders. Therefore, all expectations relating to the environmental performance of the organisation's products should also be included in this process. To detect useful information on stakeholder needs, different methods and tools can be used: market survey, benchmarking, organisation of stakeholder debates, etc.

Supply chain analysis

A preliminary picture of the product's entire life cycle should be built up, irrespective of the kind of product action the top-management decides to follow and implement (Danish EPA 2002). This preliminary picture can be obtained by performing a supply chain analysis and provides a clear idea of the whole life cycle of the product, with the identification of the actors involved. When performing the analysis, the firm's position in the product chain should be considered, because this can greatly affect the successful satisfaction of POEMS objectives and targets (van Berkel et al. 1999). Identification of the actors to be involved should also be carried out, taking into account product data requirements (thus, feedbacks with the *product environmental profile* process are necessary) and a consultation should be opened in order to understand their needs (feedbacks with the *external survey process* are necessary).

Extended cooperation and communication in the product chain is essential for successful POEMS implementation. However, it may be difficult or unnecessary to reach all the actors in the product chain from the outset of POEMS implementation; in the initial phase of application of the model a dialogue with close and direct suppliers and customers may be sufficient; cooperation will then be progressively widened in consideration of the organisation's future targets.

The supply chain analysis could be considered as part of the procedure for the identification of the environmental aspect of the organisation's activities, products and services suggested by ISO 14001. Together with market survey and the legal and other requirements, it provides a picture of the organisation's current situation.

Legal and other requirements

Legal and other environmental requirements on products should be continually monitored and traced. The monitoring and registration of these aspects should be included in the existing procedure for legal requirements suggested by ISO 14001, although the drawing up of a separate *product requirement document* could be useful.

Product environmental profile

In order to obtain detailed information on the resource consumptions and environmental impacts connected with each product life cycle phase, a Life Cycle Assessment study should be performed (on the chosen product or products). When building up the POEMS, it is better to concentrate on one single product; if the organisation has different types of products the management will apply the successful experiences to other products in the following improvement cycles. The criteria to use in order to select the product may differ, according to the organisation's aims: it could be the best-selling product, the one with the greatest potential for green market penetration, the one for which competitors are already active with an environmental label or the one for which strong cooperation activities and dialogue among different actors in the chain already exist.

In the first application of POEMS, basic knowledge of the potential environmental impacts of the product through its life cycle should be acquired, thus a simplified LCA is highly recommended to get started. This first analysis will allow identification of the phase in which it is necessary to concentrate more improvement efforts and evaluate the key actors with whom to strengthen dialogue and cooperation (feedbacks with the *supply chain analysis* process are necessary).

In the following PDCA cycles (after the first management review) a more detailed LCA study, depending on the new target fixed by top-management, will be implemented. Indeed, the LCA approach (a complete or simplified study) to be implemented should be determined in coherence with the environmental product communication system that the organisation decides to adopt (thus, feedbacks with the *product environmental communication* process are necessary). Obtaining data from other actors in the supply chain, outside the organisation, is one of the major obstacles in this process, so, in order to optimise data gathering and to ensure easy comprehension for the companies involved, the organisation should prepare a datasheet for data gathering (this could be part of the assessment procedure of suppliers).

This is one of the most important processes in the product-orientation work, because the identification and assessment of the product's environmental aspects allows identification of the *product's significant environmental aspects* on which many elements will depend, such as the identification of objectives and targets, the shape and articulation of the environmental management programme and, consequently, the activities and measures to be implemented, with the related written procedures and instructions. In order to determine whether an environmental aspect is significant, selection criteria should also be defined (such as level of environmental impact, legislative and regulatory requirements, public complaints, etc.).

The process of identification and assessment of environmental aspects is the key issue of ISO 14001, for which an organisation shall develop and maintain a specific procedure. The identification of product environmental aspects should therefore be part of this procedure. Obviously, environmental issues are not static, so the assessment of significant aspects should be regularly repeated over time and improvements will always be possible.

Definition of an integrated product-based policy

The outcomes of the different interpretation processes (organisation position within the supply chain, product environmental profile, stakeholder needs, legal and other requirements and communication criteria) allow top-management to establish an integrated product-based policy, which should be aligned with the product's significant environmental aspects and should provide a general framework for the definition of environmental improvement objectives in the relevant areas and stages of the product life cycle.

An integrated product-based policy should clearly include (in addition to what is already inserted into an integrated quality and environmental policy) considerations related to products, management involvement and commitment to continually improve product environmental performances, stakeholder focus, and the Life Cycle Thinking orientation.

Product environmental communication

In the plan and interpretation step, it is also important to choose the most appropriate and suitable product label system that the organisation will use for communication of product environmental performances. This process involves all the voluntary and regulated labels potentially related to the selected product being considered and coherently evaluated with all the other findings of the interpretation step and with the resources required. The iterative nature of the whole POEMS model implies that the choice of the product label can be repeatedly revised (e.g. on the basis of LCA results or stakeholder needs), consequently adjusting all the other connected processes, in the pursuit of continual improvement.

Objectives, targets and programme

In the objective and target definition process, the organisation should take into account the significant environmental impacts identified through the product environmental profile and legal and other requirements. Targets should be coherent with stakeholder requirements, supply chain actor involvement and cooperation, and the chosen product environmental communication system, together with technological, financial and business availability. All the information obtained in the various Plan and Integration processes allow a *product sustainability roadmap* to be drawn and this will be the fundamental document for definition of the key product sustainability drivers that will be considered for the setting of objectives and targets (see Fig. 12.4).

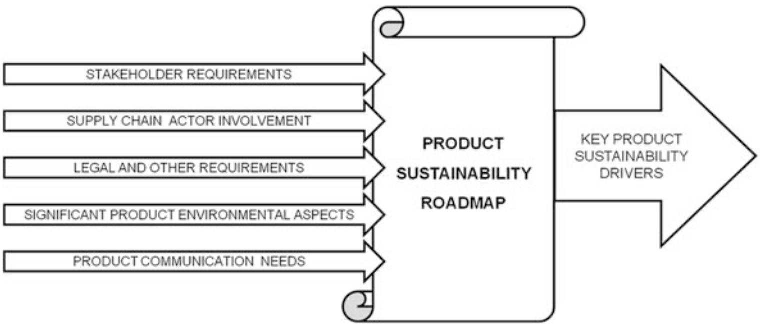

Fig. 12.4 The product sustainability roadmap

Objectives should be focused on the improvement of the environmental performance of products throughout their life cycle and on the product-related processes implemented in the POEMS (such as the process of definition of the product environmental profile).

Obtaining the chosen product label will be one of the targets that the organisation could set with POEMS implementation. Product-related objectives and targets should be integrated into the existing quality and environmental programme.

12.2.2 Do and Integration

The second step in the implementation of POEMS is the result of the combined application of the Do step (Deming cycle) and the Integration step (Capability cycle). In this phase the programme is implemented: plans are turned into actions for products and processes. In order to attain the planned objectives and targets, the Life Cycle Management approach is transmitted at each company level and solutions are organised within the firm but, given the life cycle perspective, some solutions should be found by cooperating with other actors within the chain.

Resources, roles, responsibility and authority

The organisation shall determine and provide the resources needed to perform the product-orientation of the IMS and the enhancement of stakeholder satisfaction. Management is responsible for incorporating product sustainability goals into overall business strategy by allocating sufficient skilled personnel, technology, and financial resources to ensure implementation and continual improvement of POEMS.

As for "traditional" management systems, POEMS roles, responsibilities and authorities should be defined, documented and communicated, but unlike traditional systems, product-orientation implies that organisational responsibilities should be defined, both internally and externally, within the chain, so responsibilities should be assigned both at company level and also to other actors in the product chain. In particular, organisational responsibilities should be discussed with the key actors in the chain involved in the pursuit of product-related environmental objectives and targets, so that they accept their responsibilities. These stakeholders should be involved in the decision making process of reducing the environmental impacts of a product or obtaining a product label involving common efforts.

Establishing clear product-related procedures and work instructions is highly important in order to ensure that the environmental aspects are taken into consideration throughout the whole production process of the product, including the processes carried out by other actors in the supply chain (for example by drawing up guidelines or adopting a code of conduct).

Competence, training and awareness

Employees performing POEMS activities should be qualified on the basis of appropriate education, training and/or experience. For these activities, the involvement of internal staff as well as external partners (supply chain actors involved in the product-oriented improvement programmes) is also significant when implementing POEMS. To facilitate POEMS implementation, an ad-hoc training programme should be carried out, preferably integrated with quality and environmental management training activities. In particular, dissemination of an environmental culture oriented to Life Cycle Management is highly recommended, as well as building expertise in the appropriate tools needed to apply the product-orientation strategy; areas of expertise include quality management, environmental management, supply chain management, Life Cycle Assessment, environmental product labelling (and Eco-Design, if the organisation is engaged in design activities).

Infrastructure and work environment

The organisation shall determine, provide and maintain the infrastructure and the work environment needed to achieve conformity with product and related environmental requirements.

Internal and external communication

Top management should establish and maintain communication procedures among the various internal and external levels of the supply chain. Procedures for receiving, documenting, and responding to relevant communication within the chain should be prepared. Particular attention should be paid to:

- internal communication—this is fundamental in order to increase environmental awareness among employees and to strengthen understanding of the strategic role of the POEMS in the organisation's general management;
- supply chain communication—product-related environmental targets should be transmitted to suppliers and customers in a communication of the top-management, containing environmental product requirements. Information flows through the supply chain have the role: to encourage the interaction among the actors and establish a dialogue with the chain partner involved in the improvement projects; to establish and maintain environmental management system practices; implement LCM principles to reduce environmental impacts; participate and co-operate with the organisation product-oriented initiative; provide product-related data; eliminate, avoid or minimise substances of environmental concern;
- external communication—the environmental results achieved are circulated outside the firm in order to strengthen the supply chain connection and to improve the company's image on the market (e.g. labelling of products to show that the products meet certain criteria).

Documentation, document control and records

POEMS documentation consists of a manual, process documents, procedures, documents templates, and records. It is extremely important to develop specific procedures or integrate the existing ones (when possible) in order to diffuse product-orientation in the everyday work of the organisation. In order to guarantee a product-orientation which is credible and reproducible over time, procedures must be described in such a way that the people involved (inside and outside the organisation) can easily understand them and put them into practice, obtaining the same results.

The ad-hoc supply chain documents should be easily accessible for the various actors involved in the POEMS activities (inside and outside the organisation), so this kind of document should be available using for example an archive on the organisation's web-site and also be transmitted via email.

Operational control and product realisation

All the processes connected to product realization (ISO 9001), should be updated including requirements related to the environmental performance of the organisation's products (stakeholder needs, legal and other requirements, and the planned product-related environmental objectives and targets). In the design and development processes (from planning, to review, verification, and validation), the organisation should take into consideration all the environmental aspects of products identified as significant.

For organisations that have design activities in their core business, Eco-Design should be incorporated into the product realisation processes (the ISO 14066:2011 guidelines could be used for this purpose), but this is generally not the case of organisations operating in the agri-food sector.

In quality management system, companies are familiar with the assessment of suppliers; within the POEMS, supplier assessment should be broadened: suppliers are assessed and judged on their adherence to quality requirements for products, but environmental issues should also be taken into account, together with the ability and willingness to gather and share life cycle data.

In procedures related to operational control, already present in the IMS, the organisation should also include procedures associated with the environmentally significant aspects of the product, expanding control activities to suppliers and other supply-chain operators; the aim is to control situations of deviation from the established product-related objectives and targets.

Emergency preparedness and response

The procedures for responding to emergency situations and accidents and for preventing and mitigating adverse environmental impacts should also include the potential situations identified following a life cycle perspective and decisions on actions to respond to them should involve other actors in the supply chain.

12.2.3 Check and Monitoring

The third step in the implementation of POEMS is the result of the combined application of the Check step (Deming cycle) and the Monitoring step (Capability cycle). This phase consists of reviewing the procedures implemented in order to evaluate whether targets have been met. Considering that the monitoring activities in a POEMS model should be carried out both internally and externally (throughout the supply chain), the results of these activities should be discussed with relevant stakeholders.

Monitoring and measurement

Procedures to monitor and measure the key characteristics of product environmental requirements and of the new product-related processes on a regular basis should be established and integrated into the pre-existing monitoring and measurement procedure (products and process monitoring).

For effective and efficient monitoring within the chain, it is necessary to keep track of relevant supply chain data. This includes storing all relevant information related to the environmental performance of products and performing periodic audits of monitoring and evaluation of the critical variables related to products.

Evaluation of compliance

The organisation should establish, implement and maintain procedures for periodically evaluating compliance with the defined requirements. These procedures should include the newly added product-related requirements. Indeed, customer and other stakeholder satisfaction should be monitored and methods for obtaining and using this information should be determined.

Control of records

Evidence of product conformity with the planned criteria involving the supply chain should be established, implemented and maintained and records should be legible, identifiable and traceable.

Management system audit

The audits related to the different systems (ISO 9001, ISO 14001, product label certification) should be conducted simultaneously whenever possible.

Considering the supply chain perspective, the organisation should conduct internal and external audits. In addition to first party auditing (the organisation itself evaluating its actions) and to third party (conducted by an independent auditing body, mainly linked to certification purposes), second party auditing should also be organised in order to monitor the action undertaken by suppliers and/or customers actively involved in chain management improvement actions.

Management of non conformities

The organisation should ensure that products which do not conform to product requirements are identified and controlled to prevent their unintended use or delivery (ISO 9001). The documented procedure established for controlling this aspect and the related responsibilities and authorities should be defined with integration of the supply chain perspective.

Data analysis

The organisation should determine, collect and analyse data to demonstrate the suitability and effectiveness of POEMS and to evaluate where continual improvements can be made. In addition to data already included in an IMS, a POEMS should analyse data that provide information on: life cycle data on the selected product(s); stakeholder satisfaction, product environmental requirements, supply chain, characteristics of product labelling systems.

12.2.4 Act and Communication

The fourth step in the implementation of POEMS is the result of the combined application of the Act step (Deming cycle) and the Communication step (Capability cycle). The organisation evaluates its environmental commitments, setting new targets and/or management system changes. This phase allows the setting of future directions (possible changes to policy, objectives and/or part of the management system are evaluated and addressed), and the continual improvement of the environmental performances of products in a life cycle perspective.

Corrective and preventive actions

Procedures ensuring that the actions taken were appropriate and commensurate with the objectives and targets defined should be established. These procedures should actively involve the key actors responsible for product-related processes, and corrective and preventive actions should be monitored along the supply chain. The organisation should ensure that relevant information on corrective and preventive actions is available through the supply chain both for the actors responsible for product-related process and other potentially interested actors.

Management review

Top management periodically reviews the POEMS to ensure its adequacy and effectiveness. In a POEMS, management's focus should be expanded in order to include product oriented objectives, targets and procedures and should deal with questions or complaints from stakeholders being held responsible. The management review should include assessment of the opportunities to improve the environmental performance of products and product-orientation processes. The reviews are documented and maintained as controlled records and if changes are necessary, specific plans should be established.

Depending on the results of the management review, the organisation will change its policy, objectives and/or other elements of the POEMS. The review of the system, in relation to the objectives and targets stated by the POEMS, may imply the need to perform various changes; for example, after the achievement of the goals, a new LCA study should be performed on the basis of the information acquired and of the revision of product environmental communication (if the product meets certain criteria, another label/declaration could be evaluated).

The management review ends a cycle and forms the basis for the start of a new one.

12.3 Conclusions

The POEMS model presented here was developed from a traditional EMS (ISO 14001), integrated with a QMS (ISO 9001 and ISO 9004), and is based on the PDCA cycle and the Capability cycle.

In the Plan and Interpretation phase, the product-orientation of IMS is guaranteed by the inclusion of a simplified-LCA (of one or more products), which allows the collection of data and information useful for the evaluation of improvements in the environmental performances of products. This information flow allows the initial environmental review to be changed so as to take into account the environmental impacts of products and interaction with the other actors in the supply-chain.

In the Do and Integration phase, the framework is completed with the inclusion of a Life Cycle Environmental Management strategy in order to improve the decision-making process by deploying a range of information useful to supply-chain sustainability, the definition of appropriate product documentation and the preparation of the chosen environmental product label or declaration.

In the Check and Monitoring phase, the implemented procedures are reviewed in order to evaluate whether the targets have been met, and the results of monitoring activities are discussed with all the relevant stakeholders.

In the Act and Communication phase, the organisation evaluates its environmental commitments and sets future directions for continual improvement of the environmental performances of products.

In order to support the successful implementation of this model in SMEs in the agri-food sector, three levels of key principles that the POEMS should satisfy were identified:

- flexibility principles—the flexibility of the model is the result of its modular structure, which can be adjusted by an organisation to its own level of ambition and in order to satisfy its own specific requirements; furthermore, the general character of the model is fundamental in order to ensure flexibility, because environmental strategies may differ considerably among organisations in the same productive sector, so different solutions could be organised;

- simplification principles—the simplification of the model depends on the fact that the actual management system of an organisation is not modified, but simply broadened by adding and/or incorporating (depending on the specific issue) product-related tools, information, objectives, procedures and documentation. The extent of this broadness depends on the organisation's commitments and on the ambitiousness of the objectives it wants to achieve;
- principles for translating the environmental measure into commercial benefits—in the model, this translation is related to obtaining an environmental product label and declaration; also in this case the type of label is not pre-defined, so the firm can choose the most appropriate form of product communication depending on its own needs and targets.

Considering the benefits of and obstacles to POEMS implementation, highlighted in the literature analysis presented in Chap. 11, the satisfaction of these three levels of principles should serve to encourage the implementation of POEMS and increase its potentiality for success. In any case, the main success factor for POEMS implementation is that the actors in the supply chain should see one another as partners, and the organisation implementing the POEMS must have the capability to manage and coordinate the efforts among these diverse actors in the supply chain. Unfortunately, although intra- and inter-firm coordination and cooperation activities are essential in a successful POEMS, they can be very difficult to accomplish, especially for SMEs.

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Chapter 13
The Implementation of Product-Oriented Environmental Management Systems in Agri-Food SMEs

Roberta Salomone, Giuseppe Ioppolo and Giuseppe Saija

13.1 Introduction

In Chap. 12, a POEMS model specifically tailored to agri-food companies is presented. In order to verify the effective functioning of the model, its application potentiality has been tested in pilot companies, operating in two different agri-food supply chains. The two supply chains were chosen in order to involve firms operating in important Italian sectors from an economic and/or environmental point of view:

- the olive oil production industry—olive oil is a typical Mediterranean product of great economic importance in the European Union, but, the olive oil industry causes various environmental impacts in terms of resource depletion, land degradation, air emissions and waste generation;
- the roasted coffee industry—after vegetable oil, coffee is the most important traded commodity in the world and, although it is grown only in tropical and equatorial areas, most of the coffee produced is consumed in developed countries; except for Germany and France, Italy is the biggest importer of green coffee.

The implementation potentiality of the defined POEMS model was evaluated following five main procedural analysis phases:

- supply chain analysis;
- analysis of the level of integration of the pilot firm's management systems;

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- preliminary analysis of the environmental impacts of the product/products identified by the companies themselves using the Life Cycle Assessment methodology (full LCA or simplified LCA, depending on the firm's targets);
- identification of the most suitable product environmental communication;
- identification of main future improvement options.

In the following, the two pilot experiences are summarised in order to provide a brief report of the analysis carried out within the EMAF Project.[1] The project does not include the final and complete implementation of the single tools integrated into the POEMS model, but a suggestion on how the tools could be designed and implemented in order to satisfy the companies' needs; indeed the implementation development of the suggested tools should be carried out by the firms' personnel.

13.2 Implementation of POEMS in a Pilot Firm in the Olive Oil Production Sector

The implementation potentiality of the POEMS model was tested in the Oleifici Mataluni, an important Italian company in the olive oil production sector that owns a modern plant in Montesarchio (BN—Italy) and represents one of the main agro-industrial vegetable oil complexes in the world. This company is distinguished by its ability to tie together tradition and innovation. A synthetic description of the firm and its products is given in the text box below (Oleifici Mataluni 2012).

The Firm: **Oleifici Mataluni**
The firm "Oleifici Mataluni" was founded in 1935 in Montesarchio (Benevento) as a small artisan sized oil mill; today is one of the world's most important agro-industrial oil complexes. The firm carries out the whole production process, preserving the ancient oil tradition, and giving birth to the most innovative Italian olive oil supply chain: olive press; refining; glass, PET and can bottling; production of PET bottles, caps, packaging and labels. In 2006 "Oleifici Mataluni" initiated a substantial strategic plan that will lead to the acquisition of important brands in the sector. In 2010 Oleifici Mataluni set up the Evolio Consortium, together with the biggest Italian agricultural olive consortium, representing 550,000 agricultural producers, thus shortening the production chain, to the mutual advantage of consumers and the

[1] The Eco-Management for Food research project (PRIN No.2008TXFBYT), co-funded by the Italian Ministry of Education Universities and Research-MIUR (EMAF 2012), was designed in order to propose, test and circulate a POEMS model, specifically tailored to companies operating in the Italian agribusiness sector, aimed at supporting these firms (mainly SMEs) in the introduction of organisational innovations that allow them to manage and continually improve the sustainability of their products/processes.

farming sector; an important production chain plan, combining the efforts of both olive growers and oil producers for the common aim of valorising only the best of Italian production. Today, the company has a turnover of 240 million Euros, around 200 employees (average age of 29), and a modern plant covering 160,000 m^2, equipped with a photovoltaic and trigeneration plant, a specialised laboratory for Quality Control and the Criol—Research Centre for the development of innovations in the oil and in the packaging sectors. The laboratory is equipped with an up-to-date and functional room for the sensorial analysis of oils, set up according to International Olive Oil Council directives and one section of the laboratory is dedicated to the control of packaging material compliance. The materials used for product packaging are also carefully checked in the laboratory to assess their quality, functionality and healthiness before use. Quality Control is carried out on all production phases and each process is implemented in compliance with the procedures set by Oleifici Mataluni's quality department and examined by external certified bodies. The Oleifici Mataluni management system for quality, environment and social responsibility is certified by international standards (ISO 9001, IS0 14001, IFS, BRC, SA 8000).
The Products: *Olive and Seed Oil*

- Dante "100 % Italian" Extra Virgin Olive Oil, made exclusively from Italian olives;
- Dante "Ancient Lands" Extra Virgin Olive Oil, the result of careful selection of the best oils from the most important olive growing areas in the European Community;
- Condisano—100 % Italian Extra Virgin Olive Oil, enriched with vitamin D;
- Condisano—Olive Oil enriched with Vitamin D;
- Dante Olive Oil, a blend of refined olive oil and extra virgin olive oil;
- Vitamin Enriched Various Seed Oil;
- Vitamin Enriched Soybean Seed Oil;
- Vitamin Enriched Corn Oil;
- Vitamin Enriched Sunflower Oil;
- Vitamin Enriched Peanut Oil.

13.2.1 Supply Chain Analysis

The olive oil supply chain, synthetically illustrated in Fig. 13.1, is briefly described here using the different life cycle phases of olive oil production: agricultural phase; olive oil production phase; by-product management phase; transport and distribution phase; consumption phase; waste management phase.

The agricultural phase includes the cultivation of olives with different treatments such as soil management, pruning, fertilization, irrigation, pest treatment and harvesting. Each of these treatments can be exploited in different ways;

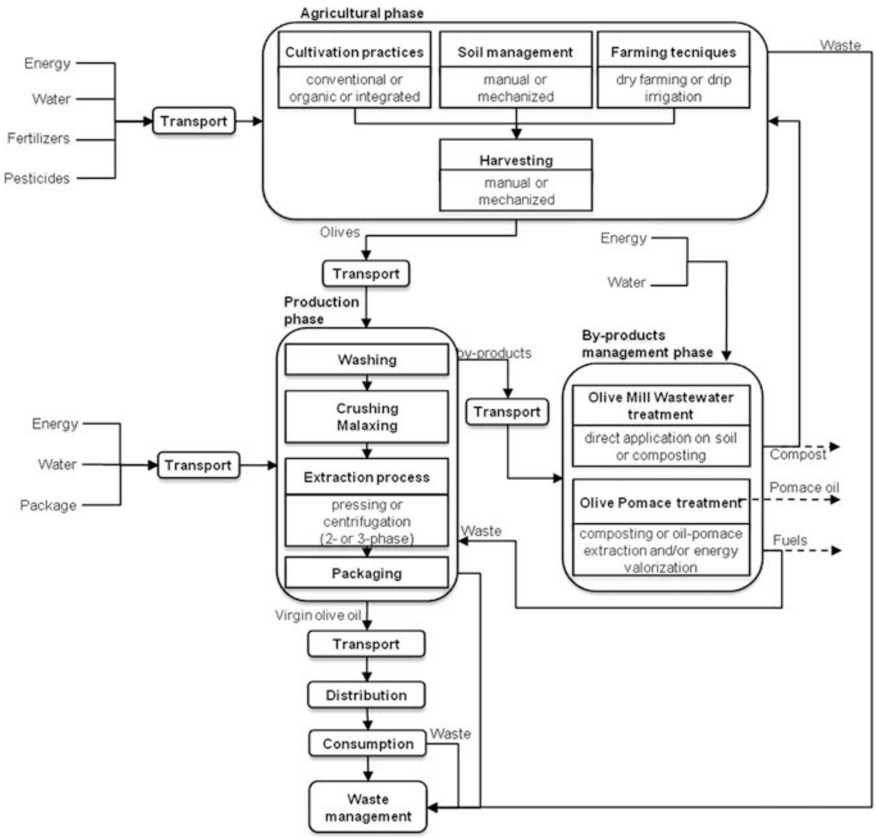


Fig. 13.1 The olive oil supply chain—main processes and main inputs/outputs (EMAF 2012)

depending on whether the cultivation derives from centuries-old trees (traditional systems) or from new intensive plants, cultivation practices can be conventional, organic or integrated, using a dry farming or drip irrigation method, with manual or mechanised soil management. After the harvest, the olives are sent to olive oil mills within 48 h in order to avoid fermentation phenomena.

The olive oil production phase includes the extraction of vegetable oil from olives; this process is conducted in olive oil mills that can use traditional pressing or centrifugation (with a three-phase or two-phase system):

- traditional pressing (discontinuous process) is still in use in some small mills that have an hydraulic press, but it is a relatively obsolete technology largely replaced by centrifugation systems that allow lower manufacturing costs, better olive oil quality and shorter storage time of olives before processing;
- continuous centrifugation with a three-phase system, although having a higher production capacity than traditional pressing, has some disadvantages such as

greater water and energy consumption (due to the addition of warm water to dilute the olive paste);
- continuous centrifugation with a two-phase system allows separation of olive oil from olive paste without addition of water and this led to removal of the vegetable water problem;
- continuous centrifugation with a two and a half-phase system (also called modified system or water saving system), which combines the advantages of the three-phase and two-phase systems.

Another innovative technology is oil extraction from de-stoned olives. In the de-stoning process the stones are removed before kneading; and it can be performed both in the three-phase or two-phase system.

The packaging process is also included in this phase even though olive oil is often sold unbottled (to final consumers or to national or multinational bottling companies) and only a few mills directly bottle olive oil with their own label.

The by-product management phase is very important in the olive oil supply chain because olive oil mill wastes have a great impact on land and water environments due to their high phytotoxicity (Roig et al. 2006) and their management is one of the main problems in the olive oil industry.

The transport and distribution phase includes all the transport activities, related to raw materials, by-products and wastes depending on production capacity and localisation of firms, and distribution of the product on the market at the local, regional, national or international level, depending on the strategy and production capacity of the firm. Transport activities can also occur elsewhere in the life cycle (other than where already mentioned), either between any two subsequent life-cycle stages or within a given stage, depending on the site-specific means of processing and the level of supply-chain integration.

The consumer phase, in the case of olive oil, is certainly not significant in a life cycle perspective, considering that product consumption does not need further preparations or treatments.

The waste management phase (end of life) includes the procedures for treatment of the bottles and other packaging waste (cardboard boxes, etc.).

Concerning the analysis of Olefici Mataluni’s position within the overall supply chain, it is possible to point out that, in particular with regard to olive oil, it follows, directly or indirectly through companies and producers’ consortium, the whole production processes at every stage. Indeed, the firm manufactures mixtures of selected oils obtained directly from olives from the Oleifici Mataluni olive oil agro-industrial complex or purchased by the largest and most reputable Italian and European manufacturers.

The entire production process is completed inside the plant, including: milling, refining and bottling in glass, PET or tin containers, production of PET bottles, caps, packaging and labels. In any case, although the company has its own olive oil mill, with five lines dedicated to the extraction of oil from olives, most of the bottled oil comes from external olive oil mills. The firm is also particularly oriented to continuous innovation in the areas of quality control, improvement of nutritional and sensory properties of the oils, innovation in production technology, development of innovative packaging for functionality and eco-friendliness, and valorisation of by-products of manufacturing processes.

Therefore, its dimension, structure and organisation, compared with the other actors involved in the supply chain, lead to the conclusion that "Oleifici Mataluni" is in a good position to influence the other actors on environmental issues.

13.2.2 Analysis of the Level of Integration of the Pilot Firm's Management Systems

The analysis of the current situation of the pilot firm's management systems was carried out taking in consideration, in addition to general requirements, the six common management system requirements indicated in PASS 99 (Publicly Available Specification for Integrated Management Systems) (BSI 2006): policy, planning, implementation and operation, performance assessment, improvement, management review. The results are reported in Fig. 13.2, where the integration of the management system standards incorporated in IMS is indicated by the use of requirement correspondence tables based on Annex B of PASS 99. In particular, the principal graphic element of the figure is based on the Plan-Do-Check-Act (PDCA) cycle, which is developed around the general requirements of IMS; it is divided into four sectors, corresponding to PDCA steps, containing six subsectors, representing common management system requirements, as follows:

- *policy* and *planning* in *Plan* sector;
- *implementation and operation* in *Do* sector;
- *performance assessment* in *Check* sector;
- *improvement* and *management review* in *Act* sector.

Each sub-sector is connected by an arrow to a correlation table between the integrable requirements and those of the several standards used by the company for implementing the IMS: indication of common requirements is reported in the first column of the table; the paragraph(s) containing the integrated requirements of the standard indicated in the row heading is (are) reported in the cells of the others columns (empty cell=no integrated requirement).

In the case under consideration, the pilot firm's IMS takes into account requirements of the following management system standards: ISO 9001; ISO 14001; SA 8000; OHSAS 18001. The analysis showed the presence of a good degree of overall integration with the presence of integrated policy and objectives; however, it is possible to increase the level of integration of the Management System.

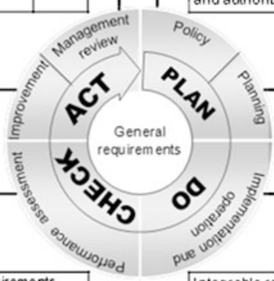
Indeed, in the company policy, contained in the manual for integrated quality, top management declares itself to be oriented towards a total quality approach in all company processes, including production, by implementing and continuously improving the Integrated Quality Management System in compliance with the

Integrable requirements	Integrated requirements			
PASS 99	ISO 9001	ISO 14001	SA 8000	OHSAS 18001
Management system policy	5.1 - 5.3	4.2	9.1	4.2

Integrable requirements	Integrated requirements			
PASS 99	ISO 9001	ISO 14001	SA 8000	OHSAS 18001
General	5.6.1	4.6	IV9.4	4.6
Input	5.6.2			
Output	5.6.3			

Integrable requirements	Integrated requirements			
PASS 99	ISO 9001	ISO 14001	SA 8000	OHSAS 18001
Identification and evaluation of aspect, impact and risk	5.2 7.2.2	4.3.1		
Identification of legal and other requirements	5.3(b) 7.2.1(c)	4.3.2		4.3.2
Contingency planning	8.3	4.4.7		
Objectives	5.4.1	4.3.3		4.3.3
Organizational structure, roles responsibilities and authorities	5.5	4.4.1		4.4.1

Integrable requirements	Integrated requirements			
PASS 99	ISO 9001	ISO 14001	SA 8000	OHSAS 18001
General	8.5.1	4.5.3	IV9.12	
Corrective, preventive and improvement action	8.5.2 8.5.3	4.5.3	IV9.12	



Integrable requirements	Integrated requirements			
PASS 99	ISO 9001	ISO 14001	SA 8000	OHSAS 18001
Monitoring and measurement	8.1	4.5.1		
Evaluation of compliance				
Internal audit	8.2.2	4.5.5		4.5.4
Handling of non conformities	8.3	4.5.3		

Integrable requirements	Integrated requirements			
PASS 99	ISO 9001	ISO 14001	SA 8000	OHSAS 18001
Operational control	7	4.4.6	IV 9.7 IV 9.8	4.4.6
Management of resources	6	4.4.2		
Documentation requirements	4.2			4.4.5
Communication	5.5.3	4.4.3		4.4.3

Fig. 13.2 Integration of management system standard requirements in Oleifici Mataluni's management system in accordance with PASS 99

requirements of the standards adopted and mandatory legislation. In addition, the IMS is also a commitment by the company to implement an environmental policy appropriate and proportionate to its activities and products.

In order to allow POEMS implementation, environmental policy should be slightly modified to include a commitment to continual improvement of product environmental performance, consequently modifying the company's environmental objectives.

Hence, the process of product-orientation should be integrated into firm's management system to allow continual improvement deriving from application of the Deming cycle in synergy with all the other processes already present. Furthermore, it is possible to include the management of product certification requirements in the same IMS framework.

13.2.3 Environmental Analysis of Products: Application of the Life Cycle Assessment Methodology

In order to define a first attempt at product-orientation of Oleifici Mataluni's IMS, the product environmental analysis was concentrated on two different olive oil packaging systems (glass bottle vs. PET bottle) related to the firm's most important product: Dante "100 % Italian" extra virgin olive oil.

This choice is the result of various considerations, primarily connected to the fact that the firm is very active in the research and realisation of eco-compatible packaging (it not only packages all its products, but also has a research centre for the development of innovative packaging, and it produces PET bottles), as well as the fact that packaging plays an important role in food supply chains and this area is one of the most intensively studied within the field of LCA (e.g. De Monte et al. 2005; Humbert et al. 2009; Zabaniotou and Kassidi 2003).

Indeed, the analysis was carried out according to the ISO 14040 standards on Life Cycle Assessment methodology (ISO 2006b, 2006c). At first an s-LCA was performed with the eVerdEE software; at a later time, the detailed level of data gathered, thanks to the firm's commitment, allowed a full LCA to be performed and this is summarised below.

13.2.3.1 Definition of Goals and Objectives

The aim of the study is to evaluate the potential environmental impacts related to different extra virgin olive oil packaging systems. The objective is to delineate a first indicative picture of the environmental impacts associated with two packaging systems used by the pilot firm in order to plan the product-orientation of the IMS. Both systems are compared based on an equivalent functional unit (*one bottle of extra-virgin olive oil*), cover the same portion of life cycle phases (from packaging production and assembly, through to distribution and end of life) and are defined using the same cut-off criteria (processes common to the two systems or non relevant by mass). Production of machinery and equipment are excluded from the system. System boundaries were defined in order to consider all direct and indirect activities involved in the packaging of olive oil and include four phases: production of raw material and semi-finished packaging products, packaging process, distribution, and end of life. As stated before, some processes have been omitted from this study; in particular, this being a comparative study, all the processes common to the two systems (such as the agricultural phase and olive oil production) were excluded because these elements were invariant with respect to the two packaging systems under study. The geographical boundaries of the study include Italy with respect to energy and Europe with respect to raw materials.

13.2.3.2 Life Cycle Inventory Analysis

Data sources of this study include foreground data, in which primary data were collected from the pilot firm and its main suppliers, and background data, in which secondary data were taken from international literature and databases (mainly Ecoinvent database) available in SimaPro 7.3.3, the software used to carry out the assessment (PRé 2011). In Fig. 13.3 the main reference flows of the two bottles are presented.

Data related to all the direct and indirect activities involved in the packaging of olive oil were included; in particular:

- *production of raw material and semi-finished packaging products*—this phase includes the production of raw materials and packaging products (bottle, cap, etc.), including ancillary products (such as ink, paint, lubrification oil) and transport from production sites to the pilot firm site. It should be highlighted that PET bottles are produced directly by Oleifici Mataluni, while glass bottles are acquired from an external supplier;
- *packaging process*—this phase includes different sub-processes such as filling, labelling and packing bottles, the transportation of scrap to waste treatment plants and waste treatment (scrap waste generated by the firm is sent entirely for recycling);

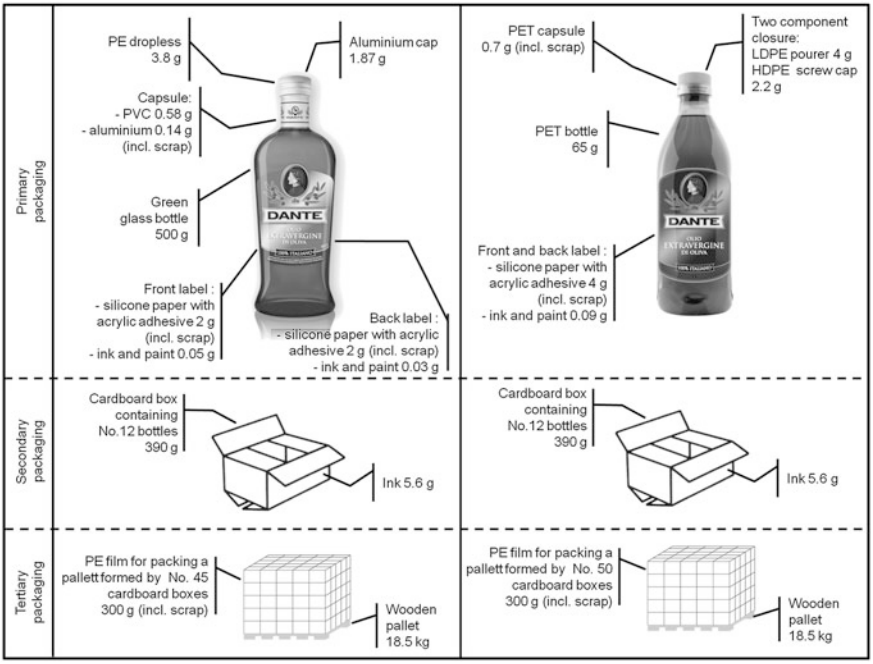


Fig. 13.3 Primary, secondary and tertiary packaging in the two systems

- *distribution*—this phase includes transportation from the production site to the wholesalers' warehouses (the entire quantity sent to Italian distribution centres was considered, while distribution from wholesalers to retailers and consumers is excluded);
- *package end of life*—the end of life of packaging generated at wholesalers, retailers or consumers is included, considering that: pallets are reused at a rate of 90 %, while waste packaging materials will be sent 46 % to landfill, 19 % to recycling plants, 16 % to municipal incineration plants, and the remainder for other unspecified treatments (in accordance with the Italian situation in 2010, described in ISPRA 2012). Municipal waste collection is also included.

13.2.3.3 Life Cycle Impact Assessment and Interpretation

The Life Cycle Impact Assessment was performed using the European ReCiPe Endpoint (H) method.[2] In Figs. 13.4 and 13.5 the results of the characterisation step [3] related to the two single systems are presented (glass and PET bottle system respectively), while Fig. 13.6 shows the comparison between the two packaging alternatives using normalised results. The ReCiPe method allows reporting on the following impact categories: climate change (human health), climate change (ecosystem), ozone depletion, terrestrial acidification, freshwater eutrophication, human toxicity, photochemical oxidant formation, particulate matter formation, terrestrial ecotoxicity, freshwater ecotoxicity, marine ecotoxicity, ionising radiation, agricultural land occupation, urban land occupation, natural land transformation, metal depletion and fossil depletion.

In Fig. 13.4 it is possible to observe that the phase of production of materials and packaging products for the glass system, contributes the most to all impact categories (the contribution is higher than 56 % for every category), followed by distribution (with a contribution varying from 35.7 to 6.9 % in the various categories, except for agricultural land occupation in which its contribution is 0.2 %). The end of life stage makes only limited contributions to each category (the highest contribution is in the ozone depletion category—14.5 %), while the contributions of the packaging process is almost negligible (less than 3.5 % in each category). In the PET bottle system (Fig. 13.5) the phase of production of materials and packaging products is also the most impacting one for all the impact categories (the contribution is higher than 43 % for every category). The distribution phase is the second contributing process in all the categories (with a contribution varying from 41.5 % for ozone depletion, to 0.46 % for agricultural land

[2] A hierarchical method that uses average weighting set, developed by RIVM, CML, Pré Consultants, Radboud University Nijmegen, and CE Delft.

[3] Figures 13.4 and 13.5 show the contribution of single process stages (in %) to the category results: the total of all contributions is set at 100 %.

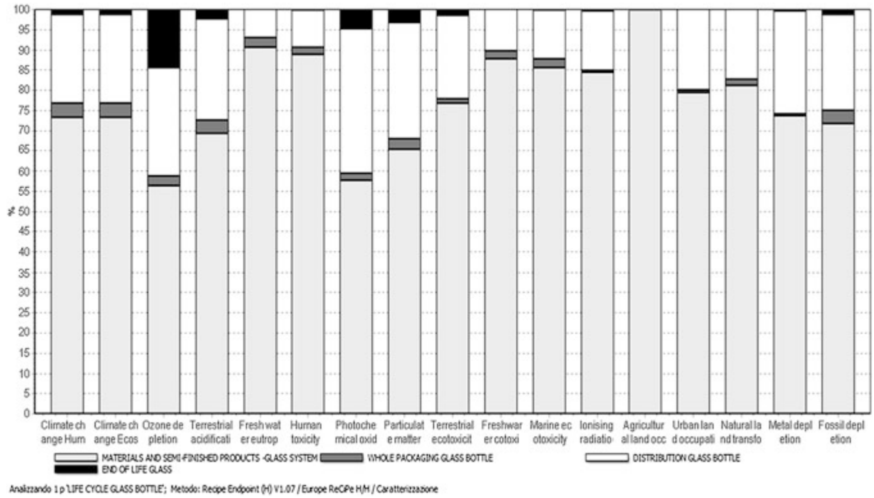


Fig. 13.4 Glass bottle system—characterisation results

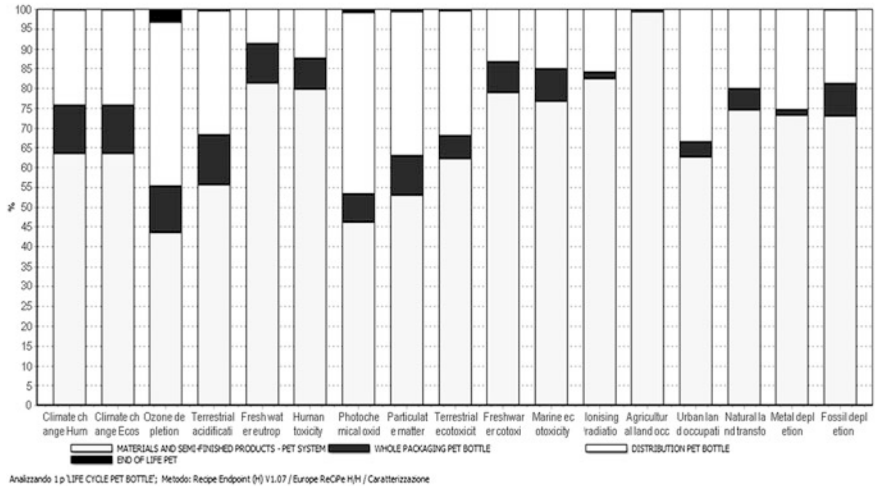


Fig. 13.5 PET bottle system—characterisation results

occupation), except for fresh water eutrophication, in which the second contributing phase is the packaging process. In the other categories, the packaging process stage contributes to each category with a percentage varying from 12.7 to 0.28 %, while the contributions of end of life are of minor importance (3.36 % for the ozone depletion category and less than 0.9 % for all the others).

Figure 13.6 shows the normalisation scores for the two packaging systems. The impact with the highest score is fossil depletion, for which the production of

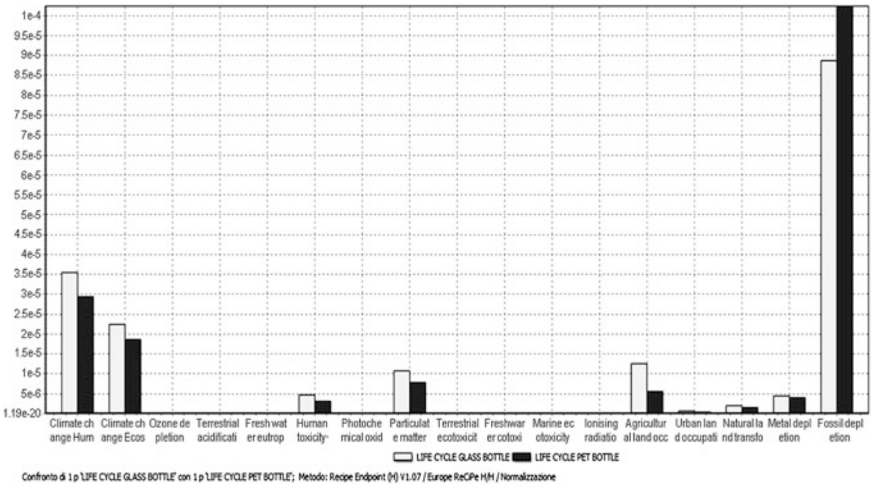


Fig. 13.6 Glass bottle system vs. PET bottle system—normalisation results

materials and packaging products is mostly responsible, and then the distribution phase, in both systems. The second most important impact is climate change (human health), followed by climate change (ecosystems): also in these two cases, for both packaging systems, the production of materials and packaging products is the dominating phase, followed by the distribution phase. In conclusion, the overall comparison highlights higher scores for the glass bottle system compared to the PET bottle system, except for the fossil depletion category in which the higher score is linked to the PET bottle system, caused by PET production.

13.2.4 Identification of the Most Suitable Product Environmental Communication

The main options the firm may take into consideration for the organisation of a proper product environmental communication process are the following two:

- a type III label—ISO 14025:2006 (International Organization for Standardization 2006a) could be an interesting option if the firm decides to perform an LCA on the whole supply chain (maybe for the "100 % Italian" product), considering that, within the Environdec EPD System, the PCR for "*Virgin olive oils and its fractions*" is available (Environdec 2010) and two EPDs on extra virgin olive oil have already been published (one for the extra virgin olive oil produced by 68 Greek olive growers and bottled in 0.75 l glass bottles, and the other for the pitted extra-virgin olive oil produced by an Italian SME, packed in a 1 l glass bottle) (Environdec 2012);

- a type II label—ISO 14021:1999 (International Organization for Standardization 1999) seems to be the better solution for environmental communication on packaging; indeed, the strong interest and commitment of the firm to the development of innovative packaging should be completed with coherent environmental information to consumers and other stakeholders. This type of label, according to the ISO definition, is not verified by an independent third party authority, and companies could internally define the form and content of communication (e.g., a declaration, a logo, or a statement);
- considering the great interest in climate change, a very appealing type of label is the Carbon Footprint and the information connected with the ISO 14064-1:2006 on the quantification and reporting of greenhouse gas emissions and removals (International Organization for Standardization 2006c). In this case the accounting for CO_2 emissions for the entire product life cycle may be used for the definition of a carbon footprint (e.g., CO_2 emissions saved with PET packaging compared to glass).

Each of these options should be carefully evaluated by the firm, considering the main targets it aims to achieve, following the guidelines presented in Chap. 9, and integrating communication procedures into the IMS structure.

13.2.5 Identification of Main Future Improvement Options

The preliminary investigation performed in the olive oil pilot firm, allowed testing of the implementation potentiality of the POEMS model and identification of several improvement options that should be considered as inputs for future management reviews and key elements in the process of continual improvement.

The experimentation carried out with "Oleifici Mataluni" was certainly positive; as a matter of fact the pilot firm decided to continue to follow the product-orientation path, planning new projects (focused both on packaging and on the whole supply chain), also after the end of EMAF project. Therefore, contrary to what happened in previous experiences, in which companies tended to return to "business as usual" after completing the project (Ammenberg and Sundin 2005), the project character of EMAF was not a weakness point, but an opportunity to stimulate the evolution of traditional management systems towards new forms of integrated management. In pursuing a complete POEMS implementation, the following priority targets should first be considered by the firm:

- improvement of data quality in the LCA study on packaging, in particular: distribution to final consumer should be included; primary data on some phases (such as pre-manufacturing packaging material production) should be evaluated with greater accuracy; and the relationship between olive oil quality and packaging materials should be further investigated and included in the study;

- identification of environmental critical points in a whole life cycle perspective, in order to define an environmental strategy with a limited number of objectives for the environmental improvement of products;
- product procedures for the application of eco-efficiency criteria to the whole cycle and particularly to the selection of products and suppliers should be prepared and coherently inserted into the more general IMS system of procedures.

13.3 Implementation of POEMS in a Pilot Firm in the Roasted Coffee Production Sector

Another firm where implementation potentiality of the POEMS model has been tested is Barbera 1870, one of hundreds of Italian companies specialised in coffee processing. Barbera is based in Messina (Italy), has a long tradition in the coffee sector, and for several years it has been engaged in improving its quality and environmental performances.

A synthetic description of the firm is reported in the following text box (Barbera 2012).

Barbera 1870 SpA
More than 140 years' experience dedicated to coffee, to processing coffee and to pleasing coffee drinkers have allowed Barbera to refine their high quality "integrated" work method: developing the product, processing, contacts with domestic and foreign clients, and environmental protection. Bearing in mind the same sound entrepreneurial, moral principles which Barbera have maintained for over a century, it has been totally natural for them to adhere to the main international voluntary norms, regarding quality, environment and product certification, obtaining prestigious recognition. Company philosophy today is concentrated on "lasting, sustainable development" which integrates economic, ecological and social aims, while at the same time working for continual improvement in company performance. Good intentions are followed by good actions. The firm has the following certifications:

- Food Safety Certification—Barbera 1870 SpA is one of the first companies in the coffee sector, on an international level, to have a management system for food safety which conforms to ISO 22000:2005 norms, for customer protection.
- Product Certification—Rigorous controls in the production process, from sourcing of raw material to packaging, is characteristic of all Barbera products, and the excellence of the coffee blend certificate is now confirmed by the Certified Special Coffee (CSC) association which has awarded the Barbera company a special counterfeit-proof stamp, placed on the packaging, for certified special blends.

- Environmental Certification—since 2004 the company has the main international certification for environmental protection, UNI EN ISO 14001, which testifies to the company's commitment to continual improvement regarding the environment.
- Quality Certification—the UNI EN ISO 9001 certificate issued by the international agency DNV Det Norske Veritas, testifies that the Barbera company management system has all the quality requirements applied to internal production processes: importation, development, roasting, packing and distribution of coffee.

Products

Barbera has a great assortment of products for home and bar use, divided into product lines with different blends (Maghetto, Pregiata, Classica, Augusta, Aurora, Esperia, Senca, etc.), including beans, pods and grounded coffee, and a variety of different packages (mainly flexible 250 or 1,000 g bags).

13.3.1 Supply Chain Analysis

The coffee supply chain, synthetically illustrated in Fig. 13.7, is briefly described here using its various life cycle phases: agricultural phase (green coffee cultivation); roasted coffee production phase; additional processing phase; transport and distribution phase; consumption phase; waste management phase.

The agricultural phase includes cultivation of green coffee with different treatments such as soil management, fertilization, pest treatment and harvesting. Each of these treatments can be exploited in different ways depending on cultivation practices (conventional or organic), typology of plantation (shaded or sunlight crops; monoculture or polyculture crops), harvesting method (manual or mechanised), etc. After harvesting, coffee beans can be processed in two different ways following the dry method or the wet one.

The dry method involves the following steps: sorting and cleaning, drying, hulling and storage. The wet method (also called the washed method) requires the use of specific equipment and substantial quantities of water and the coffee produced by this method is usually regarded as being of better quality and commands higher prices. The wet method involves the following steps: sorting and cleaning, pulping, washing (mucilage removing), drying and storage.

The roasted coffee production phase includes the coffee processing and packing stage. Coffee processing includes the following steps: storing, cleaning and weighing; roasting; cooling; blending; grinding. Sometimes coffee powder may be subjected to an additional processing phase consisting of different processes to develop product varieties such as instant or decaffeinated coffee. These processes may be performed in the same firms or in other ones.

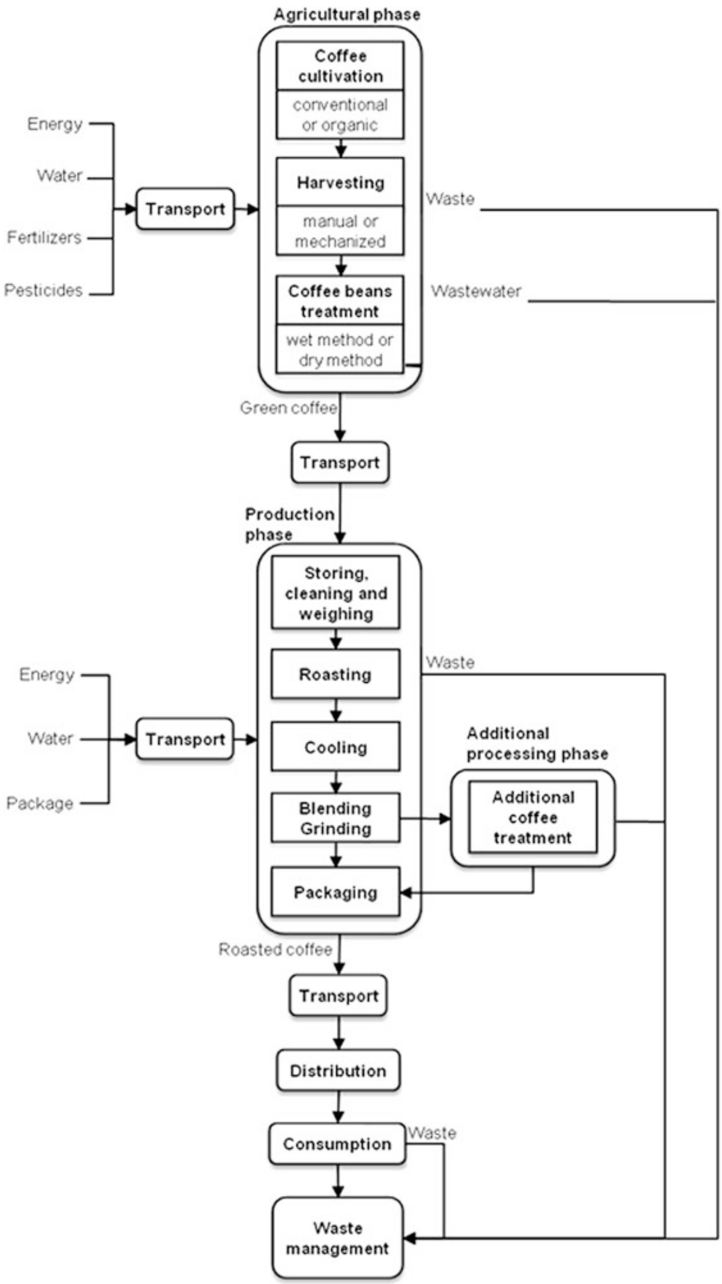


Fig. 13.7 The coffee supply chain—main processes and main inputs/outputs (EMAF 2012)

The packaging step includes many different types of primary and secondary packaging for roast coffee (aluminium cans, paper filters, etc.) depending on the company's choices.

The transport and distribution phase includes all the transport activities, related to raw materials, by-products, wastes depending on production capacity and localisation of firms, and distribution of the product on the market at a local, regional, national or international level, depending on the strategy and production capacity of the firm. Transport from coffee growers to roasting companies (generally in other countries) is especially very relevant in this phase.

The consumption phase, in the case of roasted coffee, cannot be considered as an insignificant stage in a life cycle perspective, because product consumption needs further preparations or treatments that involve energy consumption. Nevertheless, the consumption step is very difficult to measure and/or estimate because it depends on so many different factors (e.g. the type of coffee machine used).

The waste management phase (end of life) includes the procedures for treatment of packaging wastes (cardboard boxes, coffee chaff, coffee grounds, etc.). This phase can also have great impacts on the environment depending on the chosen method of waste management (for example, reuse, recycling, landfill, etc.).

Concerning the analysis of Barbera's position within the whole supply chain, it is possible to point out that it has very limited control and influence over the actors in the supply chain operating upstream from the firm, mainly because of the peculiar structure of the supply chain. Indeed, as described above, coffee has a very long and articulated supply chain generally including: growers (with very small plantations, sometimes carrying out the primary processing), primary processors, cooperatives (in some cases farmers and primary processors form cooperatives to have better control over the price and quality of coffee), intermediaries (who may be involved at many different points in the supply chain, but, generally, they buy coffee cherries and green beans from many individual farmers and sell them to processors or exporters), exporters, dealers/brokers (they simply supply the beans to roasters in the right location at the right time), roasters and retailers. Therefore, it can be concluded that "Barbera" has a weak potential to affect the choices of the whole supply chain, unless coordinated action with suppliers is organised.

13.3.2 Analysis of the Level of Integration of the Pilot Firm's Management Systems

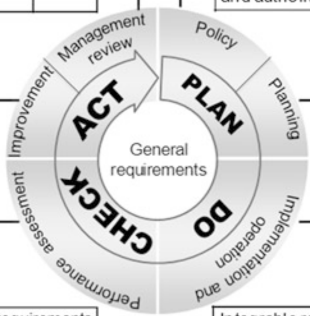
In a similar way to the previous pilot firm, analysis of the current situation of Barbera's management systems was carried out taking into consideration, in addition to general requirements, the six common management system requirements indicated in PASS 99 (Publicly Available Specification for Integrated Management Systems): policy, planning, implementation and operation, performance assessment, improvement, management review. The results are reported in Fig. 13.8, where the integration of the management system standards incorporated in IMS is indicated by

Integrable requirements	Integrated requirements		
PASS 99	ISO 9001	ISO 14001	ISO 22000
General	5.6.1	4.6	5.8 8.5.2
Input			
Output			

Integrable requirements	Integrated requirements		
PASS 99	ISO 9001	ISO 14001	ISO 22000
Management system policy			

Integrable requirements	Integrated requirements		
PASS 99	ISO 9001	ISO 14001	ISO 22000
General	8.5.1	4.5.3	8.1 8.5
Corrective, preventive and improvement action	8.5.2 8.5.3	4.5.3	8.2

Integrable requirements	Integrated requirements		
PASS 99	ISO 9001	ISO 14001	ISO 22000
Identification and evaluation of aspect, impact and risk			
Identification of legal and other requirements	5.3(b) 7.2.1(c)	4.3.2	7.2.3
Contingency planning			
Objectives			
Organizational structure, roles responsibilities and authorities	5.5	4.4.1	5



Integrable requirements	Integrated requirements		
PASS 99	ISO 9001	ISO 14001	ISO 22000
Monitoring and measurement	8.1	4.5.1	8.3
Evaluation of compliance	8.2.4	4.5.2	8.4.3
Internal audit			
Handling of non conformities	8.3	4.5.3	7.6.5 7.10

Integrable requirements	Integrated requirements		
PASS 99	ISO 9001	ISO 14001	ISO 22000
Operational control			
Management of resources	6	4.4.1 4.4.2	5.1 5.3 5.4 6.2
Documentation requirements	4.2	4.4.4 4.4.5 4.5.4	4.2
Communication	5.5.3 7.2.3 5.3(d) 5.5.1	4.4.3	5.6

Fig. 13.8 The current integration of management system standard requirements in Barbera's management system in accordance with the common requirements of PASS 99

the use of requirement correspondence tables based on Annex B of PASS 99; the figure is structured according to the same logic as Fig. 13.2 (see Sect. 13.2.2).

In the case under consideration, the pilot firm's IMS takes into account requirements of the following management system standards: ISO 9001; ISO 14001; ISO 22000. The analysis showed the presence of a medium degree of integration. Indeed, although most of the procedures are unified, the company maintains separate the internal audit processes and some items related to important requirements (i.e., policy management system, planning, management review).

Therefore, for better use of the potential advantages of the integrated management system, it would be appropriate to remove the separation existing between the processes that fall into the common requirements of the management standards used. Furthermore, in order to allow POEMS implementation, it is necessary to take into consideration the company's objectives related to product environmental performances. Hence, as the actual company environmental policy and objectives take into account exclusively performances related to production processes, the following changes should be made: the adoption of a single integrated policy containing specific references to environmental product policy that includes a life cycle perspective.

13.3.3 Environmental Analysis of Products: Application of the Life Cycle Assessment Methodology

In order to start the product-orientation of Barbera's IMS, the product environmental analysis was concentrated on a preliminary study of the whole life cycle of the product "roasted coffee".

A simplified Life Cycle Assessment was performed in order to obtain a comprehensive evaluation of the potential environmental impacts connected with the life cycle phases of the product (a complete and detailed LCA is planned for the future when the process of PCR definition for the EPD on roasted coffee is completed).[4] The analysis was carried out, according to the ISO 14040 standards on LCA methodology (International Organization for Standardization 2006b, c), using the eVerdEE software beta version[5] (a simplified LCA tool available online—EcoSMEs 2012): the study is summarised as follows.

13.3.3.1 Definition of Goals and Objectives

The objective of the study is to evaluate the potential environmental impacts related to the production of roasted coffee, in order to delineate a first indicative picture of the significant environmental impacts associated with the different life cycle phases of coffee production, to identify new continual improvement targets in a supply chain perspective, and to plan the product-orientation of the IMS.

The functional unit was defined as 1 kg *of packaged roasted coffee*. The firm has a wide range of different products but the functional unit was chosen in order

[4] See Sect. 13.3.3.5.

[5] See Sect. 7.3.

to avoid allocation (in accordance with ISO 14044), with no distinction between the various products (e.g. different blends and different types of packaging).

System boundaries were defined in order to consider all the direct and indirect activities involved in the life cycle of roasted coffee from coffee cultivation through to its processing, distribution, consumption and disposal. Production of machinery and equipment are excluded from the system.

The default structure of eVerdEE (pre-manufacture; manufacture; product packaging; distribution; use; and end of life) does not exactly describe the life cycle perspective of the different product phases as described in Fig. 13.7 (agricultural phase; primary processing; roasting; packaging; distribution; use; and end of life).

In this regard it should be noted that the beta-version of eVerdEE, in the first modelling options, allows the choice between agriculture and industry systems. Considering that, for the analysis of the whole coffee life cycle within the agricultural system option it would not have been possible to perform a complete modelling of all the industrial phases, while choosing the industrial system option, the cultivation of green coffee would have been considered as a process of the manufacturing phase, the following particular modelling choices were applied:

- first the agricultural option was chosen and a separate system was created for cultivation and primary processing;
- then this "green coffee" system was saved as a new component;
- finally a second system was created and the industry option was chosen. In this second system the new component "green coffee" was included as an element of pre-manufacturing phases and transport from cultivation sites to processing firms were considered as transport between manufacturing plants.

In conclusion, this modelling choice allowed the authors to perform an analysis more in keeping with the life cycle phases of the product in consideration.

13.3.3.2 Life Cycle Inventory Analysis

Data sources of this study include foreground data (the reference period for data collection was 2009–2011), in which primary data were collected from the pilot firm and its main suppliers, and background data, in which secondary data were taken from international literature and the database available in eVerdEE. Data related to all direct and indirect activities involved in the life cycle of roasted coffee were included; in particular:

- *pre-manufacturing*—in this phase all the process inputs related to the agricultural phase and primary processing were included, such as water, fertilizers, pesticides and correctives. Due both to a lack of primary data and a lack of more detailed data in the eVerdEE database, generic entries for pesticides and correctives were used. Indeed, it has to be noted that for the agricultural phase, great difficulties were encountered in gathering primary data, thus, for the preliminary study, literature data were used; in particular, the production of green coffee in Brazil was considered (Coltro et al. 2006). These data include both harvesting methods (manual and mechanised, called respectively picking and stripping) and both primary processing methods (wet and dry methods). Data refer to energy consumption (electricity, LPG, diesel, and wood), airborne and waterborne emissions (the emissions from the use of fertilizers and pesticides were quantified using estimation methods—Brentrup et al. 2000; Birkved and Hauschild 2006) and waste (organic residue reused as fertilizers and wastewater for irrigation); in the eVerdEE database, emissions to the soil are not considered so they were excluded;

- *manufacture*—in this phase all the processes related to the roasting steps were included. Primary data were collected for each sub-processes (storing, cleaning and weighting; roasting; cooling; blending; grinding; filling and packaging) and refers to auxiliary materials (water), energy consumption (electricity and natural gas), airborne emissions (NO_x, SO_2 and particulates declared by the firm) and waste (hazardous waste and non-hazardous waste sent to disposal or recovery). Transport between manufacturing plants included transport of green coffee from exporters to the pilot firm (considering that it comes: 40 % from Asia to export centre Mangalore; 30 % from Africa to export centre Mombasa; and 30 % from South America to export centre Santos) and transport of waste and scrap from the pilot firm to waste treatment plants. On the contrary, transport of pesticides and fertilizers to coffee growers and of green coffee from growers to primary processors, cooperatives and/or exporters was not included due to lack of reliable data;
- *packaging*—in this phase all the materials that the company uses for packing roasted coffee were entered, including primary and secondary packaging (laminate, cardboard and corrugated double cardboard for boxes, PE film). For laminate no similar processes were found within the eVerdEE database for the packaging category, so three different processes were included referring to the composition of the laminate (PE 65.7 %, PET 12 %, alluminium 15.6 %, while adhesive 6.7 % was not included for lack of similar data).[6]
  Secondary and tertiary packaging sent for reuse was not included (jute bags and big bags are reused by returning them to the wholesale company that distributes coffee; pallets are reused by the firm, suppliers and/or wholesalers). In this phase transportation of packaging material from packaging manufacturers to pilot firm is also included;
- *distribution*—for the distribution phase the transport of packaged coffee from the coffee pilot firm to local, national and international wholesalers was included, considering that roasted coffee is transported on lorries, as follows:

[6] Another option could be to create a new component "laminate", but in this case the software would include it in the pre-manufacturing phase and not in the packaging one as it is necessary for this study.

- 50 % to the region of Sicily—an average distance of 160 km was considered;
- 25 % to the region of Calabria—an average distance of 250 km was considered;
- 5 % to the region of Lombardy—an average distance of 750 km was considered;
- 10 % in Europe—for which an average distance of 1,671 km was considered;
- 10 % in North America—for which an average distance of 11,042 km by container ship and 84 km by lorry was considered.

  The distribution of packaged coffee from each national and international wholesaler to retailers, supermarkets and shops, and from these points of sale to each consumer were excluded because it was almost impossible to collect accurate data about quantities delivered regionally, nationally and internationally to each one. Consequently, this step is clearly underestimated;

- *consumption*—the consumption step is very difficult to measure and/or estimate because it depends on so many different factors, such as consumer nationality and tastes (e.g. the amounts of coffee and water used to make French coffee and Italian espresso differ greatly) or the type and brand of coffee machine used (in particular for energy consumption) amongst others and these differences are highly significant (±30 %).

  In order to estimate this phase the following assumptions were made: half of the coffee is prepared with a professional bar machine and the other half for domestic use (for the latter, half is prepared using an electric espresso machine and the other half using an electric machine for French coffee) (Gaggia 2012; Philips 2012; Cibali 2012) These assumptions allowed an estimate to be made of energy and water consumption. Sugar consumption is excluded as it is assumed to be of little importance to the whole life cycle of the product. In this phase municipal waste collection is also included considering an average distance of 15 km from the point of collection to the disposal site;
- *disposal*—waste management includes packaging and coffee grounds. It was assumed that all these materials were disposed of without any recycling.

13.3.3.3 Life Cycle Impact Assessment and Interpretation

The eVerdEE online software allows calculating the characterisation and normalisation results, respectively presented in Figs. 13.9 and 13.10.

Characterisation results highlight that the pre-manufacturing phase is principally responsible for the consumption of mineral resources (∼99 %), consumption of fresh water (∼68 %), consumption of renewable energy (∼62 %), climate change (∼60 %), acidification (∼57 %), eutrophication (∼91 %), and production of hazardous waste (∼66 %). The use and end of life phase contributes most to consumption of non-renewable energy (∼57 %), photochemical oxidation (∼59 %), and total waste production (∼52 %). Packaging and distribution contribute most to consumption of biomass (100 %), and to ozone layer depletion

Indicator	Total	Pre-manufacture	Manufacture	Packaging and Distribution	Use and End of Life
Consumption of mineral resource (kg antimony eq)	100%	99.3%	<0.1%	0.6%	0%
Consumption of biomass (kg)	100%	<0.1%	0%	100%	0%
Consumption of fresh water (m^3)	100%	68.2%	0.2%	0.7%	31.0%
Consumption of non-renewable energy (MJ)	100%	18.3%	14.6%	9.6%	57.4%
Consumption of renewable energy (MJ)	100%	1.2%	64.5%	2.7%	31.8%
Climate change (kg CO_2 eq)	100%	8.9%	56.7%	3.8%	30.6%
Acidification (kg SO_2 eq)	100%	4.9%	63.5%	3.4%	28.3%
Eutrophication (kg PO_4 eq)	100%	2.0%	92.8%	1.2%	3.9%
Photochemical oxidation (kg ethylene eq)	100%	10.4%	23.3%	7.1%	59.2%
Ozone layer depletion (kg)	100%	8.6%	4.2	60.4%	26.8%
Production of hazardous waste (kg)	100%	42.2%	37.3%	20.5%	<0.1%
Total waste production (kg)	100%	38.5%	5.5.%	0.7%	55.3%
Click on a cell to access more detailed results for selected life cycle phase and impact indicator (e.g. Manufacture Climate change)					

Fig. 13.9 Roasted coffee system—characterisation results (eVerdEE software)

Indicator	Total	Pre-manufacture	Manufacture	Packaging and Distribution	Use and End of Life
Consumption of mineral resource	$4.25\ 10^{-8}$	$4.23\ 10^{-8}$	$2.50\ 10^{-18}$	$2.57\ 10^{-10}$	0
Consumption of biomass	$7.87\ 10^{-11}$	$1.40\ 10^{-15}$	0	$7.87\ 10^{-11}$	0
Consumption of fresh water	$7.41\ 10^{-5}$	$5.05\ 10^{-5}$	$1.23\ 10^{-7}$	$5.04\ 10^{-7}$	$2.30\ 10^{-5}$
Consumption of non-renewable energy	$8.77\ 10^{-4}$	$1.61\ 10^{-4}$	$1.28\ 10^{-4}$	$8.35\ 10^{-5}$	$5.04\ 10^{-4}$
Consumption of renewable energy	0.00121	$1.48\ 10^{-5}$	$7.78\ 10^{-4}$	$3.15\ 10^{-5}$	$3.83\ 10^{-4}$
Climate change	$9.66\ 10^{-4}$	$8.55\ 10^{-5}$	$5.49\ 10^{-4}$	$3.73\ 10^{-5}$	$2.95\ 10^{-4}$
Acidification	0.00144	$7.05\ 10^{-5}$	$9.18\ 10^{-4}$	$4.82\ 10^{-5}$	$4.07\ 10^{-4}$
Eutrophication	0.00154	$3.16\ 10^{-5}$	0.00143	$1.86\ 10^{-5}$	$6.11\ 10^{-5}$
Photochemical oxidation	$1.75\ 10^{-4}$	$1.80\ 10^{-5}$	$4.07\ 10^{-5}$	$1.25\ 10^{-5}$	$1.04\ 10^{-4}$
Ozone layer depletion	$2.09\ 10^{-5}$	$1.78\ 10^{-6}$	$8.84\ 10^{-7}$	$1.27\ 10^{-5}$	$5.62\ 10^{-6}$
Normalized Results					

Fig. 13.10 Roasted coffee system—normalisation results (eVerdEE software)

($\sim$60 %). Finally, the manufacturing phase makes only minor contributions to each impact category.

The normalisation results highlight that eutrophication has the highest score (essentially due to the emission connected to the use of fertilizers in the cultivation process within the manufacturing phase). Relatively high scores are connected also with acidification, consumption of renewable energy, climate change, and consumption of non-renewable energy.

The most impacting phase is the pre-manufacturing one (essentially referred to cultivation processes), followed by the use and end of life.

Despite the limitations of the LCA data, the study not only allowed identification of the hot spots in the product chain across the whole life cycle of the product, but also allowed the firm to better understand how useful the LCA methodology can be in the decision-making process linked to the definition of a product environmental strategy; moreover it stresses the main gaps in current knowledge on which the firm's future commitment should be concentrated.

13.3.3.4 Identification of the Most Suitable Product Environmental Communication

In the case under examination, Barbera is particularly interested in obtaining EPD for one or more of its products. Currently, two different Product Category Rules (PCRs) connected to coffee are under development within the EPD Environdec System (Environdec 2012):

- a PCR on *Green Coffee*—which will be only addressed to farm level production, stopping at the farm gate, and which will probably be published, in its definitive form, by October 2013;
- a PCR on *Coffee*, *decaffeinated or roasted*—which will supposedly be addressed to the roasting processing level, but at the moment it is not clear which life cycle phases will be included. It is expected to be published, in its definitive form, by November 2012.

When the reference PCR is published, the goal of obtaining an EPD should be integrated into the firm's management system, in order to implement and manage the processes useful for the validation of the EPD in the IMS framework. The firm should firstly choose a product for which it envisages being able to establish good cooperation with suppliers, in order to have easier access to life cycle data. Bearing this in mind, a potential product on which to focus, could be Moka Arabica (a 100 % Arabica blend), which is a product certified by the Association of Certified Speciality Coffee (CSC), which assures its quality with the affixing of a holographic and numbered label on every package, guaranteeing rigorous controls in the production process, from sourcing of raw materials to packaging. These controls could be seen as a good opportunity for gathering reliable and exhaustive data in order to carry out a full LCA study on the product and, consequently, combining the CSC and EPD labels.

13.3.3.5 Identification of Future Main Improvement Options

The preliminary investigation carried out in the coffee pilot firm, allowed the POEMS model to be tested and different barriers were encountered, especially in relation to the attempt to organise close cooperation between the firm and the other actors in the product chain.

In the coffee supply chain, the agricultural phase is the most impacting one, but an objective difficulty in gathering primary data was detected, due to the complex and articulated structure of the upstream processes (from cultivation to export of green coffee). Therefore, the first step the firm should put in place is strengthening dialogue among all the actors in the supply chain with particular reference to cultivation and primary processing. Indeed, the company has already made a first attempt to gather data from a selected sample of farmers through the involvement of national coffee brokers who manage contacts with farmers' cooperatives and distribution of green coffee.

In conclusion, the outcome of the case study in question led to the consideration that indirect impacts are generally dominant, so it is unthinkable that the process of continual improvement of product environmental performances fails to take into account a suitable selection of suppliers and dialogue and cooperation with the key actors in the supply chain. Undoubtedly, this will entail further and stronger commitments from the firm's top management (in order to incorporate the product dimension into the firm's environmental work) and transaction costs (related to the need to negotiate agreements with various actors in order to define common actions for environmental improvement). Therefore, enhancement of cooperation within the supply chain is undoubtedly the biggest challenge that this firm needs to face up to in the future.

13.4 Conclusions

During the analysis of POEMS implementation potentialities in the pilot companies, some strong and weak points of the model emerged.

As regards the strong points, the model showed itself to be highly flexible; indeed it is potentially applicable in different firms and with different degrees of eco-sustainability which a company itself may ascertain depending on its aptitude to implement the product-orientation of IMS. This is a very important issue, considering that different types of firms could have different configurations of the POEMS framework, depending on which elements are stressed in the firm's strategy.

Experimentation also confirmed that an organisation already working with an IMS, can quite easily give it a product-orientation perspective introducing proper environmental assessment and/or communication tools for products. This is not only due to the modular structure of the model (which leaves a firm free to choose the extent of product-orientation), but also by the fact that it allows gradual approaches and commitments, so a firm may also start with only a preliminary orientation analysis and, subsequently, constantly enhance the commitment and/or the extent of product-orientation, defining further and more challenging objectives and targets according to its potentialities and resource availability. Obviously, the organisation may start with a pilot project in the environmental department, but success is determined by the integration of procedures into the overall management system and by its propagation in the everyday life of the firm.

Concerning the weak points, even though the model demonstrated the robustness of its general and iterative character, the need for a huge quantity of data and the necessity of defining common goals and implementing joint efforts with the other actors in the supply chain, in real practice, hindered full implementation of POEMS. Indeed, firms are reluctant to collect information from other actors and in agri-food organisations limited co-operation across the supply chain still persists: product environmental commitment is still perceived as an issue of less strategic importance than quality. This resistance to change should be faced with proper information and training activities in order to overcome the lack of a supply chain management perspective. These aspects are further complicated by the fact that the life cycle approach does not always correspond to the economic and commercial reality of the value chain, that is to say, the set of relationships between the various actors in the supply chain: indeed, some environmental impacts of products are related to actors and life cycle phases with which the manufacturer has no direct contact (often due to the presence of commercial intermediaries, such as wholesalers and distributors) and for which there are practical difficulties in establishing cooperative management relationships (Ammenberg and Sundin 2005; Cariani 2010). However, it should be noted that these difficulties differ greatly depending on the power position that an organisation has within the supply chain (the greater its power to influence the other actors on environmental issues, the greater the opportunities to establish communication flows aimed at gathering significant data on environmental impacts in the various life cycle phases).

Additionally, the implementation of POEMS initially means an increased workload for the firm and additional costs (information costs, data gathering costs, and organisational costs) arising from the firm's supplementary activities, both varying according to the specific activities implemented by the organisation, although it should be emphasised that POEMS is not an additional system but rather an inclusion of product requirements into existing management system(s). Thus, the basic idea is to optimise the structure of management systems already present in the firm (both relating to QMS and EMS), directing the additional efforts in three main directions:

- enhancement of the relationship with suppliers and contractors, especially for the availability of information relating to products and materials;
- integration of product-related environmental information into the environmental analysis; this will have an impact on all stages, from the definition of environmental policy to identifying targets for improvement;

- identification of suitable product-related environmental communication, because the promotion and marketing of products are the main factors that can contribute to successful POEMS experiences.

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Concluding Remarks and Future Challenges

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The innovative character of the POEMS model is determined by the integration approach of tools that are generally analysed as “independent”, while in the EMAF project they are closely related to one another.

The adoption of an Integrated Management System, made up of a Quality Management System and an Environmental Management System, represents a fundamental step in the transition from conventional to more sustainable business practice in agri-food organisations. At the same time, it only represents the starting point on the complex pathway toward improvement of the global performance of agri-food products and processes, in accordance with the environmental sustainability perspective. Such a vision, indeed, requires the adoption of an array of tools, aiming at a POEMS as the final target. The other tools to be integrated are a Simplified LCA and a proper product environmental communication tool. Indeed, the product-oriented approach allowed by a Simplified LCA methodology, specifically suited for agri-food SMEs, and guidelines for supporting firms in the choice of the most appropriate environmental communication system, are deemed as

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highly necessary for a successful POEMS framework: they may ensure the market orientation essential in order to counter the firm's erroneous conviction that environmental management tools are not a business opportunity. Indeed, the applicative phase of the EMAF project highlighted that various important factors affecting the application of each environmental management tool are widespread in many organisations in the agri-food sector; these factors include lack of market information, limited understanding and awareness of environmental issues, difficulty in considering these tools as instruments for creating value in the market and limited co-operation across supply chains. This means that cultural and structural changes and continual improvement are the imperatives that should be properly managed in order to directly connect POEMS and its individual components with the challenges of transforming sustained efforts into effective business opportunities.

POEMS is a developing area and further research is needed on this topic. The key contribution of this research is that it has taken a step toward increasing understanding, from a theoretical and empirical perspective, of the integration of available tools for environmental sustainability management in the agri-food industry, particularly in SMEs.

Due to its general character and structure based on iterative procedural steps, it could support companies' decision-making processes in the choice of the most suitable voluntary environmental tool for the requirements and characteristics of their products and process.

This study makes an active contribution both from a methodological and from a method standardisation point of view and its application could be extended to other production processes in order to show how versatile its applicability is.

The experience obtained carrying out the EMAF project highlighted certain limitations of the research, such as the fact that the proposed model, although certainly satisfying the aspects that were identified as key principles to encourage the implementation of POEMS and increase its potentiality of success (flexibility, simplification, translation of the environmental measure into commercial benefits), was unable to adequately support the difficulties in managing and coordinating the efforts on the part of the diverse actors in the supply chain; this is an essential element for a successful POEMS. At the same time, it represents the main obstacle for firms to deal with. Considering this limitation, future work needs to be conducted in order to strengthen those aspects of the capability cycle that could support firms in the organisation of inter-firm cooperation activities.

Furthermore, it was ascertained that the concept of POEMS is new and unfamiliar to SMEs, so in the planning of future POEMS projects, a more significant strategic role should be assigned to information and training activities.

Finally, it should be highlighted that the model proposed is specifically designed to answer the particular requirements of the agri-food production chain, but can also be applied in other sectors of production, with slight modifications, thus "amplifying" the results of the EMAF project.