

Environmental Management and Life-Cycle Assessment in Supply Chain Management – The Case of the Meat Chain

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1. Introduction

Stricter policy rules on environmental issues, changes in consumer attitudes towards the environmental effects of food production, and increasing competition regarding the quality and efficiency of production force agrifood industry to formulate management concepts and management systems which extend the traditional focus on economic efficiency to

- (a) incorporate quality assurance and quality improvement and
- (b) reduce the use of natural resources and the negative impacts of production and trading activities on the environment.

These aspects are a response to the objectives of different interest groups which have an influence on the strategic positioning and the operational success of agribusiness industries. They involve

- (a) the enterprise itself with its interest in **economic** sustainability and success,
- (b) the consumers (the 'market') with their interest in **quality** characteristics of products and services, and
- (c) the society as a whole with its interest in **environmental** sustainability.

Management activities which attempt to assure a reliable and efficient realization of these objectives are usually grouped accordingly into

- (a) business management activities (economic interests),
- (b) quality management activities (product interests), and
- (c) environmental management activities (environmental interests).

They build on a process oriented management approach which views economic success, quality of products and environmental effects as outputs of business processes which can be influenced through appropriate process organization, process control and process improvement activities. The implementation of all three types of management activities represents the core concept of today's view on integrated process management.

However, the extension of enterprise objectives from economic considerations towards quality and environmental issues represents a major increase in business complexity. It increases the need for

- (a) an integrated view of supply chains in business management and
- (b) the incorporation of qualitative and 'soft' criteria into monitoring and evaluation routines of management activities.

While this applies to all types of businesses, it is especially true for enterprises of agri-food supply chains and, especially, the meat chain. The meat chain extends from the breeding industry through a.o. agriculture, the feedmix industry, slaughter houses, meat processing and trade to food outlets where it reaches the final consumer.

Quality objectives of consumers may relate to characteristics of process activities (e.g. animal treatment) in any stages of the supply chain but may not be measurable at the final product. This asks for a chain oriented management approach, the development of a chain-encompassing information flow on quality characteristics and the development of trust in its reliability. Environmental considerations follow a similar approach but require, in addition, the delineation of an appropriate scope of analysis and the identification of environmental targets which build on aggregates of environmental characteristics which may be difficult to reach.

It is in line with increases in complexity, that present developments in industry concentrate on the integration of traditional business management with quality management and the linkages of both within the supply chain. Experiences on the integration of environmental management are still limited.

It is the objective of the paper to discuss the concept of integrated management, the incorporation of environmental management and options for their implementation in enterprises and supply chains. The discussion is supported by case studies on the implementation of environmental management approaches in the meat chain, a chain which is forced by markets and competition to steadily improve on its management concepts.

2. A General Process Management Model and the Environmental Dimension

2.1 The General View

The principal structure of integrated process management with the three dimensions of process objectives is outlined in figure 1. Management builds on process information to arrive at decisions regarding the implementation of process activities which influence the process' effects on product quality, on the environment, and on the economic performance of the enterprise.

The identification of appropriate activities in process organization, process control, and process improvement might build on

- (a) external expertise as is the case in 'business process reengineering (BPR)' approaches or on
- (b) internal knowledge of the enterprise as is the case in 'total quality management (TQM)' organizational business structures with intensive involvement of business personnel in decisions on process activities.

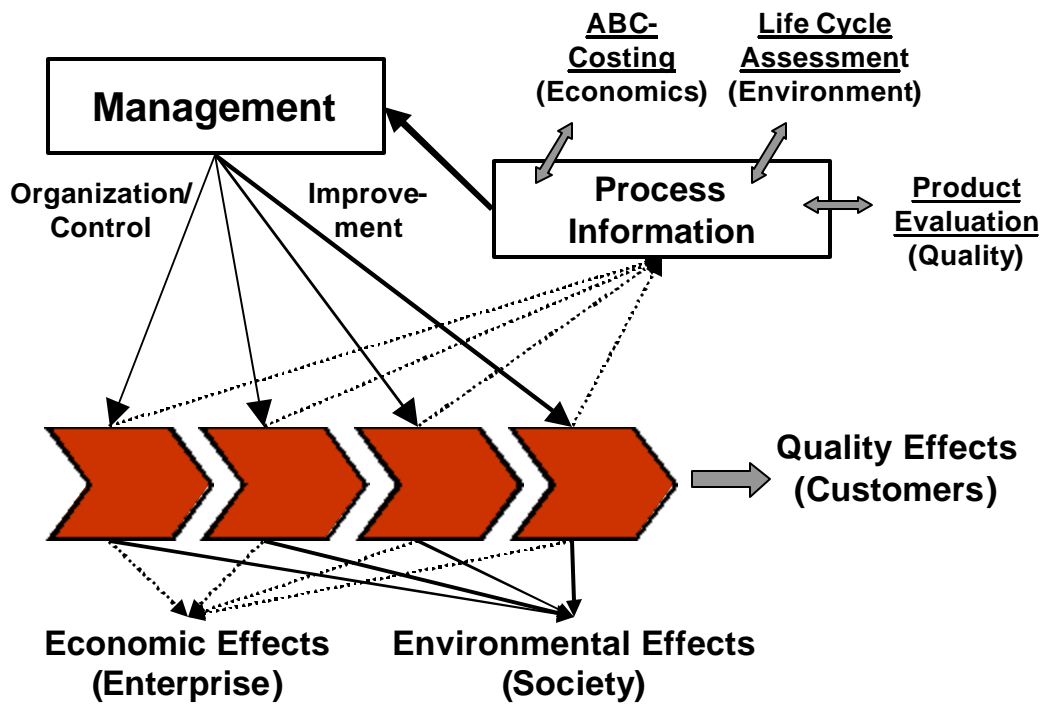


Fig. 1: Management loop

In the consideration of quality and environmental issues, both approaches may be extended from an enterprise related view to a chain-encompassing view. However, there is little experience in chain-encompassing implementations of BPR and TQM approaches.

For management use, process information usually needs to be transformed into management support information which is suitable for focussed decisions on management activities. The transformation process builds on transformation models. Common alternatives include

- (a) the process oriented 'activity based costing' approach for economic aspects,
- (b) customer product evaluation schemes for quality aspects, and
- (c) various forms of 'life-cycle-assessments' for the consideration of environmental effects.

These alternatives and the way they need to be used relate to the different levels of complexity in the management of the economic, quality and environmental aspects of enterprise activity.

Environmental Life Cycle Assessment is being used in industry for individual products or enterprises. However, the need is for an extension throughout the supply chain, either with a focus on individual products or on the chain of enterprises. At each stage of the

chain, any (e.g.) product receives a 'backpack' full of environmental effects of production processes from earlier stages. Similarly, it hands the 'backpack' together with the environmental effects of its own production process over to the next stage.

Life-Cycle-Assessment involves 4 steps

1. Specification of objectives which involves the identification of the system under consideration and its limits.
2. Monitoring (accounting) of environmental effects through an analysis of material and energy flows.
3. Identification of impacts which involves the identification of impact categories and impact assessment.
4. Assessment of the overall impact which involves judgements on the aggregation of different impact categories.

2.2 The chain view

The dependency of the quality characteristics and of the environmental status of final products on the organization of business processes throughout the supply chain asks for a chain-encompassing view in decisions on process activities.

The basic requirement for the organization of the management loop in a chain is the organization of an information flow based on common agreements on its content which relates to the different management activities.

This includes

- (a) information about production characteristics in individual enterprises to support the formulation of 'status information' regarding quality and environmental aspects,
- (b) information about the control status of products to support the delivery of guarantees and decisions on process control activities,
- (c) information on process organizations to support decisions on coordination activities for process improvement within the chain.

There are, in principle, two alternatives for the organization of the information flow (see figure 2). In a centralized approach, the information flow and communication rules are coordinated by a central institution of the supply chain. Typical examples are the strictly controlled food supply chains (IKB chains) in the Netherlands. The coordinating role could also be played by one of the participating enterprises in the chain, a common approach in sectors with great differences in the market power of chain enterprises. In a decentralized approach, the information flows are based on common agreements and direct communication lines between the individual enterprises. Example applications are known from Danish meat chains whose organization involved elements of TQM management approaches with a sophisticated system of discussion groups on different levels of chain management.

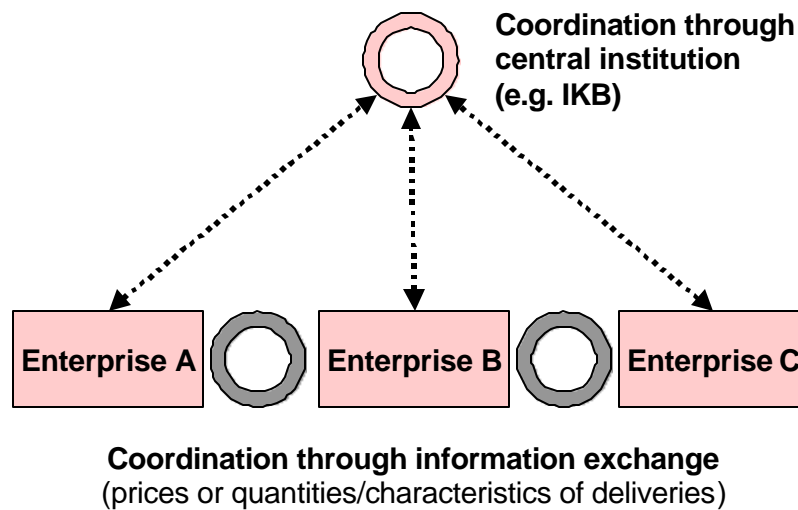


Fig. 2: Chain coordination alternatives

The coordination of process improvements within the supply chain involves two levels of coordination intensity.

At the **first level**, individual enterprises receive guidance on the improvement potential of processes or process elements within the enterprise with regard to the chain objectives. This could build on a 'matrix of environmental problems' (see figure 3) which relates impact categories to the various stages of a supply chain and marks, for each category, the stages where one encounters specific environmental problem areas. The categories may involve difficult to capture aspects like landscape, global warming, noise, smell, etc. The matrix can, therefore, only provide a rough indication of the seriousness of problem areas. Furthermore, it does not indicate the comparative level of difficulty in reducing environmental impacts in any of the categories which would be needed for a chain-encompassing agreement among participants where to act.

The **second level** considers the interdependencies between process characteristics and coordinates the process decision activities of enterprises towards an 'optimal' process organization structure throughout the chain. Such an optimal structure could be the result of

- (a) a joint planning effort of all participating enterprises (centralized approach) or
- (b) a stepwise adaptation process which has been extensively discussed in literature with regard to the coordination of activities between mutual dependent enterprises with own decision authority (decentralized approach).

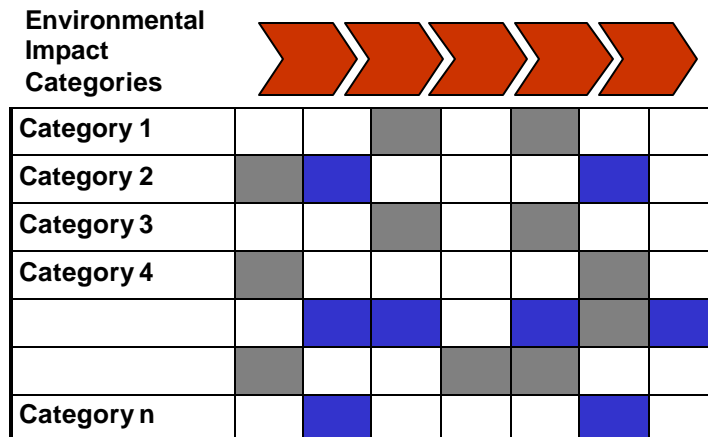


Fig. 3: Matrix of environmental problem areas

In the decentralized approach, principal coordination instruments are
 (a) prices for products and services that are being exchanged in the supply chain and, most commonly,
 (b) agreements on the quantity and characteristics of deliveries.

3. Business Implementation Strategy

3.1 Implementation Steps

In environmental management, the implementation of the process management model usually follows a three steps approach:

Step1: Consideration of **environmental objectives** of the enterprise and, where appropriate, of the supply chain through an appropriate organization of processes and information flows.

Step 2: Incorporation of **environmental reliability** by stabilizing processes through appropriate process controls in enterprises and throughout the chain.

Step 3: Realization of **environmental improvements** in enterprises and the chain through an analysis of process performance and the implementation of appropriate improvements in

- (a) process organizations in enterprises and
- (b) process coordination within the supply chain.

3.2 Process Organization

The organization of processes builds on the specification and scheduling of process activities and process controls. Process activities and process controls build on the identification and monitoring of inputs and outputs of activities.

In environmental management, inputs and outputs of activities are linked to 'Environmental Impact Categories (EIC)'. The impact of inputs and outputs on the EIC is captured through 'Environmental Performance Indicators (EPI)' and an appropriate approach for their monitoring.

The identification of EICs has to deal with two problems, the

- (a) selection of the right EICs and the
- (b) determination of the relationships between them if one wants to capture the environmental impact of a certain process, the production of a certain product or of an enterprise in an aggregated measurement.

The selection of EICs depends a.o. on the industry under consideration. However, the selection is supported by the availability of a few widely accepted agreements on the importance of environmental effects (Kaltschmidt and Reinhardt, 1997). While these agreements are quite general, they usually need some adjustments depending on the specific needs of a certain industry. Examples of categories include the 'use of resources', 'human toxicity', etc.

Relationships between EICs are determined according to environmental priorities. These priorities reflect subjective views of interested groups. This makes comparisons between enterprises or industries difficult.

Appropriate EPIs need, first, to have relevance as indicators for the EICs and, secondly, to be available in enterprises throughout chains. The latter requirement might be difficult to fulfill. As a consequence, it might be difficult to clarify the environmental impact of a chain or a product of a chain even within a specified environmental impact category.

3.3 Process Stabilization

The stabilization of enterprise and supply chain processes involves the identification of a system of routines for process control. Common suggestions for the organization of such systems have been established in the international standard series ISO 9000 for quality management systems and ISO 14001 for environmental management systems.

The implementation of an environmental management system usually builds on established quality management systems. As a rough estimate, we can conclude from case studies (Kessler, 1999) that the organizational requirements for the implementation of an environmental management system according to ISO 14001 are

already covered by a quality management system according to ISO 9000 at a level of about 80-90%. This facilitates the integration of environmental management into enterprises with established quality management systems.

3.4 Process Improvement

Process improvement may focus on an enterprise, a product or a chain. From an environmental point of view, it involves, in principle, three steps:

Step 1: Assessment of environmental impact.

Step 2: Incorporation of economic and quality aspects into an integrated performance assessment.

Step 3: Identification and implementation of improvement initiatives.

The key instrument in the assessment of environmental impacts is the 'life-cycle-assessment (LCA)' approach (Baumann and Rydberg, 1992). It integrates an 'environmental performance evaluation' which builds on the 'environmental performance indicators'. There is an extensive discussion on the evaluation procedure, as the indicators might be quite diverse and, in addition, include quantitative and qualitative elements. One suggestion for evaluation favors a so-called 'verbal' evaluation based on verbal arguments.

However, this difficulty is not specific for environmental performance evaluation but is at the heart of performance evaluation in an integrated view which combines environmental aspects with economic and quality aspects. The combination cannot easily be captured in single performance indicators and requires judgement and expertise.

4. Case Study Experiences – the Meat Supply Chain

The meat sector is characterized by a number of specifics which

- (a) put pressure on the sector to implement integrated management concepts on both, the enterprise level as well as on the chain level but which, at the same time,
- (b) make the implementation of the management concepts difficult to realize.

The first aspect is in line with country sector studies which attach the food industry in general a leading role in the establishment of integrated management systems which include environmental management aspects (DIHT, 1999).

Some of the specifics of the meat sector which are partly also of relevance for the food sector as a whole include:

1. **Sensitivity of markets** regarding consumer reactions.
2. **Organizational diversity** in enterprises which cover a range from small

family farms to large-scale multi-national industry.

3. **Diversity in EPIs** (environmental performance indicators) which are linked to different organizational types of enterprises and may not always be suitable for all types of enterprises within a supply chain.
4. Multi-stage **process focus** of expectations of consumers and society enforces process coordination initiatives and, if not measurable at final product, the establishment of chain guarantee systems.
5. **Knowledge deficiencies** regarding the interdependencies between quality and environmental aspects which create assessment problems and may have wide-reaching consequences (see the example of the BSE situation).

In recent case studies in the meat sector, the different phases of integrating environmental management and a life-cycle assessment into enterprises and the meat supply chain have been analyzed in more detail (Kesseler, 2000).

The priority focus was on a first level chain integration which is the level, industry attempts to achieve. It involves the following status regarding the organization, stabilization and improvement of processes:

1. Organizational activities:
 - (a) Focus on organization of enterprise internal processes
 - (b) Simple chain coordination through
 - the utilization of a chain-encompassing 'matrix of environmental problem areas'
 - agreements on the organization of information flows between enterprises regarding format and content.
2. Stabilization activities:
 - (a) Focus on stabilization of enterprise internal processes
 - (b) Simple chain coordination through agreements on
 - control responsibility and
 - the exchange of information on controls and control results.
3. Improvement activities:
 - (a) Focus on improvements in enterprise internal processes
 - (b) No chain coordination beyond the coordination initiatives of (1) and (2).

A key element at this level is the 'matrix of environmental problem areas' which builds on a selection of environmental impact categories and the identification of problem priorities in enterprises at the different stages of the supply chain.

In the meat chain, the selection of environmental impact categories includes two types of categories,

- (a) 'enterprise categories' which are limited to individual stages of a chain either because the interest is limited to the specific stages (as could be the case with categories like 'landscape impression' or 'noise') and/or because there is no common indicator throughout the chain and
- (b) 'chain categories' which are of interest at all stages of the chain and which

can be captured through a common indicator (as could be the case with categories like 'resource use' or 'global warming/CO₂').

Enterprise categories have no potential for chain coordination but, in a chain-encompassing environmental management approach, they need to be communicated through the chain. In contrast, chain categories could be the focus of chain coordination initiatives at more advanced levels of coordination.

In the case studies, this analysis was complemented by an analysis of the potential of environmental impact categories for quantification at each stage of the supply chain on the basis of data from individual enterprises. Of 15 impact categories with relevance in any of the supply chain stages only 9 had the potential for quantification at each of the stages.

However, there were striking differences in the positioning of the categories with quantification potential within the chain. All problem areas of later stages had the potential for quantification throughout the chain. Furthermore, almost half of the problem areas were of similar importance for all stages. In contrast, more than half of the problem areas of early stages (close to agriculture) had, at the time of the case study, no potential for quantification throughout the chain. This suggests, that the potential of enterprises for environmental improvement through coordination initiatives within the chain is higher in enterprises at later stages than in enterprises at early stages. It should, therefore, be in the interest of industry to coordinate its activities with production agriculture, to signal to agriculture its interest in impact categories (which are a subset of the impact categories of agriculture) and to initiate appropriate information flows regarding these categories. Without these signals, production agriculture might focus on impact categories which are of secondary importance for the chain and which, as a consequence, might not find appropriate attention by its chain customers.

5. Summary and Conclusion

The incorporation of environmental management into process management approaches is the latest and most complex step in the formulation of a comprehensive process management concept. However, there is still little experience in the transfer of the theoretical concept into an approach which is suitable for the management of processes in individual enterprises and the coordination of activities throughout supply chains.

Industry follows a stepwise adaptation process where the initial management focus on economic aspects is stepwise complemented by a focus on quality and, finally, environmental aspects.

The consideration of environmental aspects in supply chains requires, as a first step, the identification of environmental impact categories and of environmental problem areas in enterprises of the chain which relate to these categories. The selection of environmental impact categories could be based on widely accepted lists of priority

categories which could be adjusted to specific sector needs. They are being captured through quantitative or qualitative performance indicators which are the basis for assessments of process performance evaluations and, subsequently, for process improvement initiatives.

As has been shown in case studies of the meat chain, that the primary difficulties in environmental management in supply chains are

- (a) the formulation of an appropriate matrix of environmental performance categories,
- (b) the identification of common performance indicators with potential for quantification at all stages of the chain and
- (c) the aggregation of quantitative and qualitative performance indicators into an overall assessment of process performance.

The implementation of environmental management as part of integrated management systems requires specific implementation strategies which support enterprises through the generation of awareness (as is the case with TQM management approaches) and the stabilization of process organizations at any performance level that had been attained through, e.g. the implementation of management systems according to the standard series ISO 9000 (quality management) or ISO 14001 (environmental management).

However, the studies revealed the substantial research efforts that are still necessary for the implementation of environmental management in enterprises and supply chains and its integration with management approaches linked to economic and quality assurance objectives.

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