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Supply Chain Information in Environmental Management Accounting – the case of a Vietnamese Coffee Exporter

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Abstract:
This case study discusses Environmental Management Accounting (EMA) which are illustrated with the case example of Neumann Gruppe Vietnam Ltd., a medium-sized coffee refining and exporting enterprise in Southern Vietnam. It examines the relevance of environment-related supply chain information for corporate environmental and financial decision making and reveals possibilities for improving eco-efficiency at the site level and for its supply chain.

Keywords: *Environmental management accounting, coffee supply chain, eco-efficiency, supply chain management, supply chain costing, material and energy flow costing, environmental cost accounting, life cycle assessment*

1 Introduction

This case study discusses the use, context and application issues of Environmental Management Accounting (EMA) using the case study example of Neumann Gruppe Vietnam Ltd., a medium-sized coffee refining and exporting enterprise in Southern Vietnam. It examines the relevance of environment-related supply chain information for corporate environmental and financial decision making and reveals possibilities for improving eco-efficiency at the site level and for its supply chain.

All company related information provided in this case study has been disclosed by Neumann Gruppe Vietnam Ltd. and cross-checked by the authors. The information is partly simplified to ensure both, confidentiality and a better understanding of the case.

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2 Initial situation

Neumann Gruppe Vietnam Ltd. (called Neumann Vietnam in the following) is refining and exporting coffee. Eighty employees work at their plant in Binh Doung Province, near to Ho Chi Minh City. Neumann Vietnam is a subsidiary of the German Neumann Gruppe GmbH, one of the world´s largest coffee trading companies.

Refining and exporting coffee is only a small part of the international coffee supply chain, both in terms of environmental as well as financial importance. Therefore, attention is paid to the company's performance in relation to value chain and the system of dependences in which it operates.

Neumann Vietnam is situated at the interface of smallholders and local companies on one side and multinationals and global competition for commodities on the other. Neumann's sales follow the demand and rules of international markets, while their procurement depends on the availability and quality of the local supply from farmers and middlemen. The same appears true for environmental and social issues: International requirements for more sustainable coffee production meet the local, not necessarily congruent perception of environmental importance. In the following, the economic and environmental situation of Neumann Vietnam and the Vietnamese coffee supply chain are further elaborated upon.

2.1 Low quality, low price: The economic situation of the Vietnamese coffee supply chain

Coffee is one of the most traded commodities in the world. Until the late 1990s it was even the second most valuable commodity after oil (see Ponte 2004). Vietnam is a newcomer on the international coffee market and has experienced a rapid growth of coffee farming for the last two decades. This rise has not only made Vietnam the second biggest coffee exporter of the world after Brasil, but it has also contributed to declining prices and ever increasing competition in the world market. Since 1970 the average annual price decline has been 3% for arabica and 5% for robusta coffees (see Lewin et al. 2004).

Globally, the low prices are associated with rising unemployment and poverty in some of the coffee exporting countries. At the same time the profits made in the coffee importing countries have remained stable or even increased due to the introduction of new brands and blends and other value-adding activities (see Lewin et al. 2004). Thus Ponte (2004) characterises the coffee supply chain as a buyer-driven or more specifically "roaster-driven" one.

Vietnam is a mass producer of coffee, not a quality leader. Robusta, the main type of coffee produced in the country, is considered less valuable than arabica, which is the main type of coffee produced in most other countries. Robusta achieves lower prices in the world market and is mostly used as an ingredient of downmarket coffee products. Most consumers prefer the taste of arabica, except for certain types of espresso. Hence, Vietnam's current competitive situation is a purely price-driven one; it needs to produce a cheap type of coffee for the mass market at lowest possible costs. It should be noted though, that there are initiatives to change this situation. The Vietnamese Ministry of Agriculture, for instance, is planning to increase the production of arabica coffee, to improve the quality of coffee processing and to participate more actively in international coffee trading (see People's Daily Online 2006). This might lead to the development of higher quality grades in the future, which are less dependent on the fluctuating world market prices.

2.2 Economic situation and refinement process at Neumann Vietnam

Neumann Vietnam purchases and refines coffee to export it to roasters overseas. Their customers expect a coffee quality which is above average and they pay premiums for certain quality grades. Competitors of Neumann Vietnam are various Vietnam-based international, private and state-owned coffee exporters. The company is not aiming at a huge market share; rather it is focusing on higher qualities.

Neumann Vietnam exports coffee beans of different quality grades. To produce these grades, the coffee beans are processed once or twice through the following refinement steps:

- Coffee cleaning: This basic cleaning step produces the lowest exportable quality grade of robusta coffee beans. The step ensures that no foreign matter (e.g. stones, leaves, soil particles) is included in the exported products which could harm the customers' roasting devices.
- Gravity sorting: Neumann Vietnam's customers pay a premium for deliveries of homogeneous coffee beans. This step allows Neumann to produce export coffee beans within a determined range of size.
- Colour sorting: Further value is added to the coffee beans if they do not only consist of the same size but also of the same colour. Beans that are too dark are sorted out as otherwise the quality of the roasted coffee at the customer's site would deteriorate.
- Wet polishing: This final step produces the highest quality robusta coffee beans by improving and harmonising the bean's surface.

The selling price for the different qualities of robusta and the purchasing price for robusta beans depend on the world market and the local supply. It varies from season to season or even shorter time scales due to international commodity trading. Assuming a rather high purchasing price of €1000 per metric tonne (t), the per tonne premium for refinement ranges from less than €5 for cleaned beans up to €60 for wet polished robusta.

2.3 Coffee and the environment

Coffee is a typical example of a global commodity. Mainly produced in developing nations in tropical areas, the majority of consumers are found in industrialised countries. Highly efficient consumer markets and the large corporate wholesalers, roasters, and traders buy coffee from agricultural smallholders and middlemen. The widely spread perception of the global value chain of coffee is one where profits are made in industrialised countries at the expense of environmental and social problems in the developing world (see Ponte 2004). This has lead to initiatives promoting fair trade and sustainable coffee farming including organic, shade-grown and bird -friendly coffee products. The market share of organic and fair trade coffee is continuously increasing, however, it is still less than 2% of the world market (ibid.).

Doubtlessly, the cultivation and processing of coffee has severe environmental consequences. Deforestation, loss of biodiversity, eutrophication, depletion of water and energy resources, and erosion are examples of environmental impacts associated with the first steps of the coffee supply chain. Plentiful measures to reduce these impacts are available, for instance shade grown and organic cultivation, diversification and alternating vegetation, fallowing, planting of grass under the coffee plants, recycling of wastewater, composting of other waste, etc. These measures are perceived as costly. Therefore, the reasoning is that the fierce price competition drives harmful practices (see Clay 2004).

Admittedly, it can not be concluded that less intense competition would automatically lead to less harmful practices. On the contrary, high world market prices and profit margins encouraged Vietnamese authorities to promote coffee farming since the late 1980s and stimulated the interest of many Vietnamese to take their chance in coffee farming. Without knowing much about coffee cultivation, harvesting and processing, this boost lead to deforestation, soil degradation, over-fertilisation and further environmental impacts (see Johnston 2001).

While coffee cultivation, the supply chain's first step, is often in the spotlight of environmental attention, later stages in the value chain tend to be disregarded. However, life cycle analyses (LCA) of coffee production, conducted by Diers et al. (1999) and Salomone (2003) show that another crucial step of coffee production is coffee consumption.

3 Decision situation and company's motivation for using EMA

For several commodities, Blowfield (2003) observed a gap between the sustainability or ethical standards of parts of the demand side and the values and priorities of producers in the chain. This is particularly true for the Vietnamese coffee chain. Neumann Vietnam's customers, international coffee roasters and traders, are exposed to environmental and sustainability concerns in the coffee consuming countries. Many of the international roasters and traders have responded by establishing CSR departments, launching of codes of conduct, and offering fair trade and sustainable coffees. Neumann Vietnam's suppliers, in contrast, face almost no direct pressures and get little incentives to change their current way of mass production of coffee.

Neumann Vietnam's options to increase its business performance are related to the margin between the purchase price and the selling price of coffee. Three basic options to increase the value added can be distinguished and are linked to environmental issues:

a) *Obtain premiums for better qualities of coffee:* Neumann Vietnam is already refining robusta coffee to benefit from premiums. The export of sustainable coffees might be a further option to receive premiums, however, the supply and demand for sustainable, organic or fair trade robusta coffee from Vietnam is negligible. Thus Neumann Vietnam would have to stimulate the demand and the supply at the same time. Alternatively, Neumann Vietnam could also try to export sustainable arabica coffee from Vietnam.

b) *Reduce company-internal costs:* Considering the purchasing and selling price of coffee as fixed, Neumann Vietnam could increase profits by reducing its costs of refining and exporting coffee. This includes measures to increase energy- and material-efficiency.

c) *Purchase price reduction:* Assuming unchanged selling prices, lower purchase prices of course add value to Neumann Vietnam's operations. Eco-efficiency improvements in the supply chain might enable suppliers to reduce their productions costs and prices.

The company's motivation for using EMA is to identify if and how environmental aspects are relevant for the business success (for a more general discussion of the business case for sustainability see e.g. Schaltegger & Wagner 2006). Option a) has not been considered further as the company is considering itself not to be in a strong enough position to foster the development of a market for sustainable coffee from Vietnam. Neumann Vietnam's interest in analysing the relevance of environmental aspects on the production costs (option b), can be characterised as an ad-hoc, short-term focused analysis of available information, while option c) requires external, supply chain related information. Influencing the eco-efficiency of the suppliers requires a strategic, long-term focussed approach (for a comprehensive characterisation of different decision making situations under EMA see Burritt et al. 2002).

4 Applying EMA at Neumann Kaffee Vietnam Ltd.

As elaborated above, the EMA application at Neumann Vietnam is expected to support two different decision making situations: It needs to provide environment-related cost information on the refinement processes and eco-efficiency potentials within the supply chain.

4.1 Material- and energy flow based cost accounting of the refinement processes

The business of refining and exporting coffee is not known for environmental problems like air and water pollution or intensive energy and resource consumption. A rough analysis of Neumann's operations validated this presumption. Perceivable environmental issues at Neumann's site are energy consumption (electricity), solid waste and water consumption. Transportation has not been considered for internal accounting as it is outsourced to suppliers. The low impacts of the on-site environmental issues are highlighted by the following comparisons: For refining and exporting a metric tonne of green beans, Neumann Vietnam uses 40 kWh of electric energy, while a Vietnamese company that cultivates and processes coffee consumes roughly 50 times more per tonne (see Doan et al. 2003). The water demand for one tonne of green beans is 35 litres on average, while the water demand for traditional wet processing of coffee can amount up to 70,000 litres per tonne (see ICO 2001). An overview of material and energy inputs and outputs can be found in Table 1.

The consideration of inputs and outputs shows rather low raw material losses;

Table 1 Physical input/output table for 1 t of green bean input

Input		Output	
item	Physical amount	item	Physical amount
green beans	1000 kg	green beans grade A	430 kg
water	0.035 m^3	green beans grade B	370 kg
electric energy	40 kWh	green beans grade C	60 kg
		green beans grade D	55 kg
		green beans for local market	75 kg
		dust	2 kg
		weight loss	8 kg
		waste water	0.035 m^3

dust and weight losses due to further drying of the beans account for one percent of the total output only. Nevertheless, the financial relevance of these losses is not to be neglected. One percent loss equals one percent of the purchasing costs of green beans, which account for more than 95% of the total production costs. Furthermore, green beans grade D and green beans for the local market need to be considered as unwanted products, as the selling price for these products is not higher or even lower than the purchasing price. There is no value added for these products. Neumann Vietnam should therefore aim at reducing the amount of these products as far as possible. To better understand the refinement process for the different grades, a product-specific material and energy flow related cost accounting has been carried out to trace energy and water consumption as well as material losses to the different quality grades (see Table 2).

Table 2 Physical and monetary flows of green beans grade B

		current situation		**best case scenario**	
		physical amount	monetary equivalent	physical amount	monetary equivalent
wanted product	green beans grade B	1000 kg	1.040 €	1000 kg	1.040 €
unwanted product	green beans grade D	60 kg	60 €	0 kg	0 €
	green beans for local market	10 kg	10 €	0 kg	0 €
waste	dust and weight loss	10 kg	0 €	0 kg	0 €
raw material input	green beans	1080 kg	-1.080 €	1000 kg	-1.000 €
further input	electric energy	25 kWh	-1,50 €	23 kWh	-1,40 €
profit/loss*			28,50 €		39 €

*) not including depreciation, labour costs, and overhead costs like general administration costs, management salaries, etc.

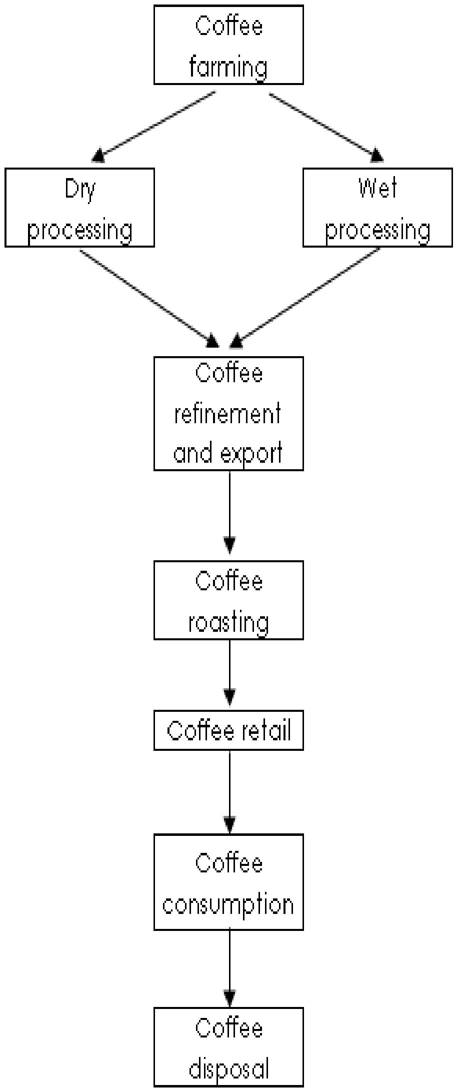
As expected, energy and water demand do not affect the profitability significantly. Material losses and the generation of lower quality grades do have financial implications, though. Assuming that it would be possible to produce grade B without producing lower quality grades and wastes, the profit would increase by 37% or 10,50€ per tonne of final product (see best case scenario in Table 2). These figures are fictional as it is not possible to fully eliminate lower quality grades and waste. Nevertheless, the results imply that paying premiums for high quality supplies, which lead to less unwanted products and wastes, is profitable within a certain margin. Furthermore, the results imply that only grade A and B coffee beans contribute to Neumann Vietnam's profits substantially.

The material and energy flow based cost accounting has confirmed most of Neumann Vietnam's assumptions, in particular that the financial importance of energy and water consumption is rather low and that the quality of the purchased coffee affects the profitability of the business.

4.2 The coffee supply chain's state of the environment

The coffee supply chain starts with agricultural processes in tropical countries and ends with the consumption and disposal stages, predominantly in industrialised countries in cooler regions of the world. The main steps comprise (see ICO 2001 and Figure 1):

Figure 1 Coffee production chain



- Coffee farming: Coffee farmers and hired workers plant coffee trees, apply fertiliser, pesticides and herbicides, irrigate the plants and finally harvest coffee cherries. These activities are associated with soil erosion and loss of biodiversity due to the extension of agricultural land use; eutrophication, eco-toxicity and greenhouse effect due to fertilisation; mammal and aquatic life toxicity due to pesticide use; and resource depletion due to the fuel and water consumption required for farming.

- Dry/wet processing: The coffee cherries have to be processed to release the green coffee beans. Robusta coffee cherries are usually treated by using the dry processing method; most arabica coffees are wet processed. Dry processing can be achieved by solar power (sun-drying) or by the use of fuels; the latter one is more common in Vietnam. After drying the coffee cherries are hulled and grinded to release the green coffee bean. The leftovers of this process, dried pulp and parchment skin, can be composted. Wet processing is more harmful from an environmental point of view, but gains higher selling prices for the coffee beans. The traditional wet processing method requires 40,000 to 70,000 litres of water input per t of green bean, the mechanical mucilage removal method reduces this demand down to 1,000 litres. The organic pollutant load of the generated waste water is similar in both cases. BOD and COD of wet processing waste water are extremely high, while the pH is low. Untreated waste water of wet processing is therefore a major driver of environmental problems caused by the production of coffee.
- Coffee refinement and export: This part of the coffee life cycle has been described above.
- Coffee roasting and retail: To roast the green coffee beans, thermal energy is required. Its generation causes air emissions including greenhouse gases. Decaffeinated and soluble coffees in particular require water in the roasting process as well. After roasting, coffee needs to be packed, Polyethylene foil (PET) ensures that no oxygen reacts with the coffee to avoid ageing. Other packaging types are glasses with screw caps for soluble coffees. Roasting does not necessarily happen after export, it is also common to export roasted coffee.
- Consumption: Energy consumption is the most important environmental issue of this step of the coffee life cycle. The making of coffee requires energy, mainly electricity, for the percolator. The habit of leaving coffee on the hot plate of the percolator to keep it warm increases the energy demand further. Of course, coffee making involves a certain amount of water input as well.
- Disposal: Consumers need to dispose of coffee grounds and filters as well as the packaging. Coffee grounds and filters are often composted, but have a comparably long and unsmooth rotting process. Packaging as well as jute and plastic bags from previous supply chain steps are recycled, incinerated or dumped. The common environmental problems related to waste treatment like energy consumption, acidification and greenhouse gas emissions are therefore present.
- Transportation: Transportation is not depicted in Figure 1, as it happens in between almost all steps of the coffee life cycle. The biggest transportation distance concerns the shipping of green beans or roasted coffee from the producing to the consuming countries. Transportation is associated with the depletion of natural resources, in particular fossil fuels, and the environmental impacts of combusting the fuels, most prominently global warming.

From a decision making point of view it is important to know at which steps of the coffee life cycle environmental improvements are most promising. Energy-efficiency optimisation of the refinement processes might reduce Neumann Vietnam's production costs slightly but it has almost no impact on the overall environmental performance of the supply chain (see chapter .(4.1)

Life-cycle assessments (LCA) are a common tool of environmental accounting, conducted by companies as well as research organisations, governments, etc. (see Schaltegger and Burritt 2000). An LCA can be used to highlight the environmental importance of different steps of a product's life cycle. Two LCAs have been conducted for coffee production (Diers et al. 1999; Salomone 2003). Looking for the highest overall improvement potential of the coffee life cycle, the conclusion of both LCAs is similar: The first and the last steps of the life cycle matter most.

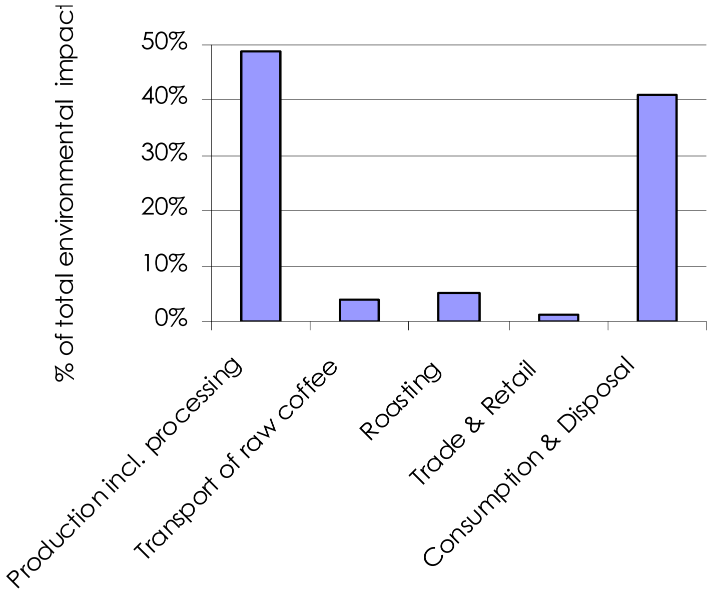
Salomone (2003) identifies consumption as the single most important step followed by cultivation. Cultivation accounts for more than 97% of coffee's total eco-toxicity and eutrophication, while consumption, comprising mainly the water use and energy demand for preparing coffee, accounts for more than two thirds of total air acidification, greenhouse effects, photochemical oxidant formation, depletion of ozone layer, human toxicity and aquatic eco-toxicity. The importance of the consumption step for the overall environmental performance of coffee production is supported by the results of a sensitivity analysis. It reveals that in terms of total weighted environmental impacts, the impact of changing the coffee making process, e.g. gas stove coffee making instead of an electric coffee machine, is substantially higher than the impact of avoiding pesticides or applying organic fertilizers in cultivation (ibid.). This does not lower the relevance of substantial environmental impacts in the farming areas, but it highlights the importance of improving coffee cooking procedures.

In the analysis of Diers et al. (1999), coffee cultivation and processing account for 49%, whereas consumption and disposal account for 41% of the environ-mental impacts (see Figure 2). Furthermore, a comparison of best case, worst case and the current situation places the current situation near to the worst case scenario, meaning that the improvement potential of the coffee life cycle is rather high (see Diers et al. 1999). The coffee processing step has a higher impact in this analysis due to the fact that wet and dry processing has been considered, while Salomone (2003) considers dry processing only. Similarly, the analysis of Diers et al. (1999) stresses the waste disposal issue more than Salomone (2003) does which leads to a slightly higher importance of the disposal stage. Both LCAs do not explicitly consider loss of biodiversity, which is likely to increase the environmental importance of the cultivation step even further.

The results of the two LCAs help decision makers to prioritise options for environmental improvements of the supply chain (see Diers et al. 1999, Salomone 2003):

- In cultivation, avoidance or *reduction of fertiliser* use is the most important impact followed by measures to *avoid erosion*. *Preservation of biodiversity* has not been considered in the LCAs, but is likely to be of importance in the Vietnamese coffee farming context as well.
- The *impacts* of wet processing can

Figure 2 Environmental impacts along the coffee value chain (adapted from Diers et al. 1999)



be substantially reduced by proper *waste water treatment* and *reduction of water consumption.* In wet and dry processing, fuels are consumed for drying. *Energy-efficiency measures* could reduce environmental impacts like global warming and resource depletion.

- Refinement, export, roasting, retail and transportation are not the highest priority for environmental *improvements* of the coffee life cycle.
- In consumption eco-efficiency can be improved by using electricity from renewable resources or by substituting *the* coffee machines run by electric energy with different devices, e.g. plunger pots, which can make use of other and less polluting energy sources like gas. A big improvement potential is the change of consumer habits which includes the avoidance of pouring one cup of coffee per can on average and the use of thermos cans or bottles instead of leaving the coffee on the hot plate for several minutes.
- Coffee ground and coffee filters are the biggest contributors to environmental impacts of the disposal stage. *Measures* to ensure proper composting are likely to reduce these impacts.

4.3 Environmental supply chain costing and management

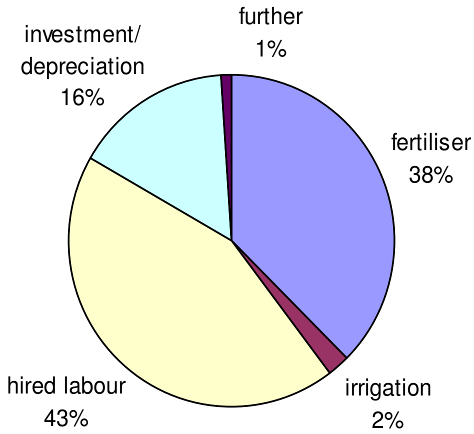
Neumann Vietnam Ltd. operates in a highly competitive market, thus financial implications of environmental supply chain improvements are of great interest. Gathering, analysing and using supply chain cost information for managerial decision making is not widely covered in the general management accounting literature. At least some authors have elaborated upon this topic in detail, in particular in the context of logistics (see LaLonde & Pohlen 1996; Cullen et al. 1999).

Supply chain costing provides information to determine the overall effectiveness of the supply chain, identify improvement opportunities, evaluate alternative supply chain structures, and select supply chain partners. The implementation of supply chain costing is a difficult task as its benefits do not necessarily occur evenly throughout the chain (see LaLonde & Pohlen 1996). "The sharing of cost information may give away a hard-earned competitive advantage or provide negotiating leverage to their supply chain partners" (LaLonde and Pohlen 1996, 4).

The environmental improvement priorities elaborated in chapter 4.2can be used to analyse supply chain costs. As Neumann Vietnam is not considering itself in a position to affect the consumer behaviour or the disposal stage of the coffee life-cycle, the environmental supply chain costing focuses on upstream stages, namely cultivation and processing. Robusta coffee processing applies dry processing, i.e. in environmental terms the processing step is less important than the cultivation stage.

In *cultivation*, the use of fertilisers is costly and harmful for the environment. Figure 3 shows the 2003 composition of production costs at an average robusta coffee farm in Dak Lak Province of Vietnam as investigated by one of the authors (see EDE 2003). Fertilisers account for 38% of total production costs. Moreover, the majority of farmers have been found to use fertilisers inefficiently. Many farmers use more than twice as much fertiliser as necessary (see

Figure 3 Composition of coffee cultivation costs (Source: EDE 2003)



EDE 2003). If farmers manage to use fertilisers in the best possible way they can reduce the costs for purchasing fertiliser by almost 50%. This reduces their total production costs by roughly 20% and doubles the average farmer's profits. Looking at these facts from a customer's perspective, the purchasing price for harvested coffee could be reduced significantly without compromising the farmer's profits.

An environmental supply chain costing can also be used to reveal the additional benefits and costs of alternative, less damaging cultivation methods, for instance by comparing the premiums paid for organic, shade-grown coffee and the consequent reduction of production costs with the reduced yields. In processing, the saving potential of more energy-efficient drying devices could be of interest, too.

The availability of supply chain cost information does not solve one major problem: "Restructuring the supply chain to exploit efficiencies or seize competitive advantages requires a mechanism capable of equitably allocating cost benefits and burdens between supply chain partners" (LaLonde & Pohlen 1996, 8). Obviously, most Vietnamese farmers have not adapted methods for efficient fertiliser use by themselves. If one supply chain actor, like Neumann Vietnam, starts to train farmers on a more efficient use it is not necessarily Neumann Vietnam who benefits. The farmers may as well sell their coffee to other middlemen and exporters or just keep the farmgate price on the same level to make more profit. At first glance, the incentive for Neumann Vietnam to facilitate eco-efficiency improvements within the supply chain is rather low. (Environmental) supply chain management is considered to be a solution for this problem.

For Cooper et al. (1997a, 68) supply chain management is "an integrative philosophy to manage the total flow of a channel from earliest supplier of raw materials to the ultimate customer, and beyond, including the disposal process". When taking the perspective of one company within the chain, the challenge is slightly different, though. In this perspective, according to the author of the definition above, the supply chain looks not like a chain, but rather like an uprooted tree. The company needs to decide how many of the roots and branches it wants to manage (see Cooper et al. 1997b, 9). In this connection, Seuring (2004) has compared different concepts of environmental management that address the flow of material and information along life cycles or supply chains. He concludes that environmental supply chain management is the most management-oriented approach of all the approaches assessed.

For Neumann Vietnam, the supply chain management challenge is to foster eco-efficiency improvements, in particular reduced use of fertilisers, at the coffee farming stage and to ensure participation in the financial benefits. According to Williamson (1975 and 1985) the three basic options for co-ordinating supply chains are price (market arrangement), command and control (hierarchical arrangement), and negotiation (co-operative arrangement):

- Neumann Vietnam could use *market arrangements* to provide incentives, or more precisely premiums, to its supplier to receive higher qualities or special types of coffee, for instance organic, fair trade coffees if there is a customer demand for it. For the reduction of fertiliser use or other eco-efficiency measures in the upstream supply chain, market arrangements are no promising option.
- *Establishing hierarchical arrangements* is nearest to the original understanding of supply chain management, where rather large enterprises *purchase* key suppliers and own or control distribution channels. However, Neumann Vietnam does not intend to buy suppliers and is also not in a position to dominate the chain.
- *Co-operative arrangements* are the most promising option for Neumann Vietnam. For instance, the company can offer its suppliers training and support on implementing eco-efficiency measures. In return, the suppliers need to agree to either pay Neumann Vietnam for these services or to share their financial benefits. This kind of verti-

cal co-operation is yet difficult to achieve as it requires monitoring of the success of eco-efficiency measures and the adherence to contracts for all partners involved. Middlemen or farmers might take the opportunity to underestimate the savings or to sell parts of the harvest to other traders and exporters without Neumann Coffee's knowledge. Thus, horizontal co-operation seems to be the best available option. Higher energy-efficiency in dry processing and appropriate use of fertilisers lead to higher profitability and/or competitiveness of the Vietnamese coffee industry as a whole. Having this in prospect, Vietnamese coffee exporters, traders and related organisations like the Vietnam Coffee and Cocoa Association (VICOFA) could share the costs of training programs for coffee farmers and companies of the processing step. Neumann Coffee could try to initialise and lobby such an eco-efficiency programme.

The findings above are in line with the results of a comprehensive analysis of sustainable cotton supply chains conducted by Goldbach et al. (2003). The authors have observed that the initial phase of environmental and sustainability supply chain management is characterised by co-operative or even hierarchical arrangements, while at later stages market arrangements gain importance. Furthermore, they conclude that environmental supply chain management cannot be viewed as a technical matter only. Instead it is an inter-organisational concept (see Goldbach et al. 2003). It implies a "change from managing supply chains based on serial dependence and power to recognising and managing the reciprocal dependence" (Cullen et al. 1999, 31).

5 Conclusions

Neumann Vietnam is one of many actors, however a large one, in the Vietnamese coffee industry and supply chain. Neumann Vietnam's business, the refinement and export of green robusta coffee beans, does not cause huge environmental impacts. EMA has been used to confirm this presumption, but it has also ascertained the financial relevance of even small raw material losses like dust and weight loss due to evaporation.

In contrast to the rather low environmental importance of its refinement and export operations, the supply chain in which Neumann Vietnam operates is exposed to various substantial environmental concerns. Using LCA information in the context of EMA has helped to identify those steps within the coffee supply chain that have highest environmental impacts and highest options for environmental improvement measures. Cultivation and consumption are the most important steps from an environmental perspective. Some of the environmental concerns in the supply chain have direct financial consequences. Energy inefficiencies and the overuse of fertiliser diminish the overall supply chain profits or lead to higher market prices. Neumann Vietnam can get a better understanding of these interdependencies by applying supply chain costing. Measures to increase the supply chain eco-efficiency need supply chain management efforts, in particular horizontal co-operation.

Besides Neumann Vietnam, further actors within the supply chain can contribute to environmental and related financial improvements. Coffee consumers have an even bigger role in this than expected. By demanding alternative types of coffees like organic, fair trade or sustainable coffee, consumers influence the supply chain indirectly, in particular the cultivation step. But consumers can also directly reduce the environmental burdens of the coffee life cycle, for instance by not making more coffee than is consumed, by using insulated coffee pots rather than leaving coffee on the percolator stove, by purchasing electricity from renewable sources or by substituting their electricity-run coffee machine.

This case study reveals the importance of environment-related supply chain information for corporate decision-making. EMA can make use of tools like LCA to satisfy this demand. In combination with concepts like supply chain costing this analysis leads to the identification and prioritisation of eco-efficiency improvements along the chain. In contrast to the still growing niche market solutions, like fair trade or organic coffee farming, supply chain eco -efficiency measures show a potential to directly enter the mass market of Vietnamese coffee production.

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