Effects of environmental measures on the sustainability indicators health and quality

Dilemmas and strategic choices

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Preface

This report has been written in the context of the "Suscof" project on sustainable coffee in Costa Rica.

The Sustainable Coffee Project (Suscof Project) is a project that aims at developing a sustainable coffee chain between Costa Rica and the Netherlands. The project is funded in the context of the Sustainable Development Agreement between these two countries (Fundecooperación/Ecooperation). Its major activities are:

- Implementation of ISO 14001 in six Costa Rican co-operatives of coffee farmers;
- Market research, approach of potential clients and building up a sales organization within the consortium of the six represented co-operatives.

The Suscof project has been linked to a project sponsored by NWO (the Dutch Organization for Scientific Research) in the field of environmental management accounting. Part of this project is the development of sustainability indicators for the coffee chain.

The Suscof project is coordinated by ISCOM. ISCOM is a young non-governmental not-for-profit organization in the Netherlands. It takes initiatives to implement sustainability strategies in international commodity chains. By so doing it contributes to the improvement of the living and economic conditions of low-income groups in the Third World, while on a global level production and consumption processes are guided into patterns that are in harmony with the existing natural resources.

Utrecht, 31 October 2001

Executive summary

An entrepreneur that just strives for maximizing profit risks loosing his social “licence to produce”. Companies do not only have a responsibility towards their shareholders, but also towards their employees and the environment. The concern for social and environmental effects should become part of the company’s core business. In this way, corporate social responsibility consists of three value-creating dimensions:

- Planet: the way and the extent in which the company respects the vulnerability of the ecosystem while producing goods and services;
- People: the contribution of a company to the quality of life of its workers and their families;
- Profit: the creation of value through the production of goods and services and through the creation of income.

“One-dimensional” policies in a company need to be integrated so as to take into account the many aspects of human life. This may be complicated since the dimensions are mutually related. Along with all kinds of synergies, the implementation of an ecological corporate policy may have adverse effects on economic and/or social sustainability aspects and vice versa.

In this report, the focus is on how environmental measures will affect social and economic aspects. Due to the complexity and the breadth of the subject, it will restrict itself to the effects that environmental measures may have on product quality, being an indicator for economic sustainability and on health, being an indicator for social sustainability. A further restriction is that the report focuses on the beginning of commodity chains, i.e. that part of the chain where cultivation and primary processing take place. Central questions are: What effect do environmental measures have on social and economic aspects? Are these effects a matter of general tendencies or do they rest on contingencies? What does contingency mean for the strategic choices a farmer has to make?

It is concluded that with regard to cultivation, environmental measures do not seem to have an impact on product quality. Care for the cultivation process was found to be more important than the cultivation method itself. In the primary process, recycling of process water or a reduction of the amount of process water may have a negative impact on quality. Energy savings and EMS, on the other hand, do not seem to affect product quality. Environmental measures have a clear positive relation with physical health thanks to reduced pesticide use, increased diversity in dietary pattern, cleaner water sources, and less polluted soils and air. The relation with mental health, however, is less clear. Environmental measures may have a positive impact on mental health, due to job enrichments and new challenges, but they may also have a negative impact due to job aggravation, accumulation of tasks and stress.

Especially with regard to economic aspects, it is not possible to take away the contingency. Consequently, it is impossible to give general guidelines about the best cultivation system or processing method. The best way of acting depends on individual circumstances. A farmer’s strategic choices will be influenced by his capability to change, the area of land under cultivation, his actual position on the market, his present cultivation method, etc. Smallholders with actually no access to agrochemicals are most likely to adopt organic farming. Farmers with medium to big areas of land who have invested in modern agricultural practices are most likely to choose for GAP. Farmers in rainforests or woodlands are likely to adopt the shade system. However, elements of the shade system may just as well be incorporated in any system, be it organic, GAP, or conventional. With regard to future environmental requirements on commodities, GAP seems to be the most appropriate first step to change the mainstream in the direction of sustainable production. GAP approximates closely the conventional system, its implementation is a gradual process of continuous improvement, pesticides remain available in the last resort, and yields are comparable to the conventional system.

Farmers in general and smallholders in particular have only limited possibilities to make their own strategic choices on production standards and certification. Different markets may have different certification requirements. Choosing for one specific market with its specific certification requirements closes the doors to other markets. Streamlining the different standards will give the farmers more independence with regard to the market for which they want to produce.

World market oriented production, asking for uniformity, endangers ecological, social, and cultural diversity. It does not leave the farmer a choice but to obey the rules or quit the system. With regard to sustainability, production for the local market should be included in the economic dimension. The participatory approach supports this type of regionalism in that sustainable agriculture may be developed based on local knowledge. The participatory approach emphasises the reinforcement of local knowledge to enable farmers to make their own strategic choices, more independent of external forces.

With regard to farmers, co-operatives and NGOs are the most important supportive network organizations. On one hand, they are in direct contact with individual farmers, which makes them trustworthy for the farmers. On the other hand, they have contacts with financial and supportive organizations. With their knowledge about the farmers' desires and the market demands, supportive networks play an important role in matching the desires of the different parties.

Chapter 1

Ecological, social and economic sustainability

1.1. Introduction

Sustainability has three dimensions: the economic, the ecological and the social dimension. "One-dimensional" policies in a company need to be integrated so as to take into account the many aspects of human life. This may be complicated since the dimensions are mutually related. Along with all kinds of synergies, the implementation of an ecological corporate policy may have adverse effects on economic and/or social sustainability aspects and vice versa.

This report wants to contribute to the knowledge about the processes leading to the integration of ecological, economic, and social sustainability aspects. The focus is on how environmental measures will affect social and economic aspects. Central questions are: What effect do environmental measures have on social and economic aspects? And: Are these effects a matter of general tendencies or do they rest on contingencies? The degree of contingency will have its impact on the way strategic choices regarding environmental measures are made at all levels of the production chain.

Due to the complexity and the breadth of the subject, this report will restrict itself to the effects that environmental measures may have on product quality, being an indicator for economic sustainability and on health, being an indicator for social sustainability. A further restriction is that the report focuses on the beginning of commodity chains, i.e. that part of the chain where the primary production and the primary processing take place.

Scientific literature has been the principal source of information. The World Wide Web has been frequently visited to look for additional information. Besides, four people working in the coffee branch were interviewed: two persons who were working for a coffee roaster, and two others who were working for a coffee trade organization. Finally, a questionnaire has been sent to 30 coffee trading organizations all over the world. This source of information, however, did not contribute significantly to this report due to the poor response.

This chapter sketches the social-economic background of the integration of sustainability policies. The three sustainability dimensions will be analysed in more detail, paying attention to the importance of these three dimensions with respect to the internalisation of external effects. Chapter 2's central question is whether the impacts of sustainability measures follow a certain pattern. In other words, can the contingency be reduced? Information from the coffee and cocoa chain (Annexes 1 and 4) form the basis for this analysis. Finally, chapter 3 will consider some of the strategic choices that have to be made in a commodity chain to realise sustainable modes of production.

1.2. Profit, externalities and sustainability

Enterprises can be seen as profit-driven organizations. In this view they are value-creating organizations, using scarce resources (capital, labour, knowledge and organizational capacity, and natural resources) in an effective and (hopefully) efficient manner. Their output of goods and services is used to satisfy human needs (SER, 2001). However, these enterprises with no other aim but maximizing financial profit have undesirable external effects such as the exhaustion of natural resources, environmental contamination, exploitation of vulnerable worker groups and adverse health effects. An external effect or externality is any impact on a third party's welfare that is brought about by the action of an individual and is neither compensated nor appropriated (Pearce & Warford, 1993). Externalities that have adverse effects are also referred to as external costs. In agreement with this, one uses the term external benefits when referring to favourable external effects. The occurrence of external costs is an indication that the company shifts the adverse effects of its activities on to the society and its environment. Government intervention aims at internalising external costs to protect a third party's welfare and its environment. Policy instruments like command and control, environmental taxes (e.g. eco-tax) and covenants between private enterprises and the government have proven to be useful tools in promoting internalisation. However, not all external effects can be eliminated by expressing them in cost and benefit terms. The abundance of sustainability aspects makes this practically impossible. Besides, sustainability measures may oppose each other, weakening the final result. Companies have to identify more specific business and chain solutions to get rid of the remaining externalities. This is a strategic process in which the company has to prioritise its objectives related to sustainability, taking into account the adverse effects that sustainability measures may have on each other. The strategic character alters the process from governmental intervention into corporate social responsibility.

1.3. Corporate social responsibility

An entrepreneur that just strives for maximizing profit risks loosing his social "licence to produce". Enterprises should be more than only profit-driven organizations. They have a social responsibility that can be characterized by the following concept of corporate citizenship:

"A company should behave like a good citizen in business. The law does not (and cannot) contain or prescribe the whole duty of a citizen. A good citizen takes account of the interests of others besides himself, and tries to exercise an informed and imaginative ethical judgment in deciding what he should and should not do. This is how companies should seek to behave."

(Watkinson report, 1973 quoted by SER, 2001)

The corporate citizen approach stimulates the company to take its social responsibility. This means that the reactive attitude that involves complying with environmental laws and regulations is not enough. The desired attitude of a company should be active or even better pro-active rather than reactive. Further, the corporate citizen approach stimulates the company to make the concern for social and environmental effects part of its core business. Social and environmental activities should become an integral part of the company's policy. In this way corporate social responsibility adds two other value-creating dimensions to the financial-economic variables profitability and share value, namely ecological and social value. In the long-term the company's activities should create value in three dimensions:

- Planet: the way and the extent in which the company respects the vulnerability of the ecosystem while producing goods and services;
- People: the contribution of a company to the quality of life of its workers and their families;
- Profit: the creation of value through the production of goods and services and through the creation of income.

The so-called "triple P bottom line" (Elkington, 1998) focuses attention on the need for cohesion and balance between the three dimensions profit-people-planet (Figure 1). It stimulates companies to consider the externalities and long-term effects of the processes taking place in their companies and to take action accordingly in order to limit adverse external effects as far as possible and to facilitate and reinforce (potential) positive effects.

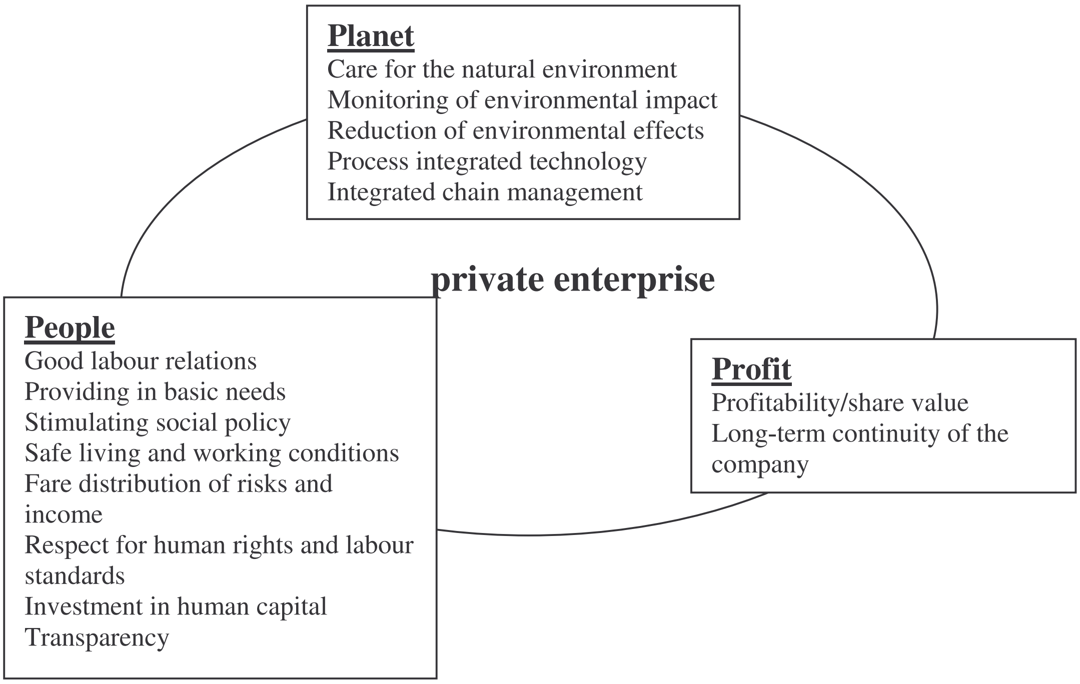


Figure 1. The triple P bottom line of a private enterprise with the three value-creating dimensions

If well used the triple P bottom line approach guarantees the continuity of companies in the long-term. It was already stated above that a company risks to loose its licence to produce by just focusing on economic gain. But even the focus on two of the three sustainability dimensions is no guarantee for continuity. Multinationals may manoeuvre themselves into difficult situations when they abuse social standards while operating in developing countries. Local non-governmental organizations and pressure groups will pillory the company, despite the company's efforts to comply with internationally accepted environmental standards. Publicity about widespread human rights violations has compelled Levi-Strauss & Co. to pull out of China and activist groups have forced Nike to pass an internal code of conduct for its suppliers.

The triple P bottom line theory has developed as a reaction on environmental problems caused by industrial activities in rich countries and is as such a very Western idea. Companies in developing countries, however, cannot act indifferently with regard to the three sustainability dimensions. As the latter examples already revealed, pressure groups in Western countries may put pressure on companies in developing countries, through the production chain. These examples refer to industrial companies, but similar examples may be found for agricultural companies. The bananas of Chiquita have regularly been subject to boycotts due to the company's allegedly indifferent attitude towards social standards and its indiscriminate use of pesticides. Pressure on companies to take their social responsibility may also come from the national government, pursuing an environmental policy either on a voluntary basis or under pressure of donor organizations like the World Bank, the IMF or the United Nations.

1.4. The three dimensions of sustainability

Planet

The philosophy behind ecological sustainability is to meet the needs of present generations without affecting the possibilities of future generations to meet their needs (WCED, 1987). Ecological sustainability being one of the three dimensions within corporate social responsibility stimulates companies to consider the impact of their activities on the environment. Care for the natural environment should be integrated into the company's business. In practice this means reducing the environmental effects through monitoring, process integrated technology, life cycle analysis and integrated chain management. At the primary production level the amount of agrochemicals used, the area deforested and/or eroded, biodiversity among other items may be used as indicators to measure the environmental impact of the agricultural activity. At industrial level the following measures can be considered as useful indicators: water and energy use, the use of renewable and non-renewable sources, size and composition of the waste stream, extent of air, soil and water pollution, and so on.

People

The social dimension of corporate social responsibility is directed both internally towards the company's own staff and employees and externally towards the outside community. Criteria for the social dimension can vary from one company to another but fair compensation, reasonable working hours, a safe and healthy environment, prohibition of child labour and forced labour, and respect for human rights are common ones. Other criteria that can play a role are the stimulation of social policy, investment in human capital, the right of association, and so on.

Profit

Profit is created through the production of goods and services that satisfy human needs and through the creation of sources of income for entrepreneurs, employees and providers of capital. The financial return for this effort reflects the appreciation of the consumer for the company's goods and services and the efficiency with which the factors of production (capital, labour, natural resources, knowledge, and organizational capital) are used. Factors influencing consumer's appreciation are for example utility, price, quality, and design. Financial return is an indicator for company's performance in the short-term and a basis for continuity of the company in the long-term.

1.5. Integration

The three P's in the triple P bottom line play an essential role in the strategic choices of a company. The choices should be based on all three sustainability dimensions (planet-people-profit), keeping into consideration that they are mutually related. The three dimensions influence and either complement or oppose each other. The implementation of a measure focusing on one dimension will influence the other two dimensions, either in a favourable, neutral or adverse way. Neglecting the linkages between the sustainability dimensions may jeopardize the continuity of the company. The business community is challenged to prioritise the sustainability aspects, and to integrate the three sustainability dimensions into their policies in such a way that the three dimensions strengthen rather than oppose each other. Looking for ways of integration it is important to consider the adverse effects that measures can have on the other dimensions. This report will elaborate on the consequences of the integration of the three sustainability dimensions in an agro-industrial production chain.

1.6. Further definition of the subject

A company as a system consists of three main processes: the environmental, the social, and the economic process (Figure 2A). The economic process refers to the so-called core business, the products that it makes or the services that it provides. The social process refers to the social interaction that takes place, both internally as well as externally. The environmental process includes all processes, in which the environment is affected in one way or another, such as the use of natural resources, emissions to air, water and soil, and waste streams. In this report the environmental process is chosen as the focal point for the integration process of the three sustainability dimensions planet-people-profit. As a result of the company's activities, a variety of environmental processes intervene with economic and social aspects (Figure 2B). Measures that can be taken to reduce adverse external effects of environmental processes will be analysed in relation to these economic and social aspects. The central question is "What will be the impact of environmental measures on these aspects?" It is evident that an abundance of economic and social aspects exists and they all may be influenced in one way or another by environmental measures. In the context of this report it would get too far off the subject to analyse the impact of all the environmental measures on all these economic and social aspects. The report therefore restricts itself to two aspects, namely product quality as an aspect of the economic dimension and health as an aspect of the social dimension (Figure 2C). It is assumed that the two selected aspects are of importance for the dimensions concerned.

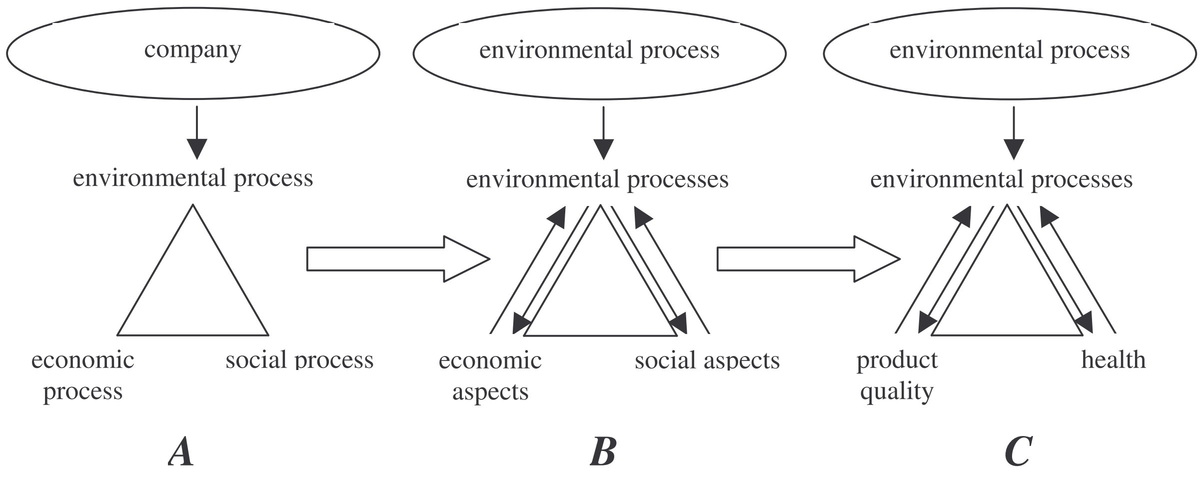


Figure 2 Schematic context of the thesis

The meaning of "product quality" depends on the final utilization of the product. Quality demands will differ between food and non-food items. This report focuses on the quality requirements for food items, with taste being considered as an essential characteristic for food quality. Another characteristic that may influence product quality is the aesthetic value. In the case of fresh agricultural products like fruits and vegetables this characteristic may be important. However, for commodities that undergo an industrial process before reaching the consumer aesthetic values are considered to be of minor importance. In this report aesthetic values will not be taken into consideration.

A product chain may be long and not always easy to fathom. In case of compound products complexity is enhanced due to converging chains, each chain being composed of more or less links. This report will restrict itself to the first links in an agro-industrial production process: the primary production and the primary processing. For many commodities of tropical origin this means that the report focuses on that part of the commodity chain that takes place in developing countries.

Chapter 2

Analysis of the contingency

2.1. Introduction

In Annexes 1 and 4 some of the processes are described, taking place in the coffee and cocoa chain respectively, followed by an inventory of the environmental burden that may be caused by these processes, and an analysis of the measures that might reduce the environmental burden. At the end of each Annex the potential environmental measurers are evaluated regarding their impact on product quality and human health.

The Annexes show that environmental measures may have either a favourable, a neutral, an adverse, or any other combined effect on product quality and human health. An overview of the possible effects is given in Table 1. The Table illustrates the numerous amounts of interactions with just as many effects, which will be discussed in the following sections. This chapter aims at discovering a pattern in the way the sustainability dimensions interact with each other. In other words, does the outcome of a certain interaction follow general rules or is it a matter of contingency?

Table 1. An overview of the potential environmental measures in the coffee and cocoa chain and their impact on some economic and social sustainability indicators

	A	**B**	**C**	**D**	**E**
Environmental measures	**Physical health**	**Job enrich-ment**	**Stress reduction**	**Product quality**	**Higher returns**
Cultivation					
Organic	+	+	-	0	+ / -
Shade, mixed cropping	+	+	+ / 0	+ / 0	+ / -
GAP	+	+	-	0	+ / -
Processing					
Reduced water consumption	+	0	0	0	+
Recycling process water	+	+	-	- / 0	-
Composting pulp	+	+	-	0	-
Waste water purification	+	+	-	0	-
Energy saving machineries	0	0	0	0	+
Implementation of EMS	+	+	-	0	-

2.2. Contingency and social aspects

The hypothesis “What is favourable for the environment, is favourable for human beings” seems to hold for physical health. In both the coffee and the cocoa chain, environmental measures have a favourable effect on the physical health of the farmer, the workers, their families and other people in the vicinity of the coffee or cocoa plantation and/or the processing plant (Table 1, column A).

Physical health problems are positively correlated with the use of agrochemicals: the problems considerably reduce when the input of agrochemical is reduced or completely eliminated. Favourable effects with regard to pesticide use may even be found on the consumers’ level, but these effects are far weaker than the effects on people’s health living in the vicinity of a plantation. Stimulation of biodiversity in an agricultural system (shade trees, mixed cropping) works also in favour of the physical state of health. Firstly, because a mixed cropping system is less susceptible to pests and diseases than a monoculture, reducing the farmer’s dependence on agrochemicals. Secondly, because a mixed cropping system, with a wide variety of products, such as fruits, medicinal plants, timber, and fuel wood, makes the farmer and his family less vulnerable to crop failure, pests and diseases. Diversification improves the nutritional intakes of a household and strengthens their financial situation. Environmental measures on the processing side also favour physical health. An important factor in this respect is the improvement of drinking water quantity and quality due to reduced water use, and water purification prior to discharging it.

On both the cultivation level and the processing level, it is possible to carry further the positive relationship between environmental measures and physical health to other agricultural products. Agrochemicals in general have an adverse effect on both the environment and human health. Consequently, their reduced use will favour both, irrespective of the crop under consideration. A similar conclusion can be drawn for increased biodiversity, as has been discussed above, and the food processing industry. The physical state of health of people living in the vicinity of a processing plant will definitely favour from reduced emissions of harmful substances, regardless which type of processing industry.

Physical health, however, is an important but not the only factor determining the general state of health. Mental health, which includes indirect health effects caused by dissatisfaction with the job, workload, and stress, may also have an effect on the general state of health. A study conducted by the Dutch research organization TNO (Wolters et al. 1995) concluded that environmental measures may have an impact on the quality of employees’ work, either in a positive or in a negative sense. Newly created and enrichment of existing jobs are positive effects that environmental measures may have on the quality of work. On the other hand, job aggravation, accumulation of tasks, and stress are mentioned as factors that may diminish enthusiasm for the work. Good Agricultural Practices and organic farming may have similar effects (Table 1, columns B and C). Such alternative farming systems may have a positive impact on job quality since new tasks and responsibilities enrich the job. Regular inspections of the crop on pests and diseases give the farmer a better understanding of the processes going on in the field. However, a shift from conventional farming to GAP or organic farming increases the amount of manual work, putting extra pressure on the often scarce labour forces. The need for more workers puts the farmer on higher costs without having the assurance that this investment will be paid back through a premium on the product. Simultaneously, a shift increases the administrative workload. Under certain conditions this may lead to involving a new employee. Otherwise it is just another task for the already occupied farmer. Stress as a result of an increased workload may cause mental and physical health problems. A reduction of stress may be observed in a shaded (agroforestry) or mixed cropping system since the farmer no longer depends on one single crop.

Environmental measures taken in the processing industries generally lead to enhancement of the job since additional processes have to be executed. At the same time, however, such measures may also increase the workload and thus stress when no extra employees are appointed. For people in the vicinity of the processing plant, a positive relationship between environmental measures and stress reduction can be expected since such measures will reduce the sorrow for clean water sources.

From the preceding, it can be concluded that environmental measures clearly affect human health. Some general tendencies can be indicated. The physical state of health generally favours from environmental friendlier cultivation and processing alternatives. The relationship between environmental measures and mental health factors depends strongly on the local circumstances. If a farmer or a processing industry is able and willing to appoint extra employees for the additional tasks arising from implementation of environmental measures, stress factors are unlikely to occur. However, in the case that no extra employees can be appointed the extra workload may have adverse effects on the mental state of health.

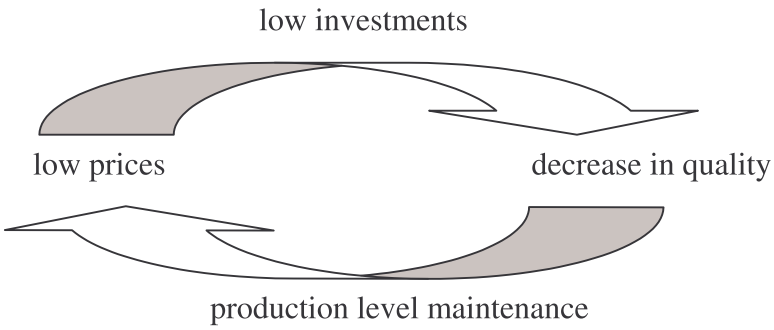
2.3. Contingency and economic aspects

Analysing the relationship between environmental measures and product quality, it appears that environmental measures may endanger product quality if not implemented correctly. GAP and organic farming may lead to more damage to the product due to pests and diseases. Increased damage will have an adverse effect on product quality. Another threat for product quality is the recycling of process water. Only water within a required quality range may be reused in coffee processing. Water of poorer quality will have a negative impact on flavour and thus on coffee quality. Although the example refers to coffee only, it is likely that a similar impact exists for other food products where process water is needed for the primary process. Especially in the case of developing countries it is questionable whether there is appropriate technology available to realise the required degree of purification of the process water.

Assuming that the environmental measures are implemented correctly, the case studies on coffee and cocoa (Annexes 1 and 4) show that it is not possible to fully assess the impact of environmental measures on product quality. In general, environmental measures in coffee and cocoa plantations do not affect product quality (Table 1, column D), neither in a positive way nor in a negative way. A positive exception is the introduction of shade trees in coffee plantations. Up to a certain degree of shading, shade trees seem to increase the cup quality of coffee. However, this relationship does not hold for cocoa, as shade reduces the size of the cocoa bean, which makes it less suitable for the cocoa processing industry (BCCCA, 1996).

The conflict between sustainable production and product quality has its impact on the market. To a certain extent, consumers are willing to pay higher prices for a more sustainably produced product but then the product must be of at least the same quality as the conventional equivalent. In this respect the aesthetic value of freshly marketed fruits and vegetables plays an important role. Organically produced vegetables and fruits often look less delicious than the conventionally alternatives. Although appearance does not necessarily affect taste, it forms just another obstacle for the consumer to choose sustainably produced products. It also has an impact on the consumers' attitude regarding products where the aesthetic value is of no importance, like coffee. The general attitude towards organic coffee was described as: "Since it is organic, it cannot be O.K." (Douque, personal comment).

Further analysis shows that not the environmental measures but the returns play a dominant role with regard to product quality. With the present low coffee prices at the world market the following cycle characterizes the situation:



Source: De Beaufort, 2000

Low coffee prices cause the farmers to give up the production of coffee or to reduce care and maintenance. In the short term this situation adversely affects the coffee quality while in the medium to long term it weakens the coffee industry (Vaessen, Van der Hulst, personal comments). The low prices as a result of decreased quality may stimulate the farmers to increase their production in order to maintain a certain income, creating an extra price reducing factor. Although care and good maintenance are seen as factors that may increase product quality, the cycle shows that higher prices will not solve the problem. Higher prices will stimulate the farmer to take better care of his crop, which definitely favours product quality. Higher prices, however, will also increase the investments, resulting in higher production and thus lower prices. This will bring the farmers back in the present situation. Consequently, additional policy measures such as fixed production levels and diversification should support an increase in the coffee price.

Since returns play such an important role with regard to product quality, a closer look will be taken at the way environmental measures affect the returns (Table 1, column E). Measures leading to environmental friendlier cultivation methods may simultaneously cause higher returns and higher costs. The higher returns originate from the premiums paid for agricultural products that are produced in an environmental friendlier way. There seems to be a relationship between the degree of environmental friendliness and the premium: the premium for organically produced coffee is higher than the premium for coffee produced under GAP. Additionally, higher returns are also a result of reduced use of agrochemicals, and returns from additional crops (shade trees, mixed cropping). The higher costs are a result of increased workload, reduced yields (organic, shade), and more expensive pesticides (GAP). It is difficult to give an indication about the net return. Returns depend on the international market for environmental friendly products and the yield. The costs depend on the local situation, where especially the price for labour seems to play a significant role.

2.4. Conclusion

Generally, environmental measures and economic aspects seem to be at odds with each other. In the case of product quality, neither positive nor negative effects of environmental measures on product quality are mentioned, assuming that the measures are implemented correctly. The effect of shade on coffee quality is a positive exception. Returns have a clearer impact on product quality in such a way that higher returns may result in better quality. Returns are affected by environmental measures in two ways. The returns may rise due to premiums, reduced use of agrochemicals, and additional income from other crops. The returns may decrease due to higher labour demands, reduced yields, and more expensive pesticides. The net returns of the farmer with regard to environmental measures depend among others on the yield, and the situation on the international market and the local labour market.

The conflict between the sustainability interests is less prominently present in the interaction between the environmental and the social dimension. Although environmental measures may have adverse effects on health due to job aggravation, accumulation of tasks and stress, they can also have a considerable positive effect on health. Reduced pesticide use, increased diversity in dietary pattern, reduced vulnerability of the production system (multiple crops), and reduced water, air and soil pollution may all contribute to a better state of health. Other positive effects may be the creation of new job opportunities and the enrichment of the work, giving it an extra challenge.

Especially with regard to economic aspects, it is not possible to take away the contingency. Some general guidelines can be given, as has been discussed above, but it is impossible to give guidelines about the best way of acting. The optimal cultivation system or production process depends on individual situations. What is the relation of the farmer or company manager to the world market? What are his possibilities on the local market? What are the net returns of an environmental friendlier production system? What is the situation on the labour market? What is the knowledge of the entrepreneur, be it a farmer or a manager of a food processing company, about environmental issues? Does he have access to support services? Etcetera. The entrepreneur himself has to make choices, taking into account his individual situation. Some of the strategic choices that a farmer has to make will be discussed in the next chapter.

Chapter 3

Strategic choices in sustainable commodity chains

3.1. Introduction

In the previous chapter it was concluded that the contingency cannot be fully reduced. This means that the farmer and the manager of a processing industry have to make their own choices, based on their individual situation. As long as the farmer has access to a good conventional market, he will probably not be interested to change his cultivation strategy. However, one day the market may change. The demand for sustainable products may increase and the farmer risks to loose his licence to cultivate if he does not react to this market in transition. The market sketches the framework, within which the farmer has to produce. The individual situation of the farmer determines which cultivation system to choose. This chapter will highlight some of the choices the farmer has when he decides, stimulated by the market, to change his production system into an environmental friendlier one.

The choices that a farmer may have to make the production of a commodity sustainable will be discussed in sections 3.2, 3.3 and 3.4. In section 3.2 the opportunities and threats related to sustainable agricultural methods will be discussed. This section will be followed by two sections (3.3 and 3.4) on the opportunities and threats of production for the world market. In section 3.5 some strategic choices in the development of a supportive network are highlighted.

3.2. Opportunities and threats of sustainable agriculture

Agricultural systems that contribute to the production of more sustainable commodities are discussed in Annexes 1 and 4. The systems constitute more or less a continuum (Figure 3), in which the sustainability increases going from the conventional to the organic system.

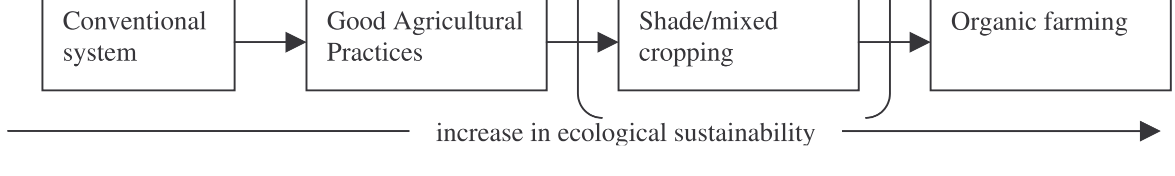


Figure 3. A continuum of agricultural systems

The position of the shade system (agroforestry) is disputable. In a shade system, the use of agrochemicals is permitted, making the system ecologically less sustainable than an organic system. On the other hand, a shade system attaches a greater value to biodiversity than an organic system, which is a credit for the sustainability of the shade system.

It is unlikely that the degree of sustainability determines a farmer's preference for a specific agricultural system. It is more obvious that his strategic choice for an agricultural system is based on ones individual situation with regard to the different systems and with regard to the different markets. An analysis of factors influencing the strategic choice of the farmer is presented in Table 2.

Organic farming
The strength of the organic system lies in its complete elimination of agrochemicals, which considerably contributes to sustainability, environmental friendliness, and a gain in the general state of health. The market offers a premium to organic products in order to pay for the increased workload and the lower yields per hectare compared to conventional production. Other advantages are that the organic market, although still small, is likely to grow in the near future, and that producers may establish a fixed relationship with customers, which contributes to more stable prices. Serious drawbacks of the organic system are the increased labour demand on a normally tight labour market, lack of knowledge about ecological processes involved, the possible decrease in yield (in the case of high input farming), and the small market. Another drawback may be the costs for certification. With regard to ones individual situation, farmers who actually do not have access to agrochemicals, due to the restricted availability on the market, or financial restrictions are most likely to be interested in changing their system to organic. However, the access to agrochemicals is not the only determining factor. An individual farmer also has to be capable to change his system. Capability is related to his financial situation, the availability of financial and technical support, and the access or the possibility to create access to an organic market. In the case of smallholders, the strategies of neighbouring farmers are of great importance (see section 3.3). Further, it is likely that the farmer estimates the returns of the new system higher than the present system.

Good Agricultural Practices
Good Agricultural Practices (GAP) are based on conventional production systems and are as such easier to implement than the organic system. Complicating factor is the use of economic threshold levels, on which pesticide application decisions are taken. This means that under GAP, in contrast to the conventional system that uses calendar sprays with predetermined intervals, pesticides will only be applied when yield losses, expressed in yield deprivation, are higher than pesticide application costs. This requires regular sampling of the crops and a profound knowledge of population dynamics and economic threshold levels. This knowledge is not always readily available. However, as the system can always rely on pesticides as the last resort, considerable yield losses are unlikely to occur. The similarity with the conventional system makes GAP attractive to farmers who are already known with modern agricultural practices, such as large farmers who are producing for the mainstream. These farmers are likely to continue their conventional practices as long as the market does not ask for sustainable products. When changes are required, their vast areas under cultivation may complicate a change to organic. Since possible yield reductions and high labour demands may be unacceptable for these farmers, GAP offers them a workable alternative.

Table 2. Comparison of three sustainable agricultural systems

	Organic system	Shade system	Good Agricultural Practices
Accents	• Agricultural production • Elimination of agrochemicals	• Ecological and social aspects • Reduction of agrochemicals	• Agricultural production • Reduction of agrochemicals
Opportunities	• Premium • Fixed relationship with customers • Market with growth potential	• Premium • Products for local market	• Premium • Large potential market • Anticipation on future requirements
Threats	• Small market • Tight labour market • Required knowledge not available • High certification costs	• Small market (restricted to USA) • Tight labour market • Required knowledge not available • High certification costs	• Premium prices small • Tight labour market • Required knowledge not available • High certification costs
Profile	• Actually no or limited use of agrochemicals • Access to subsidies and knowledge (e.g. development projects) • Returns better than actual returns • Neighbouring farmers change also to organic	• Fields located in rainforests, woodlands • Trade orientated towards USA • Demanding local market • Access to subsidies and knowledge (e.g. development projects) • Recognition of the necessity of biodiversity	• Actual system based on modern agricultural technologies and inputs • Vast areas of land with monocultures • High labour costs unacceptable • Operating on the mainstream market (e.g. via co-operatives) • No compensation possible for reduced yields • Capacity to change

Shade trees
Both the organic system and GAP emphasise agricultural production. Shade systems, as described by the Conservation Agricultural Network (CAN), differ from organic farming and GAP in that they are more ecosystem and socially oriented. Conservation of the ecosystem and wildlife, biodiversity, and community relations play a central role in the CAN system. Despite this significant difference, the shade system can be seen as taking an intermediate position, as has been discussed above. Drawback of the shade system is that – at least in the case of coffee – its market is limited to the United States. In Europe shade coffee does not play a significant role. Premiums paid for shade products may be attractive for farmers who have their fields in rainforests or other woodlands. However, without support they may not be able to find suitable markets for their products, unless they are already trade orientated towards the United States. When access to the world market appears to be complicated due to lack of support or high thresholds, the diversity of products may be attractive for local markets. Unfortunately, premium prices are unlikely to be paid on these markets. Farmers may also introduce shade trees when they recognize the necessity of biodiversity. This recognition may be based on tradition, but also on other factors like experience with the vulnerability of a monoculture, or a desire to diversify their crops, their income, their diet, their environment. This makes that the shade system may be well incorporated in both the organic system and the GAP. Organic farmers and GAP-farmers may just as well recognize the importance of biodiversification.

Conclusion
Under the assumption that the farmer has to take environmental measures in order to keep his production sustainable, this section discussed some factors related to the farmer’s individual situation that may influence his choice with regard to which production system to adopt. Although exceptions are rather likely to occur, a farmer’s profile could be given with regard to three distinguished production systems. Smallholders with actually no access to agrochemicals are most likely to adopt organic farming. Precondition is that they receive financial, technical and logistic support to adjust their actual system to the organic requirements. Farmers with medium to big areas of land who have invested in modern agricultural practices are most likely to adopt GAP. GAP is based on the conventional system and thus easy to adapt for farmers who are used to this system. A change from conventional to organic farming has too many drawbacks for them. Yields are likely to reduce since no agrochemicals are allowed while the compensating premium prices are only paid two or three years after changing the system. With GAP, production may be maintained at the same level as in the conventional system while increasing sustainability. Farmers in rainforests or woodlands are likely to adopt the shade system. However, elements of the shade system may just as well be incorporated in any system, be it organic, GAP, or conventional.

The considerable reduction of yield, the radical change in cultivation techniques and the limited knowledge of organic production systems makes organic farming for the time being an unsuitable alternative for the conventional mainstream. With regard to future environmental requirements on commodities, GAP seems to be a more appropriate first step to change the mainstream in the direction of sustainable production. GAP approximates most closely the conventional system, its implementation is a gradual process of continuous improvement, pesticides remain available in the last resort, and yields are comparable to the conventional system. These characteristics make GAP easier to accept and implement than the organic system. A drawback is that under GAP produced products will have to compete with conventional products, which reduce the chances for fetching high premiums. This will make GAP less attractive to farmers because they have to invest more time (monitoring the crop, administration) and money (more expensive pesticides) without being awarded for the extra effort. Both government and consumer may play an important role in pushing the mainstream in a sustainable direction. Policy instruments of the government such as command and control, covenants, and environmental tax may force the farmers in the desired direction. Critical consumers may do the rest. Asking for sustainable products, they are at least as influential as these policy instruments.

3.3. Sustainable agriculture and certification

The decision as to what kind of production system one should implement is part of the strategic choices the farmer has to make. Whether or not to certify the system and if so by which certification body are just two other important strategic choices for the farmer. Certification is a significant means to show to the public at large that the product complies with the standards of the certification system under consideration. This may be an organic standard, the GAP standard, the CAN standard, a social standard, etc. The choice for a specific standard will have its impact on the market of the product in question.

Certification
Generally, certification is a matter between individual farmers and a certification body. When a farmer wants his product to be certified in accordance with a specific standard, he has to contact the organization that is authorised to certify for the desired standard. This certification body will advise the farmer and control the system on compliance with the standard through regular audits.

The normal certification procedure as described above is problematic for smallholders in developing countries, since they are generally poor. Consequently there is little money to spend on inspection and certification. Another difficulty on the way to certification is the high percentage of illiteracy among smallholders, which makes it difficult to fulfil the administrative requirements of the standard. Further, it is difficult to obtain farm's field maps, being essential in the inspection procedure, since fields are frequently dispersed far within the forests. Finally, smallholders - as the name already implies - are farmers with a limited piece of land. It is an impossible task for an external inspector to visit each and every smallholder. Consequently, certification on a one to one basis (one farmer to one certification body) does not seem to be realistic in the smallholder setting of developing countries.

Smallholder group certification system
Smallholders within a group tend to have very similar operations by growing the same crops and by using the same methods. Even the size of the plots is rather similar. Based on these characteristics, organic certification bodies have developed smallholder group certification systems. In the group certification process a homogeneous group of smallholders is seen as the certification unit. Group certification supports smallholders to certify for their products avoiding the problems related to individual certification, as briefly discussed above. A smallholder group has the following characteristics. It is a homogeneous group in terms of geographical location, production, and marketing system. The cost of individual certification is disproportionally high in relation to the sales value of the product sold. The group has to be large enough to make an internal control system reliable and financially feasible. The members of the group predominately depend on family labour. Finally, the group is part of a society of a developing country in the Southern Hemisphere.

A smallholder group has to comply with certain preconditions to apply for group certification. Since there is no annual inspection on a one to one basis by an external certification body, there must be an internal quality assurance system, a so-called Internal Control System (ICS). An ICS is defined as: *"a documented quality assurance system that allows the external certification body to delegate the annual inspection of individual group members to an identified body or unit within the certified operator"* (Van Elzakker & Schoenmakers, 2001). As a consequence of this definition, the main task of the certification body is to evaluate the proper working of the ICS. In practice it means that the co-operative (or exporter) to whom the smallholder group delivers its product is responsible for the annual inspection of the group members The co-operative conducts regular control at the farmer's premises. Adequate records of these inspections have to be maintained. They form the basis of the ICS. Each individual farmer is responsible for the registration of the activities on his farm related to the production of the commodity. The certification body will conduct an annual control of the ICS. This means that not individual farmers are subject to annual control by the external certification body but the exporter or co-operative. The ICS should give information on how (frequency, method) the co-operative controlled the groups and which measures it took against non-complying farmers. Besides the annual control of the ICS a certain percentage of individual farmers is checked by the external controller. Internal group control is also built in. A farmer risks (temporary) suspension from the group if he does not comply with the standard. His non-complying behaviour may even affect the whole group. If it is impossible to trace the product of the non-complying farmer in the total, the co-operative or exporter has to refuse the whole lot. In extreme cases the whole group may risk withdrawal of certification.

Restrictions
Worldwide over 25 certification bodies for organic farming now deal with smallholder group certification. Many of them have developed their own approach for smallholder group certifications. These approaches may differ widely. A severe restriction of the various approaches is that product certification by one certification body does not automatically lead to acceptance by another. Multiple certification may be necessary if one intents to serve a wide market. Similar problems can be identified for other sustainable agricultural systems. GAP, a young, still developing system, is only recognised in the European Union. CAN is not permitted in several European countries since its label "Eco-Oke" confuses the European labelling system for sustainable products. More effort has to be made to harmonise the different approaches of the different certification bodies.

Another drawback of certification, especially in the case of smallholders, is that the farmer depends on the willingness of farmers in the vicinity. As long as the return of the farm is not large enough to allow individual certification, the farmer has to follow his fellow farmers. He does not have the means to behave independently and make his individual strategic choices. Furthermore, the large impact of surrounding conventional farms on an isolated organic smallholder through drift (pesticides) and polluted groundwater (pesticides and fertilisers) will exclude organic certification. Similar restrictions but on a larger scale may come from industrial activities in the surroundings. Heavily polluting industrial activities upstream may disable a whole group to certify for organic production.

Conclusion
Certification is a necessity to proof to the public at large that the product complies with a certain standard and consequently is eligible for the premium paid for sustainably produced

products. The internal differences between the standards limit the potential markets for the certified products. As long as these differences exist the farmer has to consider the market for which he wants to produce. Shifting from one market to another in a later stage may cost him extra money. It is likely that even in this aspect farmers are restricted in their choice. The already existing contacts of the group with a specific market may dictate the certification requirements. The market restricting effect of certification demonstrates another important cohesion between the three sustainability dimensions. Choosing for a certain standard means choosing for ecological and social requirements as have been laid down in the standard. Additionally it means a limitation of the market.

Especially in the case of smallholders, whether or not to certify does not seem to be an individual choice. It is a groups' decision that is largely influenced by the expenses and the impact of the surroundings. With regard to the expenses, group certification makes certification accessible for smallholders.

All in all, farmers in general and smallholders in particular have only limited possibilities to make their own strategic choices on production standards and certification. Streamlining the different standards will give the farmers more independence with regard to the market for which they want to produce.

3.4. Sustainable agriculture and the world market

Uniformity requirement

In the previous section it was assumed that farmers aim at producing for a market, in which certification will be of increasing importance. But even without certification, products intended for the world market have to comply with certain requirements, dictated by Western food multinationals, governments and consumers. The result of both systems is a demand for uniform products, perhaps leaving a few local specialities admixed for "spice" (Dahlberg, 1994). Uniformity limits the potentials for locally adapted agricultural systems. Cash crops replace local food crops, genetically uniform and high yielding varieties replace the locally adapted ones, Coca-Cola and MacDonalds replace local dietary patterns, Jeans replaces local clothes, etc. In general, producing for the "global village" leads to losses in ecological, social and cultural capital.

Ecological capital refers to all the biotic (plants, animals) and abiotic (water, atmosphere, minerals) elements in an ecosystem. Social capital facilitates the co-operation between people and is characterized by the following four aspects: 1. Trust in other people based on our confidence in a known social structure; 2. Rules and sanctions being mutually agreed norms of behaviour that place group interests above those of individuals; 3. Reciprocity increases trust when based on either simultaneous exchange of items of equal value or a continuous relationship of exchange being repaid and balanced over time; and 4. Connectedness through networks and civic engagement that are vital for the formation of social capital and its maintenance (Pretty, 1998). Cultural capital is the richness of social and religious structures and intellectual and artistic manifestations etc. that characterize a society (Webster, 1989).

Sustainable agriculture, with special reference to organic farming and the introduction of shade trees, helps to rebuild ecological, social and cultural capital. Natural processes are integrated in agricultural production and the use of external and non-renewable inputs is minimised. Participation of the farmers and other rural people in problem analysis, technology development, and extension strengthens social capital. Cultural capital is safeguarded by the implementation of indigenous and traditional technologies wherever possible. Additionally, production for the local market improves the connectedness between consumers and farmers. This enables the farmer to respond more easily to consumers' demand for diverse products, increasing the biodiversity. Production for the world market, on the other hand, may endanger ecological, social and cultural diversity. It threatens to eliminate local knowledge, experience and creativity. This may even be true for sustainable production since also organically produced products have to obey the rules of the world market concerning uniformity and constant quality.

Regionalism
Unlike economic capital, ecological, social and cultural capital tend to be public goods, and so rarely have a market value. To prevent losses of these public goods, economic sustainability within a sustainable production system should get an extra dimension. In addition to profitability and continuity (Figure 1), local food production systems should play a significant role. This means that sustainable agricultural systems should pay attention to local circumstances and the role of ecological, social, and cultural systems under these circumstances. This may be referred to as regionalism. Regionalism should function as a counterforce against economic production criteria dictated by the world market and threatening indigenous and traditional production methods. The call for regional products and regional agriculture, gaining ground in Western Europe after swine-fever, "dioxin-chickens", BSE and the most recent mouth-and-feet epidemic, contributes to this concept. The market for speciality coffee, originating from a specific region, is another point in case.

The participatory approach
Besides regionalism, the development of a sustainable agricultural system should take place with the full participation of the farmers and other rural people (Pretty, 1998). Environmental policy tends to describe the practices that people should do rather than create the enabling conditions for locally generated and adopted technologies. Often, agricultural methods are developed under controlled circumstances and additionally introduced in rural communities. This approach is based on the assumption that technologies are universal and thus independent of the social context. Further, it makes the assumption that new technologies always imply an improvement of the existing ones. New technologies are imposed on the farmers and if necessary, local social and economic environments adjusted to suit the technologies. Sustainable agriculture based on this technological approach can never be sustainable. The general methods in the system will lead to losses in ecological, social and cultural diversity. Farmers will be engaged in the system because of the incentives, or because it does not cost them anything and so the system is worth trying. As soon as the driving force stops (incentives are no longer paid, project ceases to exist, etc.) farmers will fall back on the established system. A better approach for introducing sustainable agriculture is the participatory approach based on interactive participation. Instead of teaching the farmers the general methods, farmers learn how to analyse their problems, how to develop solutions for these problems, and who can support them. In the interactive participatory approach farmers participate in the identification of their problems, the development of action plans and the formation or strengthening of local groups or institutions. They are not supplied with new technologies but they develop the technologies themselves based on indigenous and traditional knowledge. The group determines how available resources are used. In other words, the farmers are provided with tools that support them in making their own strategic choices.

Conclusion
World market oriented production, asking for uniformity, endangers ecological, social, and cultural diversity. It does not leave the farmer a choice but to obey the rules or quit the system. With regard to sustainability, regionalism should be included in the economic dimension. The participatory approach supports regionalism in that sustainable agriculture will be developed based on indigenous and traditional knowledge. The participatory approach emphasises the reinforcement of local knowledge to enable farmers to make their own strategic choices, more independent of external forces.

3.5. Interaction in sustainable commodity chains

Sustainable agricultural systems like organic farming or GAP are complicated systems. Both systems require a profound knowledge of ecological processes, and a comprehensive administrative system. Farmers, especially smallholders, cannot be expected to implement either system without external support. A comparison with small and medium sized enterprises (SMEs) can be made here. Like SMEs agricultural businesses generally are too small to have all necessary knowledge to their disposal to implement a sustainable agricultural system, equivalent to environmental management systems in private enterprises. External support is an essential link to manage their business in the desired way.

The supportive network should be as close to the farmers as possible. Obvious organizations that play a role in the implementation of sustainable agriculture at farmer's level are co-operatives, agricultural extension services and non-governmental organizations (NGOs). The government can greatly influence the supportive network through command and control and through its policy on subsidies. Furthermore, certification bodies may have their contribution through advising and auditing.

Three important function can be distinguished for a supportive network based on the way it tries to communicate with the target group: 1. Will influencing; 2. Supportive; and 3. Repressive (De Bruin & Lulofs, 1996). The will influencing function of a network organization aims at sharing a collective objective by influencing individual members of the target group. The supportive function supports the target group in realising this objective by providing practical guidelines, extension, information and other support. The repressive function aims at keeping the group together. Reluctant or hesitating members are pushed in the desired direction, under more or less pressure.

Co-operatives, NGOs, and governments will communicate with their target group using all three functions: influencing, supportive and repressive. The influence of the government differs from the other two organizations in that the government communicates principally indirectly with the farmers. Its influence is exerted through the co-operatives and the NGOs. NGOs, financially supported by the government, are often the initiators, implementers and executers of development projects that provide and mobilize the network. Extension services, strengthened by the activities of NGOs, are just information providing organizations that restrict their input to supporting the farmers with the required information. Certification bodies may have a supportive function in advising the farmers on sustainable agricultural practices. At the same time they have a repressive function as they may exclude non-complying farmers. In case of smallholders the contact between the certification body and the target group will mainly be indirectly through the co-operative (see section 3.3). Table 3 gives an overview of the supportive network organizations and their contribution to the implementation of a sustainable agricultural system.

Table 3. Functions of the members of the supportive network for the implementation of sustainable agriculture at farmer's level

Function Actors	Will influencing	Supportive	Repressive
Co-operative	+	+	+
NGOs	+	+	+
Extension services		+	
Government	+	+	+
Certification bodies		+	+

Conclusion
Supportive networks play an important role in communication with the target group. Their credibility and acceptance by the target group will determine the number of individuals that will share their objective. With regard to farmers, co-operatives and NGOs are the most important supportive network organizations. On one hand, they are in direct contact with individual farmers, which makes them trustworthy for the farmers. Farmers will seriously consider their advice. On the other hand, they have contacts with financial and supportive organizations. With their knowledge about the farmers' wishes and the market demands, supportive networks play an important role in matching the desires of the different parties.

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Annexes

Annex 1

Coffee

1. Introduction

After crude oil, coffee has been the second biggest traded commodity in the world in dollar value since 1977 (Vogelvang, 1988). Brazil is by far world's most important supplier followed by Colombia (see Table 4). In 1996 these two countries were together good for one third of the total coffee production. The trade in coffee is dominated by two species, namely Arabica coffee, *Coffee arabica*, that forms the major proportion of the world trade, and Robusta coffee, *Coffee canephora*. There are many other coffee species but these do not have any commercial importance. The information in this chapter focuses preliminary on Arabica coffee grown and processed in Latin America, with special attention for the situation in Costa Rica, where ISCOM participates in the sustainable coffee project "Suscof".

Table 4. Coffee: production data of 1996 [1]

Country	Area harvested (1000 ha)	Yield (kg/ha)	Production (1000 ton)	Percentage of world production
Ivory Coast	1405*	118	165	2.8
Ethiopia	95*	780	230*	3.9
Kenya	156*	626	98*	1.7
Uganda	280*	917	257*	4.3
Total Africa	*3171*		*1150*	*19.4*
Costa Rica	101*	1412	143*	2.4
El Salvador	167*	771	126	2.1
Guatemala	269	500	207	3.5
Honduras	209	630	131	2.2
Mexico	763	426	325	5.5
Total North & Central America	*1972*		*1111*	*18.7*
Brazil	1984	650	1290	21.7
Colombia	965*	852	822	13.9
Ecuador	305	403	155	2.6
Peru	180	592	107	1.8
Total South America	*3818*		*2489*	*42.0*

[1] More recent production data on coffee are given in Annex 2. In this report preference is given to the data of 1996 as presented in this table since the more recent data are only available for a limited number of countries. Besides, the more recent data lack data on the productivity per hectare.

Country	Area harvested (1000 ha)	Yield (kg/ha)	Production (1000 ton)	Percentage of world production
India	230*	783	180*	3.0
Indonesia	771	559	431	7.3
Philippines	134	1110	149	2.5
Vietnam	152*	1303	198*	3.3
Total Asia	*1601*		*1122*	*18.9*
World	**10,612**		**5932**	**100**

* Unofficial figure

Source: adapted from FAO, 1996

In this Annex, processes taking place in the coffee chain are analysed with regard to primary production (coffee growing) and primary processing (depulping). For both links, the general processes are described in section 2. This information forms the basis for the identification of adverse effects on the environment in this part of the coffee chain (section 3). Subsequently, environmental measures are formulated that can contribute to the internalisation of these external effects (section 4). The impact of the environmental measures on other sustainability aspects like quality and health are analysed in section 5 and section 6 respectively. Figure 3 gives an outline of this Annex. A process flowchart for the whole coffee chain is presented in Annex 3.

2. Coffee growing and processing

2.1. Primary production

Basic environmental requirements
Favourable growing conditions for Arabica coffee are characterized by an annual rainfall of 1200 to 2000 mm, well distributed over the year, a temperature range between 15 and 24 °C, an altitude range between 1200 and 1500 m above see level and deep, well drained, preferably loamy soils with a pH range of 5.4 to 6.0. In Costa Rica the strictly hard beans are produced at an altitude ranging between 1200 and 1700 meters. The precipitation ranges between 2000 and 3000 mm distributed over 155 days. The average temperature is 19.0 °C and the average relative humidity 84.0 % (Clévos, 1975). The volcanic soil is responsible for high soil fertility and an optimal pH-value. The favourable growing conditions in Costa Rica combined with intensive production systems have resulted in extreme high yields per hectare (see Table 4).

The growth requirements may differ slightly depending on the coffee species. For example, Robusta prefers a lower altitude (500 to 1200 m) and consequently higher temperatures.

Types of production systems
In Latin America coffee is cultivated under different production systems. These systems constitute a continuum from traditional ones, with high diversity in structure and composition of the shade canopy, to those with reduced shade and intense management. Using shade level and management as indicators for intensification, roughly five types of coffee production systems can be distinguished (Gobbi, 2000).

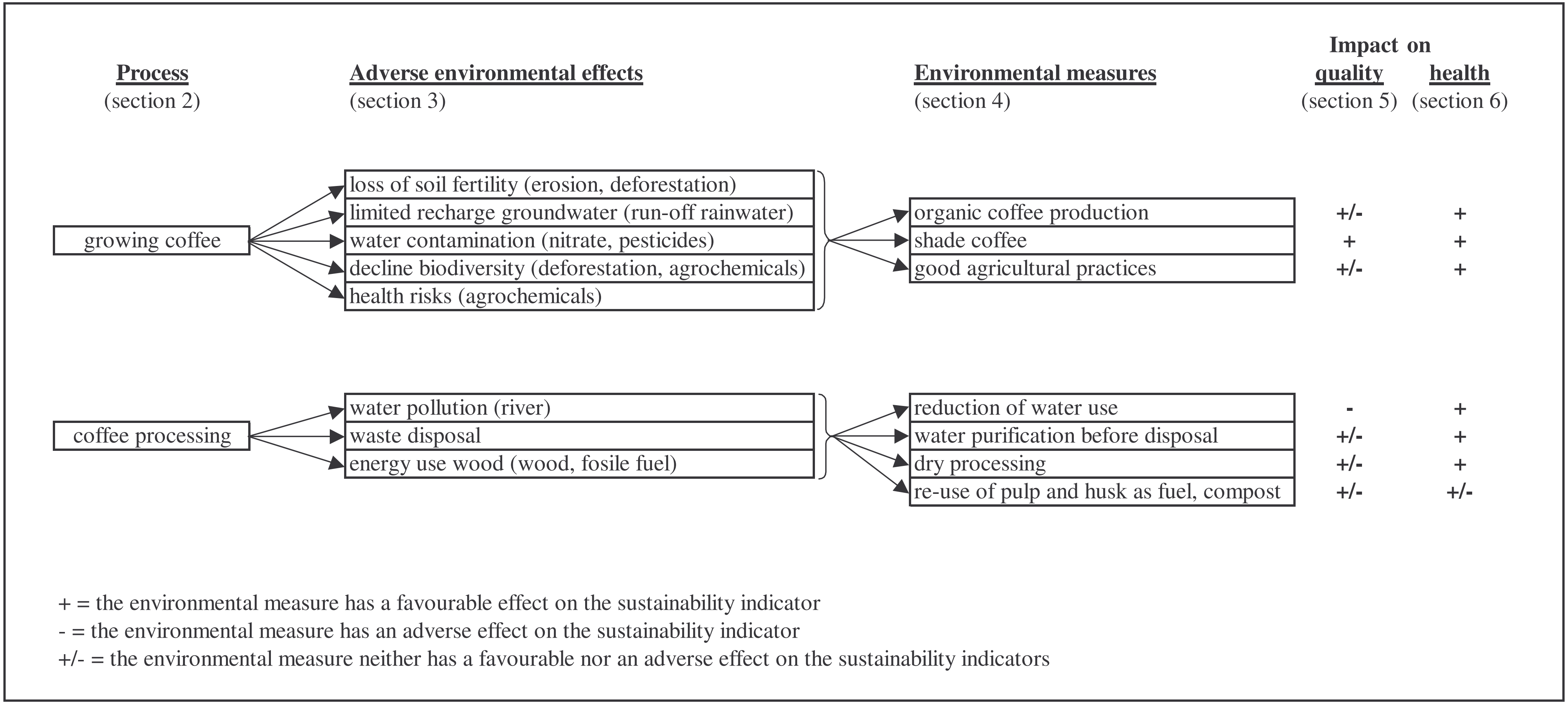

Figure 4. Outline of the subjects discussed in Annex 1: Coffee

Type 1: Traditional or "rustic" coffee system
Coffee production takes place under forest trees by substitution of plants growing on the floor of a (sub)-tropical forest with coffee. There is a minimal impact on the original forest ecosystem;

Type 2: Traditional polyculture system ("coffee garden")
This system involves the manipulation of the native forest ecosystem. It is a subsistence system where the strata composition is based on dynamic use and multi-species (native and non-native) composition of the shade. The system is linked to other crops associated with coffee.

Type 3: Commercial polyculture system
The original forest canopy trees are replaced by a commercially useful set of shade trees. The main strategy is to obtain two or more products from the same plot. The associated species provide shade for the coffee trees as well as an extra product. Citrus, banana, macademia, avocado and timber providing trees like red cedar are commonly used intercrops.

Type 4: Technified shade system
The original forest has been entirely removed and replaced by one or a few indigenous shade species. These species are planted as a canopy to protect the monospecific coffee plantation underneath.

Type 5: Unshaded monoculture system
This coffee production system involves the use of sun tolerant coffee cultivars that do not require shade. Typical elements of this system are improved varieties, high densities, high inputs of chemical fertilizers and pesticides, high financial investments, the use of machinery, intensive use of labour and the highest yields per hectare.

During the last 30-40 years, substantial transformation of coffee systems in Central America, particularly in Costa Rica, has taken place. Many multi-strata traditional coffee systems (types 1 and 2) have been converted to highly intensified coffee monocultures (type 5). This has resulted in plantations with dwarf coffee planted at very high densities (5,000 to 10,000 trees/ha), with little or no shade, and frequently treated with herbicides and other phytosanitary products.

Elements in the coffee production
Starting and managing a coffee plantation involves a number of tasks. Site selection, choice of a cultivar, propagation, erosion prevention and field planting are tasks that play an important role in the starting up phase. Fertilization, irrigation, weed, disease, and pest control, and harvesting are annually returning activities. Erosion control, although most important at the initial stage of the coffee plantation, also belongs to the annually returning activities.

Site selection
The criteria for climate and soil discussed before must be met. Additionally slope and drainage should be considered.

Choice of the cultivar
This choice will be preliminary dictated by the climatic conditions. Growing intensity is another factor of importance. In the highly intensified unshaded monocultures dwarf varieties with a high tolerance for direct sunlight are the preferred varieties.

Propagation
Arabica propagation generally takes place by seed from ripe cherries of selected trees. Seed propagation is not suitable for hybrids or Robusta. Robusta needs vegetative propagation since it is self-sterile.

Erosion prevention
Terracing, planting of windbreaks, and/or establishing live or dead barriers are measures to prevent soil erosion.

Field planting
This activity involves the transplantation of the seedlings to the field. Spacing plays an important role in this aspect.

Fertilisation
Proper fertilisation replaces nutrients removed from the plantation in fruits (pulp and beans) and in prunings. The most important nutrients for coffee are nitrogen, phosphate, and potassium. Other elements necessary in smaller quantities are calcium, magnesium, sulphur, zinc, iron, manganese, copper, boron, and molybdenum.

Irrigation
Irrigation depends on the cultivation intensity and rainfall. In areas where rainfall is marginal, it has enabled coffee to be a profitable crop. Brazil is a point in case (Vaesen, interviewed on 23 July 2001). Irrigation systems on smallholders' fields are not very likely.

Weed, disease and pest control
Since weeds compete for water and essential nutrients with coffee, dense stands of weeds can reduce the crop by up to 25 %. The most common disease in coffee is coffee leaf rust caused by *Hemileia vastatrix*. However, the incidence of coffee diseases and the damage caused varies per coffee production region. The best means of control is provided by resistant varieties. One of the most serious pests in coffee is the coffee cherry borer, *Hypothenemus hampei*, but like for diseases, also pest occurrence in coffee varies per region.

Pruning
Pruning affects the quality of the beans and the yield. Besides, it minimizes biennial bearing, which is common in coffee and consequently the risk of dieback. The pruning techniques determine the size and the shape of the tree.

Harvesting
Only ripe red coffee berries should be picked. As the berries do not ripen all at the same time, the harvest season may last for up to four months over a number of pickings. Harvesting is mainly done by hand. It is a labour intensive process that involves recruiting large numbers of people, including the family, friends and hired labour. Occasionally mechanical harvesting may take place.

2.2. Processing

Wet processing
Depulping should take place immediately after harvesting. Any delay causes the juicy fruit to start fermenting resulting in a deterioration of the coffee quality. Wet processing is the most common depulping procedure. At the wet processing site the coffee cherries are dumped in the water where the poor quality floating berries will be separated from the rest. The depulping method depends on the size of the processing site. Generally, depulping is executed mechanically at industrial scale. Only at small family sites where the farmer himself processes the fresh cherries, depulping will be done by hand. After depulping the coffee will undergo a fermentation process, in order to get rid of the remaining slimy mucilage layer. After a standard set of time (8 to 12 hours), the coffee beans are successively washed and dried. The drying process can take place in the sun or in large electric or fossil fuel dryers. When completely dry, the parchment coffee, so called due to the parchment like shell around each individual bean, is stored for about four weeks in order to ‘mature’. Thereafter, it is sent to the dry processing plant. Here the parchment will be removed (hulling) transforming the parchment beans through a mechanical process into green coffee. This is an energy intensive process, which normally takes place at large plants.

Grading and packing
The green bean is put through a number of processes that help to sort it according to weight, size, shape and colour. In this way different export and domestic grades are achieved. Finally the green beans are put into jute bags of 60 kilograms and shipped to importing countries.

Storage
Low relative humidity (50-70 %) and temperatures below 26 °C provide ideal circumstances for storage of beans (Sterling, 1980). Under these circumstances neither absorption nor loss of moisture takes place and so bleaching of the beans and loss of the desirable flavour is prevented. Nevertheless, colour and flavour slowly change, even under optimal storage conditions. In parchment form, coffee can keep up to 5 months (Woelore, 1995), and in green bean form even 3 years without much impact on quality. Once roasted, coffee should be consumed as soon as possible, with a storage life of one month.

3. Environmental aspects of coffee growing and processing

3.1. Primary production

Although modernization of the coffee culture has resulted in important gains in productivity, there are many side effects that have more or less severe impacts on the environment. The underneath mentioned environmental aspects are some examples.

Soil fertility
Soil fertility gets lost following the elimination of shade trees and ground cover. The absence of an extensive root structure and the reduced quantity of litter covering the soil do no longer impede erosion. Both wind and water erosion may occur. Renovated coffee plantations in Nicaragua where shade had been reduced showed significant higher erosion rates. The same

plantations had a lower level of soil moisture and organic material than found in shade coffee systems. Further, unshaded plantations appeared to be poorer recyclers of nitrogen than shade coffee systems. Within high-rainfall areas, unshaded coffee lost nearly three times more soil nitrogen (Rice & Ward, 1996).

Water quality
Agrochemicals such as nitrates and pesticides contaminate ground- and surface water. This not only results in a loss of floral and faunal diversity, it also threatens the health situation of the community living in this area and far beyond.

Biodiversity
Intensified coffee cultures form a severe threat for biodiversity. Deforestation is a serious trend throughout the coffee-producing countries of Latin America. Seven of the ten countries in the world with the highest deforestation rates are in this region, including important coffee producing countries like Costa Rica, Guatemala and Mexico (Rice & Ward, 1996). However, creating a monoculture is one aspect, using agrochemicals like chemical fertilizers and pesticides is another. These artificial agricultural inputs have a devastating effect on the environment, including biodiversity. Pesticides do not only kill the target organisms. They generally affect a much wider range of organisms on a much larger scale than the direct surroundings of the coffee plantation. Marine life near river mouths appeared to be affected by contaminations from coffee pulp (Loria, 1992 quoted in Njoka & Mochoge, 1997). The excessive use of nitrogen fertilizers causes a progressive soil acidification that reduces soil life activities.

Health
The workers at a coffee plantation run the highest risk to fall ill or die as a consequence of the exposure to agrochemicals. In this context a difference should be made between acute and chronic poisoning. In case of acute poisoning the relation between the use of an agrochemical and the symptoms is clear since the symptoms occur while working with the chemical. Chronic poisoning is more difficult to proof, however, there are strong indications that many agrochemicals are carcinogenic. People who work on a regular basis with agrochemicals run a higher risk to develop cancer than people who do not. Besides the plantation workers, the people living in the vicinity of a place where pesticides are used are also in danger. A clear example of acute poisoning is the explosion in the pesticide plant in Bhopal, India, in 1984. In this explosion 40 tons of ("registered") toxic substances were released that killed more than 3,000 people and left 200,000 injured. Chronic exposure to dangerous substances often passes unnoticed. Not surprisingly since in first instance it has less dramatic effects than a catastrophic event such as Bhopal. However, in the long run the effects may be more disastrous. In Mexico, public health and water quality impacts have been linked to pesticide use. In 1987, more than 200 people became sick from drinking water contaminated with pesticides and fertilizer (Rice & Ward, 1996).

Despite the general impression that pesticide residues do not threaten the consumer’s health (Hoitink, personal comment), research conducted in the late 1970s and early 1980’s by the U.S. Food and Drug Administration (FDA) has revealed frequent detections of DDT, BHC and other pesticides banned in the U.S. on samples of imported green coffee beans. Other tests using detection methods many times more precise than the FDA procedures revealed multiple pesticide residues on all samples of green beans. The roasting process reduces detectable levels on bean samples, but with the more precise detecting methods, residues may even be detectable on roasted beans (Rice & Ward, 1996).

3.2. Processing

Water
Large quantities of water are used in the depulping process and the washing process after fermentation. Figures on the amount of water used for the wet processing of cherries range between 11 to 15 litres (BTG-report, 1995 and Morera, 1995) and 40 to 50 litres (Avalonne, 1999) per kilo of processed beans. Table 5 shows the water consumption of six co-operatives in Costa Rica per kilo of processed beans.

Table 5. Total volume of waste water (m^3) and the volume of waste water (litre) generated for the processing of one kilo of green beans for 6 co-operatives in Costa Rica in 1997/1998 and 2000/2001

		Cooperatives					
Year	**Volume waste water**	**A**	**B**	**C**	**D**	**E**	**F**
1997-1998	total (m^3)	5,556	7,505	75,026	81,045	28,934	152,821
	per kilo (litre)	9.1	11.5	26.1	26.1	8.7	26.1
2000-2001	total (m^3)	1,995	7,849	37,496	20,365	58,590	60,410
	per kilo (litre)	3.7	10.2	15.2	10.9	17.4	10.9

Source: Chacón et al. (1999), with updates from the Environmental Management System (ISO 14001)

The waste water has a very high organic content, although also the data on the exact content vary widely. According to BTG Biomass Technology Group the chemical oxygen demand (COD) measures about 190 grams COD per kilo of green beans (30,000 tons COD for 160,000 tons of green coffee). Morera on the other hand mentions a COD of 330 grams per kilo of green beans, which is equivalent to the daily pollution of 5,6 adults. Half of this organic load is caused by the depulping process, the other half by the washing process. Historically, the waste water was dumped into the river. Beside the waste water from the depulping process and the washing process, there is the remaining pulp that may also be dumped into the river. This will definitely have the highest impact on the COD.

Energy
The energy demand in coffee processing is another important factor having an impact on the environment. Electricity and firewood are the main energy resources. Firewood is used in the drying process after fermentation and rinsing. The total wood consumption and the wood consumption per kilogram of processed green beans is given in Table 6 for six cooperatives in Costa Rica.

Table 6. Total wood consumption (m^3) and the wood consumption for the processing of one kilo of green beans ($*10^{-3}$ m^3) for 6 co-operatives in Costa Rica in 1997/1998 and 2000/2001

Year	Wood consumption	Cooperatives A	B	C	D	E	F
1997-1998	total (m^3)	217	1,000	3,029	4,670	7,176	4,065
	per kilo ($*10^{-3}$ m^3)	1.7	1.5	1.2	1.5	2.2	0.7
2000-2001	total (m^3)	176	1,204	4,740	1,222	2,780	5,755
	per kilo ($*10^{-3}$ m^3)	0.2	1.5	0.4	0.7	0.9	1.1

Source: Chacón et al. (1999), with updates from the Environmental Management System (ISO 14001)

The yearly amount of wood that the cooperatives require may create a serious threat to the local forest, as supplies from local plantations are insufficient. The considerable reduction in wood consumption in 2000-2001 is a result of an environmental measure, in which husk is used as an alternative energy generator. Cooperative A substituted the drying machines by open-air platforms, but this method is not a feasible solution for larger cooperatives (Wolters, 2001).

The production of one ton of dried green coffee in a rotating drum batch drier requires 9 GJ (Rolz et al., 1982). The electricity consumption for the seven cooperatives in Costa Rica is given in Table 7.

Table 7. Total energy consumption (kWh) and the energy consumption (kWh) for the processing of one kilo of green beans for 6 co-operatives in Costa Rica in 1997/1998 and 2000/2001

Year	Volume waste water	Cooperatives A	B	C	D	E	F
1997-1998	total (kWh)	91,787	107,544	656,594	654,040	993,174	1,500,076
	per kilo (kWh)	0.18	0.17	0.23	0.20	0.31	0.23
2000-2001	total (kWh)	91,686	128,925	459,572	446,950	896,962	870,001
	per kilo (kWh)	0.17	0.16	0.20	0.24	0.27	0.18

Source: Chacón et al. (1999), with updates from the Environmental Management System (ISO 14001)

4. Alternatives to reduce the environmental impact

4.1. Primary production

Organic coffee production
Organic production aims at establishing an equilibrium between the farming system and the environment. To re-establish this balance, the drawbacks of production and processing have to be reduced to a minimum through the use of appropriate conservation principles. These principles involve maintenance and improvement of soil fertility by using natural and – as much as possible – local resources. They also involve the minimal use of fossil fuels and other non-renewable sources, and the exclusion of agrochemicals. Besides agro-technical aspects, socio-economic aspects should be improved. It may be clear that growing coffee without any form of chemical input does not automatically qualify for organic coffee. A wide range of other criteria has to be fulfilled, including:

- Clearance in a selective way that does not affect the environment and the local population;
- Terracing, contour planting, soil covers, mulching and abolishing clean weeding to prevent soil erosion;
- Maintaining or improving the long-term soil fertility by replacement of removed nutrients, recycling of organic material, etc.;
- Increase of organic matter by using legumes, organic matters like compost and manure, shade trees loppings, etc.;
- Taking measures to prevent deforestation caused by the demand for firewood;
- Soil activation by correcting the pH;
- Use of clones[2] and seedlings resistant to pest and diseases and adapted to the local climate;
- Regulation of the micro-climate and improvement of the ecological diversity to encourage the natural control of pest and diseases;
- Shade planting integrated in the organic farm management;
- Recycling of by-products from the processing to the fields like the water used in the wet processing system and the coffee pulp that remains after depulping. Dumping these by-products into the river system is prohibited;
- Clear separation of the organic and the conventional commodity chain during the whole process from producer to consumer. All tools and machinery used in the conventional coffee line must be carefully cleaned before they may be used in organic coffee. An alternative approach is to set up a dedicated organic tools and machinery line.

(Source: IFOAM, 1996)

Shade coffee
The principal aim of shade coffee is the conservation and increase of biodiversity in coffee plantations. The introduction of shade trees is a first step to promote biodiversity. In a later stage, when the conditions are favourable other organisms may migrate to the shaded coffee

[2] Clone = (member of a) group of organisms produced asexually from one ancestor.

plantation, increasing the biodiversity. The description “birds’ paradise” shows that the approach is successful. And not only birds are abundant. Shade coffee also provides essential habitats to many other organisms like plants, arthropods and mammals. In the perspective of this biodiversity a lower pest and disease incidence is often mentioned (Rice & Ward, 1996; Anonymous, 1999). This is in agreement with the generally accepted idea that a relative abundance of species means an ecological equilibrium (Beets, 1990). Other authors, however, are convinced that diseases are more likely to occur (Bergamin, 1946; Agrios, 1982, both quoted in Soto-Pinto et al., 2000). The higher humidity is often seen as a catalyst for diseases. To lower disease incidence good shade management is essential. A shade system has to be developed that protects the coffee trees from sunshine without increasing humidity too much. This requires regular pruning of the shade trees. Weeds form a minor problem in shaded coffee plantations. Biodiversity is not the only merit of shade trees. Soil erosion by wind or water is prevented by an extensive root structure. This root system also prevents rainwater to run off superficially so that rainwater can penetrate into the soil, recharging the groundwater. Soil fertility is improved due to decomposing organic material and nitrogen fixing by leguminous trees. This results into a considerable reduction of the need for chemical fertilizer (Rice & Ward, 1996; Rafflegeau et al., 1999). The high organic content of the soil and no direct exposure to sunlight conserves the soil moisture content. Consequently, stress due to water or mineral deficiencies is less likely to occur.

Generally it is believed that shade trees reduce the yield of a coffee plantation. However, Soto-Pinto et al. (2000) showed that did is not necessarily the case. Only when shade cover exceeded 50 % they could observe a decrease in production. Between 23 and 38 % shade cover they could even observed an increase. An additional merit of shading is a more stable production (Rafflegeau et al., 1999). This merit is generally attributed to a reduction of biennial alternation and a reduction of overproduction that can cause the trees to die as a result of dieback.

Studies have shown that agroforesty systems are more sustainable, more respectful of the environment and often more profitable than those based on intensive monoculture (Beets, 1990; CATIE, 1999, quoted in Rice & Ward, 1996). The Conservation Agricultural Network (CAN) has used this finding as its starting point for the CAN Coffee Standard. The conservation and diversification of the ecosystem is enhanced by protection of the natural forest, reforestation where possible and the use of mixed cropping systems where practical. An important difference with organic farming is that in shade coffee agrochemicals are permitted under strict preconditions. Another important difference is that organic coffee farming puts less emphasis on biodiversity. An unshaded plantation can still be an organic one. However, all the merits of shading discussed above show that shade conditions in coffee plantations, although not required, are highly profitable for organic farming. Good Agricultural Practices on the other hand, as will be worked out below, differs from the CAN Coffee Standard by the emphasis that is put on the safe and proper use of agrochemicals.

Good agricultural practices

For intensive monocultures it is often not possible to change the system overnight. High yielding varieties in combination with heavy dependence on agrochemicals in the past have made the system too vulnerable to pests and diseases. There is a long way to go to change such a system into an organic system. But even without such a radical change in the production system environmental gains can be realized. One of the practical instruments to enhance sustainability in conventional agriculture is the Good Agricultural Practices (GAP), a

European standard for sustainable agriculture (Eurepgap, 2000). Originating from European food production industry, the GAP needs to be adapted to local conditions in coffee producing countries.

Integrated pest management (IPM) is an important element of the GAP. IPM is a pest management system that integrates multiple pest control methods like sanitary measures, resistant varieties, cultural methods (e.g. intercropping, mulching), and biological control. If all the previous methods do not result in the desired effect, chemical control can be used as a final option. IPM is not aimed at elimination of species but at the reduction or maintenance of pest populations at a level below the level that causes economic injury and loss of money. The techniques used in an IPM system should lead to as little damage as possible to non-target organisms on one hand and to an optimal yield and good quality on the other hand.

Within IPM pesticides are allowed to use in a selective way only. “Selective” in the sense that pesticides are only applied when it is really necessary. This means that sprays based on field monitoring results replace calendar sprays. But the word “selective” also refers to selective action of the applied pesticide, which means that the pesticide is less toxic for non-target organisms. Finally, “selective” refers to selective application. Instead of spraying the whole field, only alternating lines or trap plants are sprayed.

4.2. Processing

Water

Reduction of the organic content in the water can be realized by:

1. Reduction of the water use.
2. Filtering the waste water to remove the pulp.
3. Removal of suspended particles.
4. Removal of the dissolved organic material.
5. Dry processing

(Sources: BTG, 1995 and Morera, 1995?)

Ad. 1. Reduction of the water use.

Re-use of water in the depulping process is a feasible option. Research has shown that re-use not only reduces the amount of water needed in the depulping process, but that it has a number of positive side effects as well (Morera, 1995?). So diminishes the re-use of waste water the release of nutrients from the pulp. This effect is thought to be a result of the high organic content of water. Less organic material dissolved in the water means that the pulp remains its nutrients making it a high valuable organic fertilizer. Further, re-use of waste water speeds up the fermentation process. The increase in turn over enlarges the processing capacity. In case a pump is used to pump the processing water from the river to the processing plant and the waste water from the processing plant back into the river one may even come to an energetic advantage. Re-using the waste water is supported by the finding that it has no negative side effects on coffee quality related to odour or taste. Rather the contrary. Re-use of the process water during one or two days increases the acidity of the coffee, which contributes to a better aroma. In an agreement between the beneficios and the government, Costa Rica has set its target at 3.87 litres of water per kilo of processed beans (Morera, 1995?). Some beneficios even realized 1.55 litres per kilo.

Ad. 2. Filtering the waste water to remove the pulp.
This method is already widely established in Costa Rica. The used wire (“type V wire”) withholds all particles larger than 0,75 mm.

Ad. 3. Removal of suspended particles.
In a sedimentation tank floating and suspended particles are removed. After this step the water may be re-used in the depulping process.

Ad. 4. Removal of the dissolved organic material.
The final step in the waste water treatment is a treatment in an anaerobic digester. In this process, in the absence of oxygen organic materials are converted in methane and carbon dioxide by bacteria. The by-product methane can be used as fuel in the drying process. The anaerobic technique has evolved over the past 25 years and nowadays its efficiency may be up to 80 %.

Ad. 5. Dry processing
In the dry processing method the use of water is reduced to a minimum. Worm screws are used to depulp the cherries and to transfer the depulped fruit and the pulp. This technology reduces water use to 1.8 litre per one kilogram of cherries (Avalonne et al., 1999). The cherry pulp resulting from the dry processing contains less water and consequently is easier to dry as compared to pulp from the wet processing. This makes the pulp attractive as a fuel source for the drying process. Dry processing asks for adjustment of the processing machines. Problems faced are the separation of the coffee beans from the pulp, as well as the separation of unripe cherries from the pulp and the transport of pulp over long distances. Another disadvantage of the dry processing is that the energy demand seems to be 2.5 times higher than for the wet processing (Morera, 1995?). Dry processing is a common practice in Brazil where water is scarce (Vaessen, personal comment).

Energy
Reduced energy use in coffee processing can be realized by the use of more efficient machineries. One may think of machineries that use less energy to process the same amount of coffee but also of machineries using alternative (“green”) energy sources such as coffee pulp, husk or solar energy. As already mentioned above, coffee pulp will only be a viable option if the water use in the depulping process is reduced to nil or almost nil. If not, an additional step is necessary to remove the excess of water from the pulp. Sun-drying of the pulp may be a cheap but slow and space consuming option. A press may be a more realistic option. Solar energy is a very promising source of alternative energy since it is abundant in most coffee producing countries. Air-drying of coffee beans on open-air platforms is a traditional but efficient method. With the present knowledge about solar energy, air-drying can and should be modified into a modern, highly efficient drying method. Costs are probably the principle obstacle.

Environmental Management Systems
An environmental management system (EMS) on industrial level is more or less the equivalent of GAP on farmer’s level. An EMS is a way of moving information around inside an organisation, taking into account an organization’s structure, responsibilities, practices, procedures, processes and resources for determining and implementing environmental policy

(British Standards Institute, 1994). It is that part of the total management system that aims at a gradual but continuous reduction of the company's externalities, without affecting the quality of the product. It follows a step-by-step approach adapted to the company's capabilities. A selection of the above mentioned environmental measures on the reduction of water pollution, and water and electricity consumption is likely to be incorporated in a beneficio's EMS.

5. Impact of environmental measures on quality

5.1. Primary production and quality

The quality of coffee is an important aspect of economic sustainability since it influences the price: the higher the quality, the better the price. Therefore, quality is an indispensable part of coffee farming, responsible for determining the farmer's income. A wide range of factors influences coffee quality. The consumer is exposed to cup quality only which is determined by organoleptic means (tasting). However, overall quality depends on the raw bean, the roasted one as well as the liquor quality or brewed flavour. Raw bean size, shape, colour, texture and chemical composition are important determining factors for coffee quality, and so is the roasting process. This section will focus on the impact of environmental measures on quality aspects of the raw bean.

Bean size is an important feature for coffee quality (Cannell, 1974). Generally, there is a positive relation between bean size and coffee quality. Although partly genetic, the size can be modified by ecological conditions and crop husbandry.

Factors affecting quality
There are many factors that may affect the cup quality of coffee.

Ecological conditions
Ecological conditions affect the growth of coffee trees. This ultimately is reflected in the coffee quality. For example, coffee grown in a sub-optimal (low altitude) coffee-zone is generally inferior to coffee grown in the optimal coffee-zone. Coffee grown on a southern oriented slope will be superior to coffee grown on a northern slope.

Variety effects
The choice of cultivar, variety or species of coffee is an important factor in coffee quality. Arabica coffee is superior to Robusta. Some rust resistant Arabica varieties produce inferior bean and liquor quality.

Nutrients
Nutrients play an important role in coffee quality. An optimal balance of nutrients gives the highest quality. Imbalanced nutrition does not lead to an increase in yield of high quality beans. Nitrogen is a good example in this respect. Nitrogen is an important nutrient for protein syntheses, and thus for the quality of the coffee bean (since large beans tend to be of better quality). An increase in nitrogen application does not necessarily lead to a higher percentage of large beans since another nutrients may be the limiting factor.

Some other known effects of nutrient imbalance are shortly mentioned hereafter. High levels of potassium and calcium may cause magnesium deficiency that reduces the coffee quality. Iron deficiency in soils with a high pH produces ‘amber coloured beans’, which have a low liquor quality. Applications of nitrogen, phosphor and potassium (NPK) to increase the yield per tree may result in a decline in bean size and hence in quality (Njoroge, 1985). Continuous use of cattle manure may result in beans with a dull roast and a liquor with a light acidity (Blore, 1965 quoted in Kamau, 1976).

Crop protection factors
Insects, weeds and diseases can affect the quality of the coffee bean. Insects may have direct or indirect effects. Damage to the flowers or the coffee bean are direct effects that lead to deformed beans or no bean development at all. Destruction of leaves is an indirect effect leading to smaller, lower quality beans. Weeds affect both yield and quality by the production of fewer and smaller beans. Diseases like leaf rust or bacterial blight lead to poor quality of the final product.

Mulching
Mulching has a positive effect on both yield and quality (Njoroge & Mwakha, 1985; Kamau, 1976 and Cannell, 1974). This benefit is especially found in low rainfall areas. An explanation may be found in the effects of mulch on soil moisture conservation, weed suppression, and improvement of the soil structure. However, the use of mulch over a prolonged period affected slightly the flavour of mulched coffee (Kamau, 1976).

Pruning
Beans on uncapped coffee trees grow more vigorously (Njoroge & Mwakha, 1985). This is probably due to better feeding. However, capping allows easy picking and spraying at a convenient uniform height. Fruit thinning has a positive effect on the coffee quality.

Irrigation
Proper irrigation increases the production of high quality beans. Benefits are higher where nitrogen fertilizer application is also practised (Njoroge & Mwakha, 1985).

Harvesting
Good harvesting is related to the selection of properly ripe and undamaged cherries. Uniform ripeness is an important feature for subsequent processes (Van der Hulst, personal comments). Unripe berries should be avoided, as well as ‘black beans’, cherries from the ground, and cherries with insect damage, twigs, leaves and other materials. Before further processing, these undesired contaminations should be sorted out.

Organic coffee production
Although most of the criteria for organic coffee farming will have an impact on the quality of the end product, generally organic farming is not a guarantee for better quality. The impact of the measures taken depends strongly on the way of implementation. Careful farming will increase coffee quality, but this result is inherent to the system. Conventional production will give the same result (Van der Hulst and Top, personal comments). Mulching is the only criteria related to organic production that has a positive effect on coffee quality (Kamau, 1976). The benefit from mulching is mainly found in low rain areas. The slightly negative effect on the quality after prolonged use does not seem to be alarming. A nominated coffee

expert once stated that he could taste the use of chemical fertilizer (Vaessen, personal comments).

The quality of organic coffee on the Western market depends strongly on availability (Van der Hulst, personal comments). The total supply of organic coffee on the world market is limited resulting in a limited choice when looking for a special quality. Since the conventionally produced coffee takes the lion share of the coffee supply on the world market, the buyer is offered a wide selection. The chance that the desired quality is found among these conventional coffees is bigger than in the case of organic coffee with its restricted choice. Therefore, as long as the supply of organic coffee is restricted, its quality tends to be lower than the quality of conventionally produced coffee. It has nothing to do with the farming system.

Shade coffee

There is more and more evidence that coffees grown under shade trees are of better quality. In an experiment in which two coffee varieties were compared, it was concluded that shading improved the appearance of green and roasted coffee as well as acidity and body of the brew for both varieties (Muschler, 2001). Only the effect on the aroma of the brew was slightly negative for one of the varieties and neutral for the other. Other studies also showed improved cup quality from shading due to increased acidity and sucrose content (Guyot et al., 1996). A practical example comes from Starbuck Corporation that invested US $ 200,000 to help Mexican farmers improve the quality of beans grown under a forest canopy. Though the expectations were low, the premium-priced coffee turned out to be so tasty, that Starbucks is extending its sales to oversees markets (Deutsch, 2001). Explanations for the good quality of shade coffee go in the direction of lower fruit load per tree in combination with a longer period of bean maturation. Shade promotes slower and more balanced filling and uniform ripening of the berries, thus resulting in a better quality product than unshaded coffee plants. The reduction of temperature extremes may also play an important role. This might even be the main reason for improved bean quality under sub-optimal (low altitude) conditions.

Good agricultural practices

As for organic coffee, coffee produced under Good Agricultural Practices (GAP) will not per definition differ qualitatively from conventionally produced coffee. It is the way of husbandry that makes the difference.

5.2. Processing and quality

Reduction of water use

The quality of the process water has an essential impact on coffee quality. Generally, the interviewed resource persons were wary of the recycling of process water. However, according to Morera (1995), research has shown that re-use of the process water during one or two days increases the acidity of the coffee, contributing to a better aroma.

Water purification

Purification of the process water by removing the pulp, suspended particles and dissolved organic material will not have any quality effect on the coffee but for re-use of the water.

Dry processing
In Central America wet processing is the common procedure. Tradition or not, it is generally believed that wet processing has a positive effect on cup quality. All resource persons contacted during the preparation of this paper were also convinced that coffee from wet processing is superior to coffee from dry processing. They stated that the washing process makes the coffee milder. However, Avalonne et al. (1999) compared the wet and the dry depulping process and came to the conclusion that there was no difference in cup quality. Cup quality of the end beverages as well as the biochemical composition of the green coffee obtained from the two processes were judged to be identical.

An important precondition of the fermentation process is that it is stopped once the required acidity is reached (pH = 3.5-3.8). Here one may find an explanation for the fact that, despite the findings of Avalonne et al., beans produced through wet processing are generally qualified as better quality than beans produced through dry processing. The fermentation process following dry depulping appears to be a faster process than the fermentation process following wet depulping. In the experiment, it took the dry depulped beans 15 hours to reach the required acidity while the wet processed beans needed 25 hours. The difference in fermentation time is attributed to the difference in the mucilage simple sugar content after depulping. The presence of these sugars enables micro-organisms to develop rapidly. The wet processing dissolves the sugars in the substrate, resulting in lower mucilage sugar content and consequently slowing down microbial growth. It is very likely that the quick fermentation after dry depulping makes the process more difficult to control. Over-fermentation may easily occur, which has a negative impact on coffee quality. As long as the fermentation process is not better controlled, wet processing is more favourable to quality than dry processing. Better control over the fermentation process to avoid quality loss favours the dry processing procedure since it is ecologically sounder.

Sun-drying of the beans after depulping, fermentation and washing with full exposure to sunlight has a positive effect on the quality. Since the raw bean colour is photosensitive, the bluish colour is formed at this stage (Njoroge, 1998).

Other environmental measures
Neither energy savings through investments in more efficient machineries nor the implementation and operation of Environmental Management Systems are likely to have an effect on the product quality. Both measures aim at making the process more effective while retaining product quality.

6. Impact of environmental measures on health

6.1. Primary production and health

Organic coffee production
Pesticides used in coffee production are the most serious threat for human health. They most directly affect persons who work with the pesticide, like the employees in the pesticide

industry, applicators of pesticides, and other workers on the coffee plantation, etc. But pesticides may have an effect on a much wider scale. They may cause health problems to people living in the vicinity of plantations, for example through drift during application or through contamination of water sources. But even organisms, including human beings, living further away from the coffee plantations can be affected. The classical example of accumulation of the persistent pesticide DDT in the food pyramid is one example, pesticide residues on green coffee (see section 1) another.

There is no doubt that refraining from pesticide use, as is the case under organic production circumstances, will have a positive effect on the health of all living creatures that come in one way or another into contact with these pesticides. There will be a positive correlation between exposure to the pesticides and health gain. When no longer exposed to harmful pesticides, the health of the pesticide applicator and his surroundings will profit more than the health of the coffee consumers elsewhere in the world. But also indirectly health can be positively affected. If the grower refrains from pesticide use, under certain conditions he can sell his coffee as organic coffee. This will give him a better price for his products. The premium that the grower receives for his organic products should compensate for the extra costs made to potential yield reduction and higher labour costs. A better income leads to better social circumstances, including better health.

Shade coffee

The Organic Crop Improvement Association International (OCIA) encourages its coffee-producing members to diversify the shade cover. By doing so growers can benefit from a variety of products associated with their holdings, which makes them less dependent of one crop. Sources of income from a shaded coffee plantation are besides coffee, wood for energy provision or construction, food products from roots, leaves, and fruit, medicine, condiment, handicrafts, and others. Both the diversification of income as well as the diversification of daily food pattern will positively influence the health of the growers, their workers and their families. Reduced pesticide use that is likely to occur in shaded coffee production (see section 4.1.) is an additional health aspect as has been discussed above.

Good agricultural practices

Good agricultural practices (GAP) may influence health in multiple ways. General hygienic requirements and basic health care for workers are included in the standards for GAP. The same goes for safety measures and routine health check-ups for pesticide applicators and other workers who are regularly exposed to dangerous substances. Since GAP is a means of incorporating integrated pest management (IPM) important restrictions are put on the use of pesticides. These include the reduction of pesticide use to the necessary and avoiding the use of the most dangerous pesticides, like representatives of the so-called “Dirty Dozen”.

In the GAP much attention is paid to the safe handling of pesticides. Training of workers on safe pesticide handling and application is considered to be of uttermost importance. This not only includes safe application, but also the use of spray equipment and protective clothing, pesticide storage, and the disposal of surplus spray-mix, empty containers and obsolete pesticides.

There are many other benefits from GAP. One can think of pruning trees, which makes pesticide application easier. Harvesting of pruned trees will also be easier. All in all, it can be concluded that although pesticides are not completely excluded in GAP, it is obvious that the gain on health aspects is considerable. The use of less toxic chemicals in lower quantities and safely applied and disposed will be a gain for both human health and the environment.

6.2. Processing and health

Rivers polluted with effluent water from the beneficios is unfit for irrigation, livestock and fish culture (Njoka, E.M. & B. Mochoge, 1997). The high organic content is also a threat for human health. When alternative water sources are not available people do not have a choice but using the contaminated water. This may take them ill. Therefore, purification of the processing water before dumping it into the river will be highly beneficial for all living creatures that depend on the river, definitely including human beings. For the same reason, dry processing is in favour for health conditions. If less water is used in coffee processing, consequently the contamination of the river with organic matter will be reduced. However, this reduction is not necessarily proportional since the concentration of organic matter per unit of waste water may be higher.

When local energy sources are used, investments in more efficient machineries in order to reduce the energy consumption of a beneficio will have a considerable positive effect on the physical state of health. When fossil energy sources are used, a health effect is less likely to be perceptible. This does not mean that there is no effect at all. Any reduction in the use of fossil energy contributes to the prevention of global warming.

Environmental Management Systems aim at reducing the environmental impact of human activity through continuous improvement of the environmental achievement. As such it is obvious that the implementation and operation of an EMS will also contribute to improving physical health conditions.

7. Conclusion

Quality
Generally it is believed that a tasty cup can be produced in any production model, be it regular, organic, shaded, fair trade or whatever. Taste generally depends on other factors than production system, including plant genetics, field location, care in harvesting and sorting beans and roasting skills (McLean, 1997; Van der Hulst (personal comments)). Care also plays an important role. In this context, Van der Hulst adds the importance of a reasonable price. When farmers are well paid for their product, they will be stimulated to invest more time and money in their crop, which will definitely be reflected in a better quality. With regard to processing, especially environmental measures on process water may hamper the quality. Recycling of process water may have an adverse effect when the quality of the recycled water is poor.

Health
In general, incorporation of environmental measures is beneficial for human health. A more deliberate use of agrochemicals, diversification of income, and availability of clean water sources form the basis of health improvement. The change in pesticide use can either be realised through IPM that reduces the exposure to and the toxicity of the pesticides used or through organic production that eliminates the use of pesticides completely.

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Annex 2

Coffee: production data of 1999 and 2000

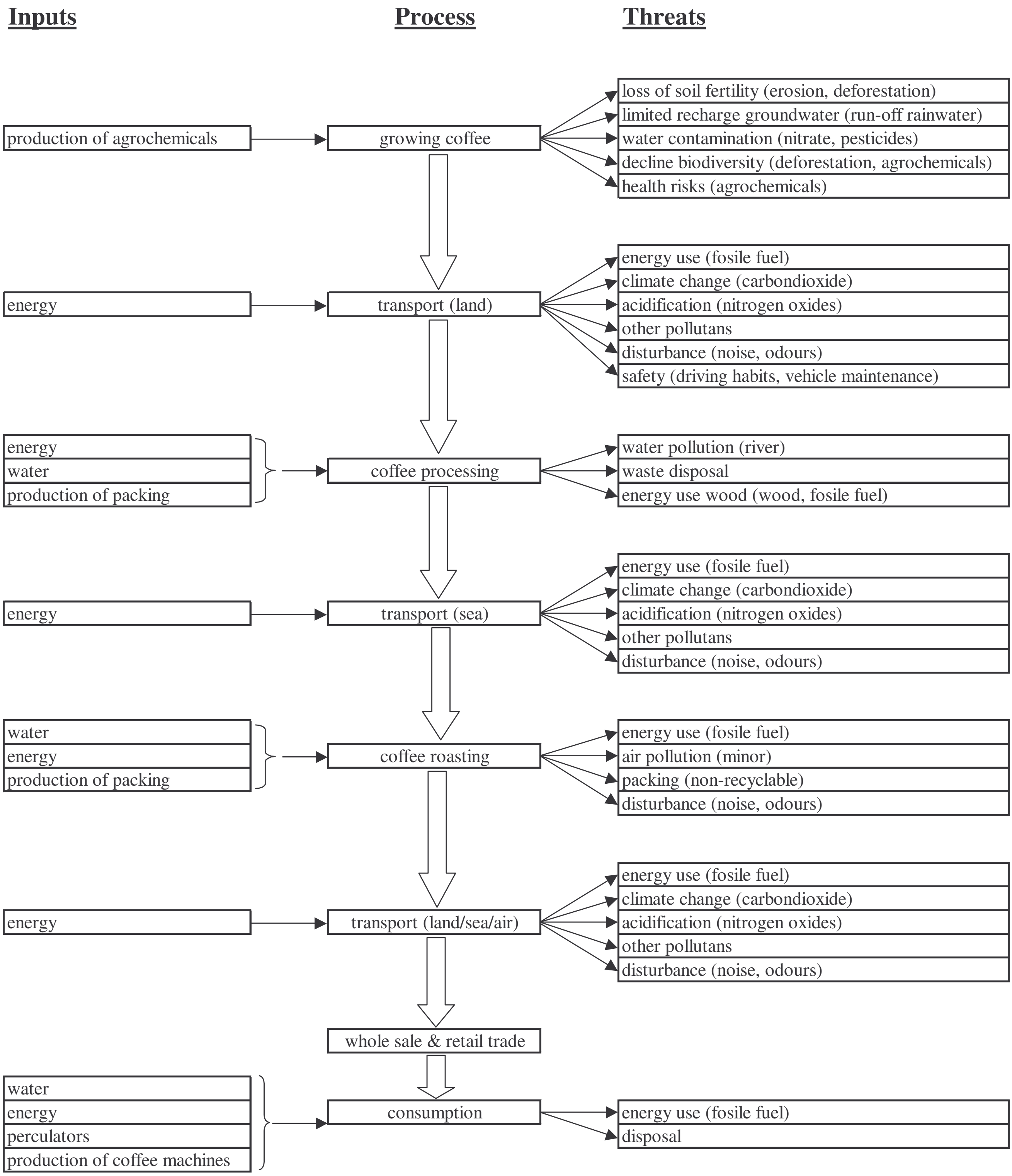
Country	**Production in 1996* (1000 ton)**	**Production in 1999 (1000 ton)**	**Production in 2000 (1000 ton)**
Ivory Coast	165	250	260
Ethiopia	230	230	226
Kenya	98	86	72
Uganda	257	253	258
Total Africa	*1150*		
Costa Rica	143	n.a.	n.a.
El Salvador	126	n.a.	n.a.
Guatemala	207	270	270
Honduras	131	n.a.	n.a.
Mexico	325	372	318
Total North & Central America	*1111*		
Brazil	1290	1630	1734
Colombia	822	558	720
Ecuador	155	n.a.	n.a.
Peru	107	n.a.	n.a.
Total South America	*2489*		
India	180	n.a.	n.a.
Indonesia	431	368	438
Philippines	149	n.a.	n.a.
Vietnam	198	450	480
Total Asia	*1122*		
World	**5932**	**6235**	**6492**

* = Source: FAO, 1996
n.a. = Data not available

Source: FAO, 2001

Annex 3

Process flowchart for coffee



Source: adapted from De Beaufort, 2000

Annex 4

Cocoa

1. Introduction

Within the Theobroma genus cocoa, *Theobroma cacao*, is the only species of economic importance. The species presumably originated on the lower eastern equatorial slopes of the Andes where nowadays a wide range of variation in natural populations exists. It is believed that the Spaniards are initially responsible for the distribution of cocoa over the world. Through Mexico and New World countries like Venezuela, Trinidad, Jamaica, Haiti and Brazil, cocoa reached the Gulf of Guinea in the seventeenth century. From there it spread over Western Africa. In the same century it was introduced in Asia (Philippines in 1670) by the Spaniards and the Dutch.

While world's main producers of coffee are found in Latin America, world's main producer of cocoa has to be looked for in Africa. With almost 40 % of the total cocoa production of the world, Ivory Coast is without any doubt world's most important cocoa producer (see Table 8). Africa as a whole is the leading continent, accounting for more than half of the total cocoa production. More than 80 per cent of this amount is produced by smallholders.

Table 8. Cocoa beans: production data of 1996[3]

Country	Area harvested (1000 ha)	Yield (kg/ha)	Production (1000 ton)	Percentage of world production
Ivory Coast	2150*	584	1254	38.8
Ghana	1200*	283	340	10.5
Nigeria	400*	363	143*	4.4
Cameroon	360*	349	126	3.9
Zaire	22*	352	75	2.3
Total Africa			*1976*	*61.2*
Dominican Republic	137	235	63	2.0
Mexico	91	578	53	1.6
Total Central America			*137*	*4.2*
Brazil	688	511	373	11.6
Ecuador	350	250	88	2.7
Colombia	124	522	65	2.0

[3] More recent production data on cocoa are given in Annex 5. In this report preference is given to the data of 1996 as presented in this table since the more recent data are only available for a limited number of countries. Besides, the more recent data lack data on the productivity per hectare.

Country	Area harvested (1000 ha)	Yield (kg/ha)	Production (1000 ton)	Percentage of world production
Total South America			*571*	*17.7*
Indonesia	332	826	274	8.5
Malaysia	205	610	217	6.7
Total Asia			*509*	*15.8*
World	**6,514**		**3229**	**100**

* Unofficial figure

Source: adapted from FAO, 1996

This chapter analyses the processes taking place in the cocoa chain with regard to primary production (cocoa growing) and primary processing (depulping). The structure of this chapter is similar to the one in the previous chapter. This means that successively the general processes in both links are described (section 2), followed by the identification of adverse effects of cocoa production on the environment (section 3), and the formulation of environmental measures that can contribute to the internalisation of these external effects (section 4). The impact of the environmental measures on other sustainability aspects like quality and health are analysed in section 5 and section 6 respectively. Figure 4 gives an outline of this chapter. A process flowchart for the whole cocoa chain is presented in Annex 6.

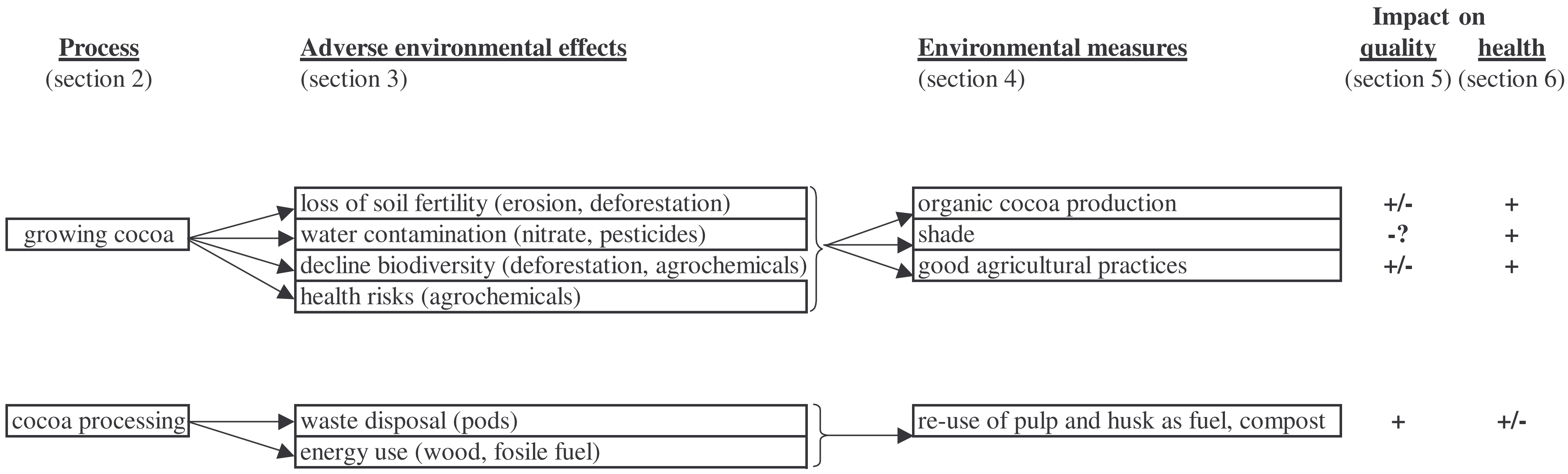
2. Cocoa growing and processing

2.1. Primary production

Basic environmental requirements
Cocoa develops well in areas where temperature and humidity are high without much variation over the year. Rainfall should also be high and well distributed. Such conditions are found in Equatorial regions. No wonder that 75 % of the world's cocoa is grown within 8° of the Equator (see Table 8). Annual rainfall of most cocoa-growing regions lies between 1150 mm and 2500 mm. Temperature in these regions ranges between 18 and 32 °C though long periods over 30 °C may affect essential physiological processes in the tree.

Besides a favourable climate, cocoa requires a well-drained deep soil. It may be a sandy loam, loam or clay soil, provided that it has a good water-holding capacity without getting waterlogged. The pH of the soil should range between 5.0 and 7.5.

Methods of cocoa cultivation
As in the case of coffee a continuum of cocoa production systems can be found ranging from traditional systems with a high diversity in structure and composition of the shade canopy to those of reduced shade and intensive management. Based on the degree of shading and management intensity, roughly four types of cocoa cultivation systems can be distinguished (N'Goran, 1998; Greenberg, 1998):



\+ = the environmental measure has a favourable effect on the sustainability indicator

\- = the environmental measure has an adverse effect on the sustainability indicator

+/- = the environmental measure neither has a favourable nor an negative effect on the sustainability indicator

Figure 5. Outline of the subjects discussed in Annex 4: Cocoa

Type 1: Rustic cocoa system
This system is widespread in West Africa and local in northern Latin America (from southern Mexico to Brazil and Peru). It involves the clearing of the undergrowth on the forest floor, followed by the elimination of certain species of trees that are harmful to cocoa. Cocoa is planted and cultivated under the shade of the remaining trees. Both primary and older secondary forests can be used.

Type 2: Artificial shade system
This method consists of planting shade trees according to a specific plan. All indigenous vegetation of the forest land is removed and replaced by new local or exotic species. The planting system can range from a traditional polyculture having multiple species of planted shade trees with occasional remnant forest species, to commercial shade with other crop trees interspersed amongst planted shade trees and cocoa, to a monoculture where the shade is dominated by one or a few tree species.

Type 3: Technified cocoa systems without shade
High-yielding, Upper-Amazonian hybrids can be cultivated in direct sunlight. In combination with other agricultural practices (e.g. fertilizer application, plant protection) yields are increased considerably. This system is common in Malaysia and gains ground in parts of Colombia and Peru.

Type 4: Abandoned cocoa plantations
Political instability, disease problems and/or low cocoa prices cause farmers to cease good farm management. The cocoa farm gradually reverts to secondary forest, with the associated forest flora and fauna.

Cocoa is predominantly cultivated by smallholders in multi-product, multi-strata agroforests (Leplaideur, 1985 quoted by Duguma, 1998) similar to type 1. Smallholders account for more than 80 % of the total cocoa production.

Elements in the cocoa production
Any cocoa production system involves a number of activities, with some activities restricted to the starting-up phase of a plantation and others occurring on an annual basis. Activities restricted to the initial phase of a cocoa plantation include site selection, choice of a cultivar, propagation, site preparation involving forest (floor) clearing, erosion prevention measures, and field planting. Annually returning activities are fertilisation, shade management, pruning, plant protection, and harvesting. Some of the above mentioned activities will be briefly discussed hereafter.

Site selection
The criteria for climate and soil discussed before must be met. Additionally slope and drainage should be considered.

Propagation
Most cocoa is raised from seed, which is easier and cheaper than vegetative propagation. Vegetative propagation is used only when plants of specific clones are required.

Fertilisation
The quantity of fertilizer required will depend on the amounts of nutrient available in the soil. Cocoa planted into rich soils may not need fertilisers at all in the early years, whereas cocoa on a relatively poor soil will need fertilisation from planting onwards. Shade is another important factor that influences the need for fertiliser. Fertiliser application to heavily shaded cocoa plants has little or no effect on crop yield, whereas unshaded plots will show a substantial increase in yield. The use of organic manures on cocoa is beneficial. Apart from providing nutrients, organic manure improves the soil structure and the holding capacity for water and nutrients.

Shade management
Originally, cocoa is a shade plant. Nursery plants and young plants need shade to produce trees of the desired shape. Mature cocoa, however, will give a higher yield if grown unshaded, provided that adequate moisture and nutrients are available throughout the year.

Pruning
Pruning aims at getting the trees into such a shape as to maximize production, to ease harvesting and maintenance and to achieve the best control of pests and diseases.

Plant protection
Different from many other crops, major pests and diseases have not followed cocoa around the world. However, they have transferred from indigenous hosts, which has resulted in a wide range of pests and pathogens attacking cocoa. These pests and pathogens thrive in the warm, humid climate in which cocoa is grown.

Pathogens constitute the most serious production constraint for cocoa (Gotsch, 1997). Since more than 80 % of the cocoa is produced by smallholders chemical control of these pathogens is not very obvious. This makes horticultural management within and around the plantation extremely important. Regular sanitation including the removal of all diseased material is the most important measure that can be taken to control diseases. Indigenous vegetation may serve as an alternative host for a pathogen of cocoa. Removal of this vegetation may consequently destroy alternatives for these pathogens. Tree spacing and pruning enhances the effectiveness of sanitation and provides an environment within the plantation that minimizes the spread of pathogens. Not many success stories exist about the use of resistant plant material.

Besides diseases, cocoa suffers from a heavy pest load, making pesticide use a common feature in intensive cropping systems. Mirids are the principal constrain for cocoa in Ivory Coast (Fleischer et al., 1998). Maintenance of an adequate level of shade may help to control this insect pest, but can be favourable to some diseases. The choice of the shade tree is crucial. Shade trees may create a favourable micro-climate but simultaneously they may act as alternative hosts for cocoa pests or diseases.

Crop loss due to weeds can be considerable due to the strong growth of weeds that can be expected in the hot humid climate suitable for cocoa. Slashing is the traditional method of weeding. The cut material is left to form a mulch. Control by herbicides is less laborious and may even be cheaper. Shading by mature cocoa and shade trees reduces weed growth in established areas.

Harvesting
Pods should only be harvested when fully ripe. Unripe pods contain too little sugar for the fermentation process, which is an essential part in the flavour development of cocoa. Overripe pods are vulnerable to fungal attacks and animal pests (monkeys). They may dry and germinate in the pod, which jeopardize the quality of cocoa. Since the pods remain in a suitable harvesting condition for 2 to 3 weeks, harvesting should be carried out regularly at intervals of 10 to 14 days. After harvesting the pods are opened with a knife to remove the beans. Worldwide this is a manual process. The husk is a waste product.

2.2. Processing

The processing of the beans consists of fermenting, drying, polishing and grading.

Fermentation
Cocoa can be fermented in heaps, in baskets usually covered with banana leaves (West Africa) or in special wooden boxes (other countries). Fermentation takes up to one week, during which time the beans may be stirred on the third and fifth day to allow good aeration and to prevent the temperature from rising above 50 °C. During the fermentation sugars in the pulp are broken down and the flavour and aroma of cocoa are developed. The fermentation process stops when temperature drops below 35 °C.

Drying
After fermentation the beans are air-dried in the sun during approximately seven days. They are covered with mats or movable roofs to protect them from rain, dew, or excessive heating by the sun. Stirring of the beans is needed to ensure uniform drying. Sometimes artificial driers are used.

Polishing
The beans may be polished mechanically or by wetting them and trampling on them with bare feet.

Grading
Shells, broken beans and extraneous matter should be removed by hand or by machines. The quality of the cured beans is judged by the following characters:

1. the beans should be plump and of even size with not less than 1 gram of fermented dry weight;
2. shells should be intact, free from mould, of a uniform brown colour and should not be shrivelled;
3. the content of the beans should be friable, chocolate brown in colour and on roasting should develop the characteristic chocolate flavour;
4. the beans should have a fat content of minimal 55 %.

3. Environmental aspects of cocoa growing and processing

33.1. Primary production

As in the case of coffee, cocoa production may endanger biodiversity and water quality, may enhance the loss of soil fertility, and may have an impact on the health of the workers on a cocoa plantation, the people in the vicinity and even on the health of the consumers. As far as water quality, soil fertility and health aspects are concerned, reference is made to Annex 1 (Coffee). In this section the different aspects of biodiversity in cocoa production will be discussed shortly. As is the case for coffee, the loss of biodiversity is primarily caused by deforestation and the use of agrochemicals.

Deforestation
Cultivation of high-yielding species in direct sunlight, in association with fruit trees and other food crops has resulted in considerable deforestation. In Ivory Coast cocoa plantations are responsible for 14 % of the deforestation (Pallix & Comolet, 1996, quoted by N'Goran, 1998). The process of deforestation has not stopped yet. While the productive life of a cocoa tree can be up to 30 years, in the unshaded system tree vigour declines already after 10 years (Evans, 1998). Factors causing this decline include increased water stress due to increased soil moisture evaporation, excessive leaf transpiration and damage by pests and diseases. The loss of productivity is a threat for natural forests. As land is abundant and agrochemicals expensive increase in cocoa production is realised through extending the area under cultivation and not through increasing the yield per hectare (Fleischer et al, 1998). The loss of tree vigour is a proof that cocoa production without shade is not sustainable.

The production of cocoa in a shaded system does not necessarily safe biodiversity (Alves, 1990 quoted in Alger, 1998). In a rustic system (type 1 in section 2.1.) the original forest is thinned and the undergrowth eliminated before the cocoa trees are planted. Birds and other animals that depend on the undergrowth will disappear out of the plantation. Mammals become an easy prey for hunters since their hiding-places are eliminated with the shrubs. As natural tree species age and fall they are not replaced by natural species, since the undergrowth is systematically cleared. In this vicious circle of declining biodiversity it may occur that young plantations preserve more biodiversity than the old rustic system without undergrowth.

Agrochemicals
In Ivory Coast phytosanitary products and fertilizers are applied on a very limited scale (Fleischer et al., 1998 and N'Goran, 1998). According to Fleischer et al. pesticide use is limited to 5-15 % of the total cocoa growing area. Nevertheless due to the extensive area of cocoa production 25 % of the total pesticide consumption is used in cocoa. With 93 % of the total pesticide consumption, insecticides represent the lion's share of the pesticide consumption. Environmentally harmful insecticides like Lindane, Aldrine, Dieldrin, Heptachlor and DDE are used against mirids, the most important cocoa pest in Ivory Coast.

As already discussed for coffee, pesticides do not only kill the target organisms. Depending on the type of pesticide used and the mode of application biodiversity is affected to a greater or lesser extent.

3.2. Processing

The primary processing of cocoa lacks the adverse environmental impact as seen for coffee. The removal of the pod is a manual process in which no water is used. Fermentation is followed by drying. The drying process is preferably carried out in the sun. If other means are used, the energy demand may cause an impact to the environment in the form of firewood harvesting and carbon dioxide production. The firewood demand may be considerable.

4. Alternatives to reduce environmental impact

4.1. Good agricultural practices and organic cocoa production

Increase of the cocoa production without continuing deforestation can only be realised through better crop management practices like good agricultural practices and organic cocoa production. Parallel to the situation in coffee, good agricultural practices in combination with integrated pest management should optimise the use of pesticides and other agricultural chemicals in cocoa. Unfortunately, an integrated pest management to control mirids has not yet been well developed (Fleischer et al., 1998, Padi & Owusu, 1998). As long as no effective control method has been developed against this insect pest, its control will continue to depend on environmentally harmful pesticides that are presently used.

Cocoa seems to be a crop that is very suitable for organic production. Historically cocoa has been grown in a biodiversity friendly manner. Further, smallholders who produce the largest part of the total cocoa production do not have access to agrochemicals. Criteria for organic cocoa production are comparable to those for organic coffee production. As in the case of coffee, the aim of organic cocoa production is to reduce the drawbacks of the production and processing. Losses from mirids and other pests and diseases are minimized by putting emphasis on the use of varieties well-adapted to the environment, a balanced manurial programme, fertile soils of high biological activities, suitable intercrops, green manures, the protection of natural enemies, etc. Plant protection concoctions made from local plants, animals and micro-organisms are allowed as long as they do not jeopardise the quality of the ecosystem or the organic product.

4.2. Shade

As already said, cocoa is a shade plant. Although it tolerates extremes in light intensity, photosynthesis is at a maximum in a light intensity of 25 % of full sunlight. Cocoa can survive in dense shade, which would kill many other species. This tolerance to low light intensity makes cocoa a suitable crop to grow under natural forest cover, making deforestation needless. An additional advantage of shade is that cocoa grown under shade trees has a very low fertilizer demand. Shade trees, shrubs and the cocoa itself contribute a considerable amount of nutrients by providing litter from their fallen leaves. High fertilizer applications under heavy shade may even be counterproductive. Further, pest incidence is lower under shaded circumstances, especially in cocoa plantings on the cleared forest floor. Generally it is believed that shade has a positive effect on biodiversity that on its turn suppresses pest and disease outbreaks. Exceptions on general rules are always present. Phytophtora is a point in case. Its infestation appears to be higher in shaded circumstances due to the favourable high humidity.

Shading also has its drawbacks, as we have seen for coffee. Yields in shaded cocoa plantations are significantly lower than in unshaded ones. The trees produce fewer flowers, pod loss by wilting is higher and bean weight per pod is lower (see Table 9).

Table 9. Productivity factors influenced by the presence of shade trees

Treatments	Shade	Sunlight and fertilizer	Sunlight without fertilizer
Average intensity of flowering/month	504.8	1,346.1	1,103.1
Number of pods/tree	25.1	69.6	62.2
Weight of fresh beans/pod	88.0	116.2	112.6
Weight of fresh beans/tree	2,209	8,088	7,004

Source: Lachenaud, 1985 (in: N'Goran, 1998)

Cultivation under artificial shade (type 2 in section 2.1.) with coconut (Willson, 1999) or plantain (Lachenaud, 1987 quoted in N'Goran) as shade trees has proven to be very fruitful.

5. Impact of environmental measures on quality

5.1 Factors affecting quality

The two determining aspects in cocoa quality are flavour and purity or wholesomeness. Flavour is the main criterion for the chocolate manufacturer. The criterion includes both the intensity of the chocolate flavour, together with any ancillary flavour notes, and the absence of flavour defects. Defects include effects of under-fermentation, over-fermentation and taints. Purity or wholesomeness refers to any impurity that may affect the consumers' health. The principal sources of impurities are pesticide residues, bacteria, pest infestation, foreign matter, heavy metals and mineral oil (BCCCA, 1996).

Planting material
The inherent potential chocolate flavour of a particular source of cocoa beans is determined principally by the variety of the trees. Different trees may produce cocoas with distinctly different flavour profiles. Bitterness and astringency are, among others, associated with certain planting materials.

Soil
Beans produced on acidic soils may contain an increased level of heavy metals, especially lead and cadmium.

Plant protection
The use of pesticides on cocoa trees and in cocoa stores can lead to the presence of residues in the dried beans. Internationally and nationally limits are set for the acceptable level of pesticides in cocoa beans.

Post-harvest fermentation process
Where there are major effects of the planting materials on flavour, conditions of post-harvest processing become more critical and demanding in order to compensate for the inherent genetic differences. On the other hand, careless or faulty post-harvest processing will negate the potential benefit of particular planting materials on flavour. Prolonged fermentation causes mouldy, and to a lesser extent smoky off-flavours. Acid taste is due to excessive amounts of certain acids that are formed during fermentation. Differently from the other two off-flavours, the acid taste can within certain limits, be corrected by the manufacturer. Bitterness and astringency are associated with poor fermentation and certain planting materials.

Drying
Inadequate or too slow drying and adsorption may cause mouldy off-flavours. Smoky off-flavours arise from contamination by wood smoke during drying. Too slow drying or the storage of wet beans may cause excessive contamination with bacteria and fungus.

Storage
Smoky off-flavours may also arise from contamination by wood smoke during storage. Mouldy off-flavours are caused by moisture during storage under adverse conditions. The high fat content of cocoa beans acts as an extremely effective absorbent for off-flavours. Infestation by several species of insects often occurs during storage. If these infestations are not treated by effective pre-shipment fumigation, these species will survive the voyage and infest cocoa stores and chocolate factories in Europe and USA.

Hygiene
Excessive microbiological contamination can also result from contamination of stored beans by birds, rodents, other animals and human beings.

5.2. Good agricultural practices and organic cocoa production

Organic production and in a lesser extent good agricultural practices stimulate the use of plant varieties that are well-adapted to local conditions. These varieties do not necessarily correspond with the favourable taste, but coincidentally it may be the case. Reduction or complete elimination of pesticide use will definitely favour bean quality as long as pest and/or disease infestation of beans is not increased. A higher pest or disease incidence will neither favour the quality nor the purse of the cocoa grower. Hygiene is an important issue in good agricultural practices. If the instructions of good agricultural practices are followed up correctly, contamination will no longer be a problem resulting in a quality gain.

5.3. Shade

Shade does not seem to contribute significantly to the quality of cocoa as it did to the quality of coffee. In fact, rather the contrary seems to be the case. Shading leads to lower yield and smaller beans. Especially the smaller beans affects the quality demanded by the chocolate manufacturers. It is strange that a cocoa tree, an outstanding example of a shade tree, looses quality when grown in the shade. However, this conclusion is probably too premature since other characteristics not related with chocolate quality like longevity or germination power are not taken into consideration. A positive effect already identified is the reduction of mirid infestation.

6. Impact of environmental measures on social aspects

The effects on health aspects through good agricultural practices or organic cocoa production are similar to the effects in coffee. As discussed in Annex 1, section 6.1. the elimination of pesticide use or the reduced and safer use of pesticides will primarily favour the health of the worker responsible for the applications. But also the health of other workers, the health of the people living in the vicinity of the cocoa plantation and even the health of people living further away from the cocoa plantation is favoured by this change in plant protection practices.

As for coffee, shade trees may diversify farmers' income and the daily food pattern, which may affect the farmer's health in a positive way.

7. Conclusion

Quality
The mode of production may affect quality in two directions: good agricultural practices and organic production may either improve or deteriorate the quality. As in the case of coffee the mode of production does not seem to determine the cocoa quality. Good crop management and care for the product are definitely more important determiners for quality. Low cocoa prices on the world market hamper good crop husbandry. Sustainable cocoa growing, safeguarding biodiversity in cocoa plantations and good quality cocoa will only be realized when economic incentives are made available to farmers who invest time and labour in their product.

Health
It is not surprising that health aspects are influenced in the same way, as was the case for coffee. Reduction or complete elimination of pesticide use, safer pesticide handling and diversification of food pattern and sources of income are the guarantees for better health conditions for those who depend on cocoa production.

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Additional sources of information

Internet sites

www.acri-cocoa.org
www.oardc.ohio-state.edu/cocoa

Annex 5

Cocoa beans: production data of 1999 and 2000

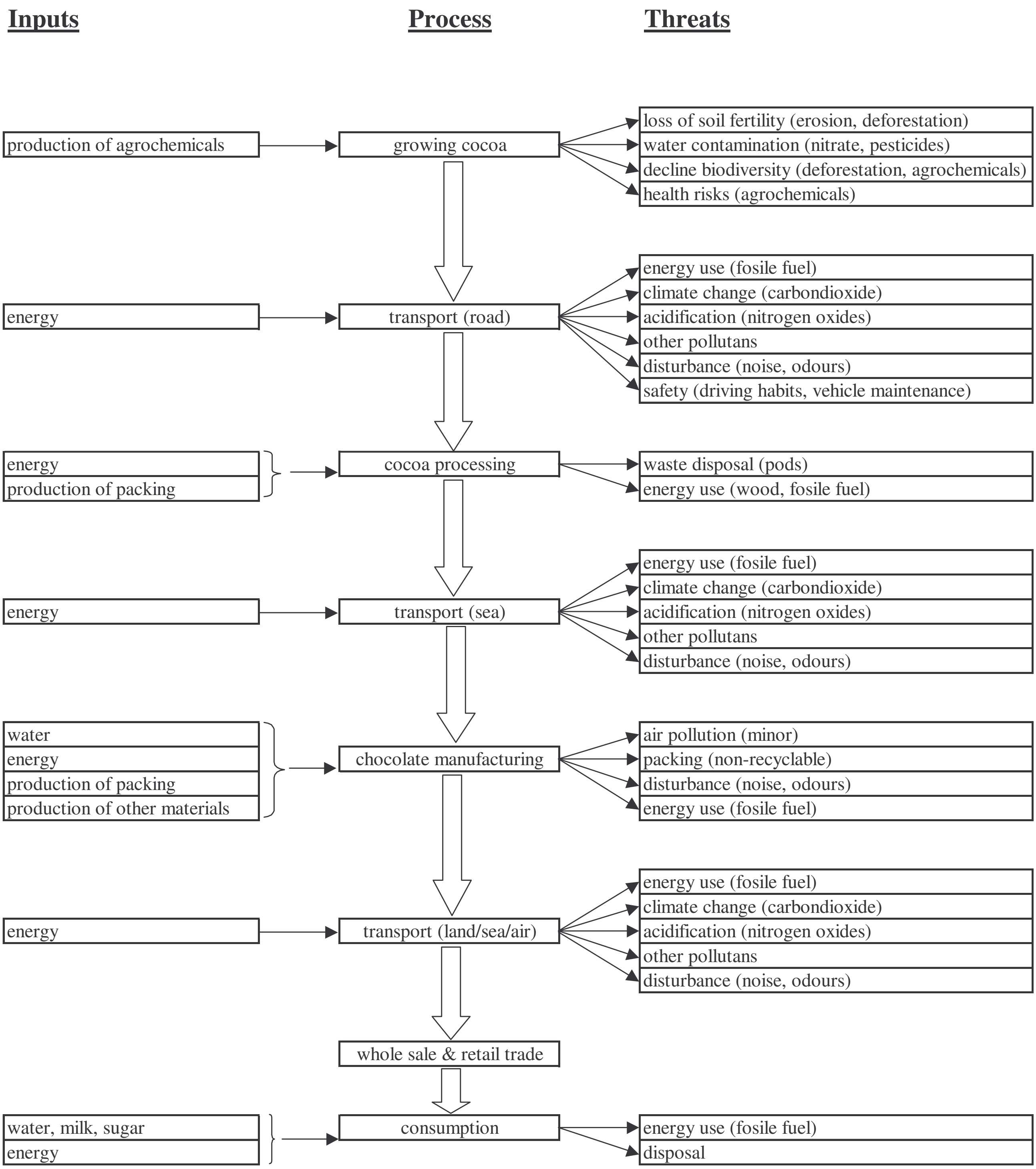
Country	**Production in 1996* (1000 ton)**	**Production in 1999 (1000 ton)**	**Production in 2000 (1000 ton)**
Ivory Coast	1254	1163	1300
Ghana	340	398	445
Nigeria	143	198	165
Cameroon	126	124	120
Zaire	75	n.a.	n.a.
Total Africa	*1976*		
Dominican Republic	63	26	47
Mexico	53	n.a.	n.a.
Total Central America	*137*		
Brazil	373	138	130
Ecuador	88	75	95
Colombia	65	n.a.	n.a.
Total South America	*571*		
Indonesia	274	390	420
Malaysia	217	75	80
Total Asia	*509*		
World	**3229**	**2802**	**3025**

* = Source: FAO, 1996
n.a. = Data not available

Source: FAO, 2001

Annex 6

Process flowchart for coffee



Source: adapted from De Beaufort, 2000