GLAMUR

Global and local food assessment:
a MUltidimensional performance-based approach

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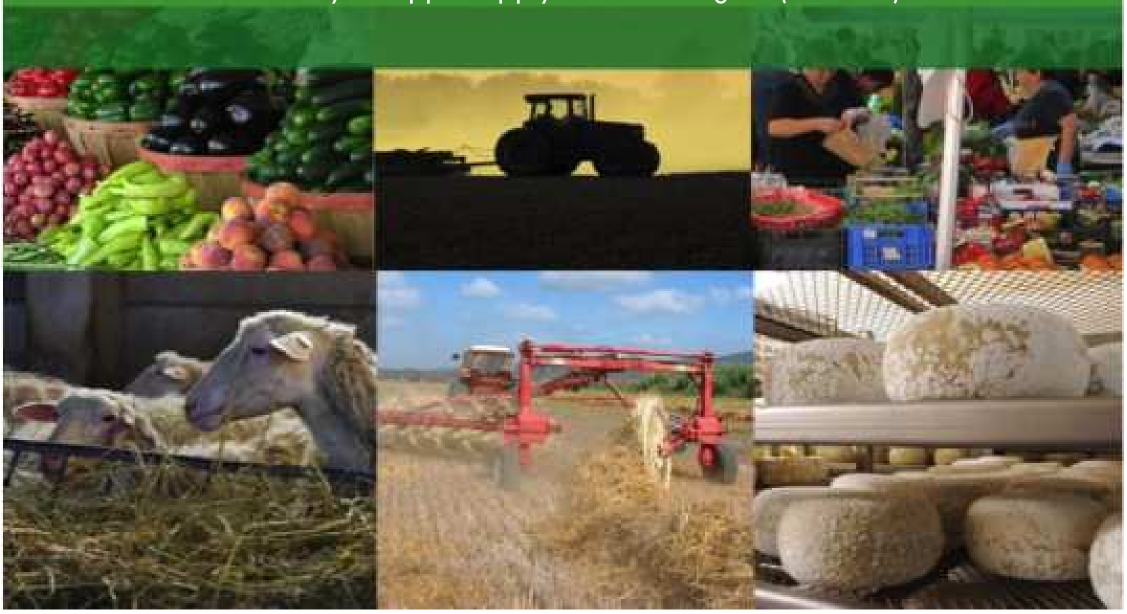
Case Study on apple supply chains in Belgium (Task 3.5)



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Summary

In this report we present a case study on apple supply chains. More specific, we present a study on two different types of apple chains, a local one and a global one, through which apples are being supplied to consumers in Flanders, a region in the north of Belgium. The study was conducted within the framework of work package 3 of the GLAMUR project. The case study on apples is part of the case study group 'fruits and vegetables', which is one of the five groups defined in GLAMUR for which products are being assessed (besides wine, pork, grains and dairy). Our direct partner within this category is the ICTA research team of the UAB in Spain. Hence, the same research on the performance on local and global apple supply chains will be carried out from a Spanish perspective.

The general objective of this study is to evaluate and to compare the multi-dimensional performance of the local and global apple supply chain. In particular, we are interested in how both chains are contributing to economic development, on their use of resources and their impact on the environment, on the fairness of distribution of costs and benefits between actors in the chains and on labour conditions. The study uses both quantitative and qualitative methods.

The global chain represents the most common practice. The apples are first cultivated in commercial apple farms in Flanders based on integrated fruit production methods. Afterwards they are transported to a cooperative auction where they are sorted, stored, packed and sold. A big retailer buys the apples and transports them to its supermarkets in Flanders. In the local chain, on the other hand, the apples are being cultivated on a small scale organic farm and sold directly to a group of consumers through seasonal fruit and vegetable baskets.

In a first step we identify main issues related to these local-global cases based on insights from work package 2, a review of additional scientific and public documents and interviews with actors in the chains. Critical issues are 'the viability of the farm', 'pesticide hazard' and 'productivity'. Based on these three critical issues and we defined 5 research questions:

R1: What is the contribution of both chains to economic development in the region?
R2: How fair are costs and benefits distributed among actors in the chain?
R3: What is the difference in resource use between both chains?
R1: What is the difference in environmental pollution between both chains?
R5: Are there differences in labour conditions between the two chains?

Attributes and indicators were defined in order to evaluate the performance of the selected chains and in order to answer the above presented research questions.

Our results suggest that the local chain contributes more to economic development in terms of added value created along the chain and the creation of jobs. Farmers in the local chain also receive a larger share (90 percent) of the price paid by the consumer

compared to farmers in the global chain. The global chain was on the other hand more land and labour productive and more efficient in terms of energy use. The global chain has also a lower environmental impact when these impacts are expressed per kilogram. In other words it is more efficient in terms of environmental pollution. But at the same time the global chain is more intensive, which means that it has a greater impact than the local chain when expressed per land unit. In other words, the global chains has a greater environmental impact on a certain area than the local chain. We compared our findings with previous studies on New Zealand apples imported to Europe. The main conclusion from this comparison is that the NZ chain emits most greenhouse gasses and depletes most fossil fuels because of the long distance that the apples have to travel (more than 20 000 km by boat).

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1. Introduction

1.1 General introduction

An increasing number of European consumers is willing to apply sustainable food consumption principles. Scientific research is needed in order to better inform these consumers and other decision-makers on the performance and quality of existing food supply chains. Scientists and other actors have recently claimed that local food chains can be a solution to negative effects of the global food system (e.g. Pollan, 2006). However, other actors argue that 'local' does not necessary mean better (e.g. Desrochers, 2012). In GLAMUR we investigate and compare 'local' and 'global' food chains and we evaluate the performance of food chains related to the health, social, economic, environmental and ethical dimension. Insights from this research project will be used to inform European policy makers and other decision-makers.

In this report we discuss the performance of apple supply chains. We focus on apples that are being supplied to consumers in Flanders, a region in the north of Belgium. The study was conducted within the framework of work package 3 of GLAMUR. In the previous work package we have already explored different attributes that can be linked to the performance of food supply chains (Annaert et al., 2014; Kirwan et al. 2014). Indicators will now be linked to these attributes in order to evaluate and to compare the chains under study.

The case study on apples is part of the case study group 'fruits and vegetables', which is one of the five groups defined in GLAMUR for which products are being assessed (besides wine, pork, grains and dairy). Our direct partner within this category is Spain. Hence, the same research on the performance on local and global apple supply chains will be carried out from a Spanish perspective. This will enable a comparison between the two countries which will be made in a report of work package 4. Other case studies from the fruits and vegetable sector are carried out on blueberries (assessed in Latvia), raspberries (assessed in Serbia) and asparagus chains (assessed by our own team in Belgium and Peru).

The general objective of the present study is to evaluate and to compare the performance of apple supply chains from a Flemish perspective. In particular, we are interested in how chains are contributing to economic development, on their use of resources and their impact on the environment, on the fairness of distribution of costs and benefits between chain actors and on labour conditions. The study uses both quantitative and qualitative methods.

In the next paragraph we first give a brief presentation of the fruit and apple sector in Flanders. Afterwards we present the local and global chain under study and the main differences between both chains in more detail. The subsequent chapters discuss the main issues that are relevant when comparing the performance of our local and global chain and the attributes and indicators that are linked to these critical issues. The fourth chapter describes how the data was gathered and how indicators were calculated. Afterwards the results are presented and discussed. In the sixth chapter we will compare our findings with previous studies on imported apples from New Zealand. The last chapter will present the main conclusions of this study.

1.2 General presentation of the sectorial national context

The fruit production sector in Flanders covers approximately 16000 hectares. This is one percent of the total area of Flanders and 2.5 percent of the total agricultural area (ADSEI, 2011). The extent of this area has remained constant since the end of the nineties. The biggest share is allocated to open air apple and pear production.

Most apple cultivators are located in the south-east of Flanders, a region called 'Haspengauw'. They generated in 2010 a total added value of 110 million Euros (ADSEI,2011). This was 30 % of the total fruit sector and 7 % of the total agricultural sector in Flanders.

The farmers are mainly cultivating apples, sometimes in combination with pears. They cultivate different apple cultivars. The 'Jonagold' cultivar is the most common one. Plantations with Jonagold apples and Jonagold mutants are covering more than 60 % of the total area on which apples are being produced (ADSEI, 2011). Other important cultivars are 'Golden delicious', 'boskoop', and 'Elstar'. Most companies have only one fixed worker, possibly supported by one or more family members. There is however a lot of seasonal work on the farms, especially during the harvest period in September and October.

The largest amount of apples is, as in the case of most horticultural products in Flanders, sold through a cooperative auction. Several auctions exist in Flanders. The biggest one in the fruit sector is the 'Belgium fruit auction'. Other important auctions are 'de Limburgse tuinbouwveiling', 'Belorta', and 'veiling Haspengauw'. There used to be more auctions but many of them have merged into bigger ones during the last decades. The main objective of these auctions is to lower the operational costs of farmers by sharing the costs for sorting, cooling, storing and selling. All auctions are organized into an association (VBT). This had led to increased transparency in price formation.

The best quality apples are sold at the national market. Big retail groups are buying them at the auctions and sell them in their supermarkets. The three biggest retailers in the Belgian national market are Colruyt, Delhaize and Carrefour. They represent more than 70 % of the market share. Delhaize and Colruyt are Belgian companies, Carrefour is a French multinational.

A large share of apples is also exported. The country that is importing the biggest quantity of apples is the Netherlands (64 million kg in 2010). Germany (46.1 million kg) and Russia (46.7 million) are also in the top three of importing countries. The recent ban on agricultural products by Russia had a huge impact on the sector. A big part of the apples were not harvested this year because the harvesting costs were too high compared to the revenues. However, the farmers have been granted compensation from the European Union for the lost revenues due to the Russia ban.

2. Context of the case study

2.1 Selection of a local and global chain: selection criteria and differences between both chains

In the next parts of this report we discuss the performance of two specific chains. We have defined one chain as being 'local' and the other one as being 'global', especially based on their production method and their distribution method. The global chain represents the most common practice in Flanders, that is, the apples are produced based on integrated fruit production methods and sold through the auction and supermarkets across Flanders. So, although we defined the chain as being 'global', we only consider stages of the chain in Flanders four our performance assessment. A part of these apples are however also exported to other countries. Second, in the local chain the apples are being produced organically and sold directly to a group of consumers through seasonal fruit and vegetable baskets. This is summarized in table 1.

Table 1. Conceptualization of the local and global chain

	Distribution	
Production	Long (auction + supermarket)	Short (direct selling)
Integrated apple production	Global chain	
Organic apple production		Local chain

Both chains are supplying fresh Jonagold apples. As mentioned in the paragraph above it is the most produced cultivar in Flanders. Hence, the local and global apples look very similar, nevertheless there are differences in how these apples were produced and how they reach the consumer. The local chain is more embedded in a certain territory and ecosystem whereas the apples in the global chain are more commodified. We are interested in the influence of this difference on the performance of both chains.
Before giving a more detailed description of the local and global chain, we will first discuss them in relation to four global/local dimensions that have been identified in the GLAMUR project. These four dimensions are: physical/geographical distance; governance and organization issues; the kind of resource, knowledge and technologies employed in the production process; the role of territory in defining the identity of the product.

Physical / geographical distance

The distance between producers and consumers in the global chain is larger than the one in the local chain. The main stages (farm, auction, retail) of the global chain are located across the region of Flanders while the stages of the local chain (farm, distribution) are located much closer to each other, often at less than 20 km.

Governance and organization issues

The global and the local chain are organized in different ways. There is a more personal and direct relation between the producer and the consumer in the local chain. This relation is based on trust and solidarity. Producers in global chains do not have this bond with the consumers, communication between them occurs via labels and information on the product. Another important difference is that producers in the global chain are working together through cooperative auctions to lower the working costs and to stay competitive on the national and international markets. This is not the case for the producer in the local chain.

The kind of resources, knowledge and technologies employed in the production process

The methods of production in the two chains are different. The most common practice for producers in the global chain is to cultivate the Jonagold apple with integrated fruit production techniques. Integrated production is defined as "an economically responsible production of quality fruit, where preference is given to cultivation methods that are more environmentally friendly, with a minimal use of chemical substances, and where the undesirable side effects are limited in order to protect the environment and human health" (Flemish Government, 2004).

The most common practice in the local case is organic production. Therefore, they are not using herbicides and they are limiting the use of inorganic fertilizers. In that sense it goes a step further than the global farmers in protecting the ecosystem and maintaining the local environmental quality.

The role of territory in defining the identity of the product.

Throughout history horticulture has always been an important part of the territory of Flanders because of the good quality of the soils in the regions where the apples are grown. Apples are therefore perceived by many as a regional product. This is emphasized in the global chain by the ‘Flandria’ label. The best quality apples are sold under this label in national and international markets.

2.2 Description of the global chain

There are around 400 apple cultivators at the basis of the global chain that we have been evaluating. They all supply apples to the Belgian fruit auction, the biggest fruit auction in Flanders with a market share of more than 50 percent. The large majority of farmers is using integrated fruit production techniques to grow the apples. They harvest the apples in the months September and October. Most farmers harvest three times. Apples with a good red color are harvested during the first harvest, the other apples stay a little longer on the trees and are harvested during the second or third time. Apples that are damaged are not harvested. They will fall from the tree and they will nourish the soil. Seasonal labour is needed to harvest the apples. Most of these seasonal workers are coming from Romania, Poland and Bulgaria. Apple farmers need to register every seasonal worker. The government is conducting at least once a year controls to see if the farmer is respecting the labour conditions.

The farmers are also cultivating according to environmental and food safety standards which are imposed by retailers, the government and the fruit auction. Two independent control organisms perform controls at the farm: 'TUV Nord Integra' and 'SGS'. The apples are also controlled when they arrive at the Belgian fruit auction.

Most farmers stay up to date with the latest production techniques through the research centre 'Proefcentrum fruitteelt'. This research centre delivers advanced knowledge on integrated fruit production techniques.

After harvest, the apples are transported by the farmers to the Belgian fruit auction, mostly using tractors with an open load. The apples are thus not cooled during transport. The load capacity is between 9 and 14 tonnes. When the apples arrive at the fruit auction, they are first pre cooled in transit refrigerators until they reach a temperature of 4°C. Afterwards they go in ULO (ultra low oxygen) cool cells with a temperature of 1°C. The apples stay in the cells until they are sold.

The Belgian Fruit auction started in 1952 with 34 members and after several mergers with other cooperative auctions it became an important international player with more than 1500 members. Today it has 4 separate sites located in Flanders, in order to be close to all the farms that supply fruit products to them. The four sites are:

- The main office in the city of Sint-Truiden where delivery, sales, packing and administration take place
- A second site in the village Glabbeek with delivery, packing and cooling
- A hypermodern cooling centre in the village Zoutleeuw
- Another cooling installation In the village Hannuit

When a cooling cell is opened, often the total content of it is sold. But before selling, the apples are first sorted. This occurs with an intelligent quality sorting system (IQS) and modern machines. The machines sort 15 tonnes of apples per hour based on size, weight and colour. Every apple is photographed 72 times during the sorting. In that way it is even possible to trace back the origin of every apple. Water is being reused during sorting.

After sorting, the quality of the apples is controlled and approved by people from the auction. Then they are packed and presented to buyers at the auction. Buyers can come two times a week to the auction where they gather in the sales room. In this room the price of the apples is shown on a big clock. The price decreases until one of the buyers pushes a button meaning that he buys the apples for that price. When the price

decreases too much, the apples are removed and later they will be sold again. If the apples are still not sold the second time, one can choose to sell them to the processing industry. In that case the farmer will receive a smaller amount of money for his produce. Lower quality apples go the processing industry. On average 25 percent of the apples at the Belgian fruit auction go there. If the quality of the apples is too bad for the processing industry there are two options: or they are spread again on the fields, or they go to a biogas installation.
In our global case study the apples are bought at the auction by Colruyt, one of the three big retailers in Belgium next to Delhaize and Carrefour. Then they are transported to the national distribution centre of Colruyt in Halle. The apples are not cooled during this transport and it takes on average one hour to transport them from the auction to Halle, a distance of 100 km. The apples are stored maximum 2 days in the national distribution centre of Colruyt in a refrigerated space. From there they are transported to the supermarket stores in Flanders. The different stages of the chain are presented briefly in figure 2.

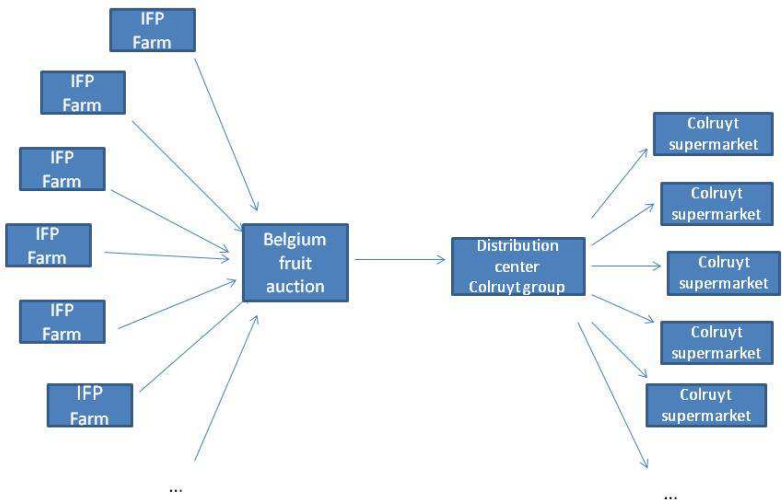

Figure 2: Main stages of the global chain

The most important stakeholders are presented in figure 3 : the farmers, the Belgian fruit auction (BFV), the retail group Colruyt, consumers, the control organisms SGS, TUV Nord Integra and FAVV (the Federal Food Safety Agency) and the research centre PC fruit (Proefcentrum fruitteelt). The blue arrows indicate a trade relation, for instance between BFV, Colruyt and consumers. The light blue arrow between farmers and BFV indicates that farmers are members of the auction. The green arrows indicate a control relation, and the orange arrows a collaboration relation. TUV Nord Integra and SGS are two independent control organisms that collaborate with BFV to carry out controls at the farm stage. The research centre PC fruit collaborates with the farmers and BFV to deliver advanced knowledge on fruit production techniques. FAVV carries out food safety controls at different stages of the chain.

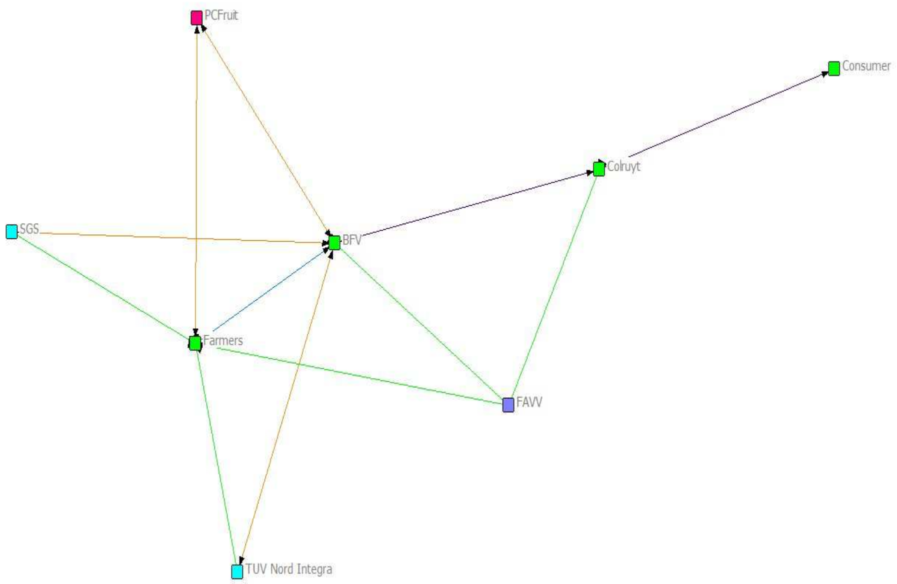

Figure 3: Main stakeholders in the global chain

2.3 Description of the local chain

There exists a very small community of 15 organic apple farmers in Flanders (Van Eykeren, personal communication, 2013). They gather several times a year to exchange knowledge and most of them sell apples through the auction and through direct selling to consumers. We are interested in the latter marketing channel and in the differences between this local type of chain and the global chain that we have described above.

The apples in the local chain are also harvested in the months of September and October. Just as in the global chain, there are seasonal workers working on the farms.

The apples are sold directly to consumers who are organized in so called 'food teams'. These teams exist of on average 20 households that work together to buy fresh food products directly from local producers. The team of consumers can order its products through the web shop of the association 'Food teams'. This umbrella association gathers all the food teams across Flanders and supports the creation of new teams. The association started in 1996 And since that year the number of members has been increasing. Today 167 food teams exist in Flanders.

Before reaching the food team the apples are first transported to a central farm where they are put in baskets together with other fruits and vegetables from other local

producers. The baskets are transported afterwards to a depot owned by the specific food team. This can be for example the garage of one of the food team members. Members of the food team collect their food basket including the apples every week at the local storage room. The households go to the storage room and collect the baskets themselves. We assume that apples are transported with a small van, with a load capacity of on average 300 kg.
The main stages of the local chain are presented in figure 4.

Figure 4: Main stages of the local chain

2.4 Critical issues

Different important issues related to the local-global debate came out of the discourse analysis conducted for work package 2. This however was an analysis focusing on the total food system in Flanders. Thus, we analysed additional scientific and public documents focusing on the apple sector and performed interviews with actors in the chains. The resulting main issues are the viability of the agricultural farm, pesticide hazard and productivity which are further explained in the next paragraphs.

2.4.1 Viability of the agricultural farm

The number of apple producers in the global chain has been decreasing in recent years. As in most agricultural sectors farmers are encountering difficulties to stay profitable and competitive on the national and international markets. Farmers demand a correct and viable price for their products. In other words, they demand that costs and benefits are fairly distributed among actors at the different stages of the chain (farm, auction, retail, consumption). Flemish farmers in global chains have the perception that this is not always the case (Annaert et al., 2014).
The price farmers receive when selling directly to local consumers is less influenced by events on the international markets. Hence, farmers have freedom to set a fair price. Because of this reason the local farm is sometimes being perceived to be more viable (Annaert et al., 2014). However, it takes time to build a local network so viability can be a problem at the beginning when farmers switch to direct selling. Moreover, some operational costs are not shared in the case of direct selling as opposed to the global chain (where farmers are organized in cooperative auctions), so they are less cost efficient. Hence, local chains are being perceived by some actors in global chains as adopting less efficient methods and measures and hence being less profitable (Annaert et al., 2014).
The viability issue was also discussed in the Flemish report of work package 2 in relation to the attribute that we have defined as 'fair distribution of costs and benefits'. In the

comparative European report of work package 2 the issue is being discussed within the attributes 'profitability/competitiveness' and 'fair trade'.

2.4.2 Pesticide hazard

Pesticide use is an important issue in the Flemish fruit production sector and also relevant for the comparison of our chains because both chains use different cultivation techniques and hence their use of pesticides is also different. Pesticide use can be toxic for the environment, the workers on the field and the insects and animals in and around the field. Fruit producers in Flanders perceive this issue as the main environmental threat (De Meyer, 2012). According to the farmers in the study of De Meyer et al. (2012) the limitation of the quantity of pesticides and the reduction of drift to surroundings are important steps to take in the future. Pesticide use is also related to food safety, an important issue for the Federal government since the dioxin crisis in the nineties hence, there are severe controls performed by the federal agency for food safety. They control the use of pesticides and residues on the final products. Every pesticide has an allowable dose and since the European REACH (registration, evaluation, authorisation and restriction of chemicals) reglementation there is a more severe control on the products that are entering the market. A critique from NGO's is that the effects of combining different pesticides and the long term effects on human health are unknown. Organic farms have a stricter list of fungicides and insecticides that they can use compared to integrated apple production. Organic farms also do not use herbicides.

2.4.3 Productivity

Agricultural production methods are often very intensive in Flanders because of the limited area of farmland. As well in the horticultural and fruit production sector. Hence, productivity has been identified as an important food chain performance issue by Flemish actors from public, policy, scientific and market spheres in the discourse analysis of work package 2 (Annaert et al., 2014). This especially because of economic reasons and concerns about food security.

3 Research design

3.1 Research questions

There are three overall research questions in the project GLAMUR:

1. What are the key food chain performance issues with regards to a global-local comparison?

2. What is the methodological strength and weakness of overall applied pairwise comparative analysis?
3. What are the specific interactions of the food chains under study and the policy settings?

In addition, we have defined several specific research questions for the apple case study based on the insights of work package 2 and previous exploratory research. Some of these questions are related to the critical issues presented in the previous paragraph. Others are related to the more general debate on local and global chains. The five specific research questions are presented below.

R1: What is the contribution of both chains to economic development in the region?

R2: How fair are costs and benefits distributed among actors in the chain?

R3: What is the difference in resource use between both chains?

R1: What is the difference in environmental pollution between both chains?

R5: Are there differences in labour conditions between the two chains?

3.2 Selected attributes and indicators

The comparative report of work package 2 presents a list of 24 attributes that are related the performance of food chains in Europe (Kirwan et al., 2014). From this list we have selected some attributes that are relevant for the present case study. The selection was made based on insights from the national discourse analysis, interviews with stakeholders and existing studies. An important study on which we have based our selection is a recent study on the sustainability of Flemish fruit farms performed by De Meyer et al. (2012). This study has used participatory approaches to identify main criteria for the evaluation of the sustainability of fruit farms in Flanders. To identify the most important criteria in the environmental dimension we have reviewed existing LCA studies on apples (e.g. Blanke et al., 2005; Mila I canals et al., 2005; Edwards-Jones et al., 2008, Alaphilippe et al., 2013). Findings from these studies were discussed with the interviewed stakeholders.
The selected attributes are presented below. These relate to our research questions and each attribute is represented by a set of indicators that are shortly mentioned below and will be discussed in detail in section 3.3.

Contribution to economic development

This attribute has been defined in work package 2 as "the contribution that food supply chains can make to economic development at a national, regional and local level" (Kirwan et al., 2014). It is clearly linked to the economic dimension of food chain performance. In our assessment we will concentrate on the added value of the food chains and the jobs that they create in the region.

Labour relations

This attribute covers "worker-related social issues" (Kirwan et al., 2014). In the case of apple chains it will especially be discussed in relation to seasonal work. We will investigate the difference in seasonal work conditions between the local and the global chain. It is related to the social and ethical dimension.

Resource use

This attribute was defined in WP2 as "the use and management of the resources used to make food" (Kirwan et al., 2014). We will focus on energy, labour and land resources and investigate to what extend there are differences in resource use between the local and global chain. These resources are necessary factors to sustain the food chains. Hence, they also demonstrate in a certain way the resilience of the food chains. The attribute is related both to the environmental and the economic dimension.

Pollution

Pollution encompasses any input into the natural environment which causes adverse changes to ecosystems. This attribute covers the different forms of pollution which may be caused by food supply chains - for instance, water, soil and/or air pollution through green-house gas emissions and/or the use of chemicals in fertilization processes, which may cause disruption to ecosystems (Kirwan et al., 2014). The attribute is clearly linked to the environmental dimension and to a lesser extent also to the health dimension. It is closely related to the attribute 'biodiversity'.

Fair trade

Under this attribute we understand a fair distribution of costs and benefits between actors in the food chain. Especially farmers are often complaining about high costs and low benefits compared to other actors in the chain. We will investigate if and how this is different for the global and the local chain. This attribute belongs to the social dimension.

3.3 Selected Indicators

Based on the attributes and the related research questions we have defined a set of indicators that will ultimately be used to assess and compare the performance of the apple supply chains. The indicators are presented in table 2.
Most indicators are adapted from existing impact assessment methods. We have especially used indicators from three sources: the Musiasem approach (Giampietro, 2009; Life cycle analysis (ISO..) and the SAFA guidelines (FAO, 2013a and FAO, 2013b).
The selected indicators are presented below in table 2. The table includes the name and description of each indicators, the unit and the source of the indicator. The indicators are sorted according to the attribute they belong to. A description of how indicators were calculated is given in the paragraph following the table.

Table 2: Description of the selected performance indicators

Attribute	Indicator name	Indicator description	Unit	Source
Contribution to economic development	Total added value	The difference between the sum of all revenues in the chain and the sum of the non factor costs in the chain, expressed per ton of apples	€/t	GLAMUR
	Work created	Work hours created in the whole chain per ton of apples	h/t	Musiasem
Fair trade	Distribution of revenues	Price received by the producer compared to the price paid by the consumer	%	GLAMUR
Resource use	Fossil energy efficiency	Use of direct and indirect fossil energy in the total chain per tonne of apples. Direct fossil energy use includes fuel use for transport and machinery; indirect fossil energy includes fossil energy use for the production of fertilizers, pesticides and electricity	MJ/kg	LCA
	Fossil energy intensity	Use of direct and indirect fossil energy at farm stage per land unit. Direct fossil energy use includes fuel use for machinery; indirect fossil energy includes fossil energy use for the production of fertilizers and pesticides.	GJ/ha	Musiasem/ LCA
	Labour productivity	Total kilograms of apples produced per labour unit at farm stage	kg/h	Musiasem
	Land productivity	Total kilograms of apples produced per land use unit at farm stage	kg/ha	Musiasem
Pollution	GHG emissions	Total emissions of greenhouse gasses in the chain. Direct emissions from field operations, cooling and transport are taken into account. Indirect emissions from fertilizer and pesticide	g CO2 eq./kg	LCA

		production are also included.		
	Pesticide hazard	Toxicity caused by the use of pesticides at the farm stage. Toxicity factors are taken from Kovach et al (1992). Impacts on the environment, farm workers and consumers are included.	EIQ/ha	LCA
	Eutrophication	Total contribution to eutrophication at farm stage stemming from emissions related to fertilizer use (losses of phosphorus and leaching and volatilization of nitrogen)	g PO43- eq./kg	LCA
	Acidification	Contributions to acidiphication at farm stage stemming from emissions of sulphur oxides and nitrogen oxide related to machinery use and ammonia emissions related to fertilizer use.	g SO2 eq./kg	LCA
Labour relations	Work contracts	Shares of workers who have a legally binding work contract and no vulnerable employment	%	SAFA (adapted)
	Working hours	Percentage of workforce whose working time arrangements are fully compliant to the standards of the International Labour Organisation (ILO)	%	SAFA (adapted)

3.4 Synoptic table

Table 3 gives an overview of the research questions that we have defined and the attributes and indicators that were chosen in order to evaluate the performance of both chains. In addition, we give a first overview of the data collection methods that were used to gather data to calculate the indicators.

Table 3: Synoptic table with research questions, selected attributes and indicators and data collection methods.

Dimension	Attribute	Brief attribute description (cf. Comparative Report)	Used indicators	Research questions	Data collection methods
Economic	Contribution to economic development	"the contribution that food supply chains can make to economic development at a national, regional and local level"	• Total added value per tonne apples • Work created	1	• Interview with local farmer • Review of company accountings • FADN data
Social	Fair trade	"the extent to which individual actors are achieving a fair return for their contribution"	• Distribution of revenues	2	• Interview with local farmer • Review of accounting studies
Economic/ Environment	Resource use	"use and management of the resources used to make food"	• Fossil energy use per ha harvest year • Fossil energy use per kg of apples	3	• Review of FADN data • Interviews with local farmers • Review of general statistics

			• Land productivity • Labour productivity		• Interview with auction representatives • Interview with retail representatives
Environment / Health	Pollution	"any input into the natural environment which causes adverse changes to ecosystems"	• Pesticide hazard • Greenhouse gas emissions • Eutrophication potential • Acidification potential	4	• Review of FADN data • Interview with auction representative • Interview with retail representative • Review of existing studies
Social	Labour relations	"worker-related social issues"	• Seasonal work contracts • Wage payments • Working hours	5	• Review of existing publications • Interview with local farmer • Interview with farmer union representative

4 Methods

4.1 Methods of data collection

We have used several methods to gather data in order to calculate the performance indicators. First, we conducted qualitative unstructured interviews with actors and stakeholders of the chain. More specific, we have interviewed farmers both from local and global chains and representatives of the Belgian fruit auction and Colruyt. We have also interviewed a representative from 'Boerenbond', the biggest farmer union in Flanders. These qualitative unstructured interviews gave a good insight in the different stages of the chain and the critical issues.

Second, we gathered specific quantitative data related to the farm stage. We received this data from the Regional department of Fisheries and Agriculture. The data belongs to the farm accountancy data network (FADN). We could gather data both for integrated fruit farmers as well as for organic fruit farmers. Of course, the number of integrated fruit farmers is larger than the number of organic apple farmers. We analyzed data on inputs used (fertilizers, pesticides, energy carriers), labour hours, revenues, land use and the produced amount of Jonagold apples. This was done for three growing seasons (2010-2012). The sample with integrated apple farms existed of 50 farms with in total 97 plots. The organic sample exists of only 3 farms with in total 5 plots.

Third, we collected additional quantitative data from key respondents and company accountings. Useful data was also found in annual reports of the Belgian fruit auction and Colruyt, in existing regional agricultural statistics and in scientific studies.

The different data collection methods and target respondents are summarized in table 4.

Table 4: Data collection methods and target respondents.

Data Collection Method	Target Respondents / Information Source
Qualitative unstructured interviews	• Farmers • Auction representative • Actors from the retail group • Actors from the farmer union
Collection of quantitative data from key respondents and company accountings	• Farmers • Retail group • Auction representative
General quantitative data from existing databases and annual reports	• Regional agricultural statistics (from the department of agriculture and fisheries) • Year reports from the retailer and auction in the chain
Collection and analysis of primary FADN data	• The Flemish department of agriculture and fisheries
Literature and document review	• Scientific studies • Reports on the state of the agrifood system in Flanders

4.2 Methods of indicator calculation

4.2.1 Contribution to economic development

Total added value

The added value expresses the essence of producing and processing, i.e. adding value to a product. It is created in the global chain at three different stages: the farm stage, the auction stage and the retail stage. We have summed the added value created at the different stages to obtain the total added value of the chain. In the local chain added value is created at only one stage: the farm stage.
We compare the total added value of the global chain with the added value of the local chain in order to understand how much value they both add to the Flemish economy. In the calculations we include revenues from sales and operational costs. Operational costs are costs for inputs and at the farm stage we include energy costs, pesticide costs, fertilizer costs, post-harvest-and sales costs and maintaining costs related to machinery.
Values for the global chain are taken from Van Broekhoven et al. (2010) in which average costs and revenues were calculated for a sample of 59 farms. The added value

created at the farm stage in the local chain is calculated based on the accountings of only one local farm which is the only farm from which we could receive accounting data. Because of limited data availability and the necessity of comparison between the two chains we only consider accounting data for the year 2008.
Added value created at the auction stage (in the global chain) is calculated by subtracting the auction's operational costs from the revenues and then multiplying this amount by the share in weight of Jonagold apples at the auction. The costs and revenues were taken from the accountings of the Belgian fruit auction for the same year (2008) as data from the farm stage.
Added value at the retail stage was estimated by multiplying the consumer price index of Jonagold apples in 2008 with the profit margin of Colruyt in 2008.

Work created

The total labour hours per tonne of apples in the two chains are calculated as a proxy for the number of jobs generated in the chain. For the global chain we include the labour hours needed for cultivating the apples during one growing season, labor hours needed to transport the apples (from farm to auction, from auction to distribution centre and from distribution centre to supermarket) and labour hours to control, to sort, to store and to pack the apples at the auction.
Calculation of total labour hours in the local chain included labour needed for cultivation during one growing season and labour needed for distributing the apples to the food team members (transport from the farm to the central farm and from the central farm to the food team store included).
Average labour hours at the farms stage were calculated based on the FADN database. This average value was calculated from the organic farmers sample (3 farms with in total 5 orchards) and integrated farmers sample (50 integrated farms with in total 97 orchards) for three growing seasons (2010-2012).
Labour hours needed during distribution were estimated based on interviews with chain actors.

4.2.2 Fair trade

Distribution of revenues

The indicator 'distribution of revenues' compares the price received by the producer to the price paid by the consumer for a certain amount of Jonagold apples.
We calculate this indicator for the global chain by dividing the average consumer price of apples for 2008 by the average price received by farmers in the same yearas calculated by Van Broekhoven et al. (2010) for a sample of 59 farmers.
For the local chain we calculate this indicator based on the farm accountings and interviews.

4.2.3 Resource use

Fossil energy efficiency

Fossil energy efficiency is expressed in Mega joules per kilogram of apples. It is used to study how much fossil energy is being consumed over the chain to produce a certain amount of apples. Both direct and indirect forms of energy use are included in the calculation. Direct energy is being consumed at the farm stage during field operations and during transport, and during stocking, cooling, sorting and transport at the other stages of the chain. We considered 100 days of cooling for both chain as this can be assumed as the average(Karel Belmans, personal communication, 2014). Indirect energy is consumed to produce and supply fertilizers and pesticides. Coefficiënts to convert quantities of inputs into amounts of embedded energy were taken from the ecoinvent database, following a life cycle analysis (LCA) approach. More information about this approach will be given in the paragraph on environmental pollution.

Fossil energy intensity

The second indicator is fossil energy intensity which refers to the fossil energy use at the farm stage per unit of land. It demonstrates how energy intense a farmer is cultivating on a certain area. Also for this indicator we included direct and indirect energy.

Land productivity

Land productivity refers only to the farm stage. It is expressed as kilogram of apples produced per hectare. We took the average value for the 291 observations in our sample of integrated farmers (50 farmers cultivating 97 orchards and observation for the growing seasons 2010-2012). In the same way we calculated the average value for the organic sample (15 observations: 3 farmers, 5 orchards, growing seasons 2010-2012).

Labour productivity

The second indicator is labour productivity. It is defined as the total amount of apples that is produced per hour of labour input and is expressed as kilogram apples per hour. We included also the distribution stage in this calculation (auction and retail for the global market and preparation and distribution of baskets in the local chain). Average values related to the farm stage were calculated based on the FADN database in the same way as described above for ‘land productivity’. Values for the other stages were estimated based on interviews.

4.2.4 Pollution

Indicators related to the attribute 'pollution' were calculated based on the life cycle analysis (LCA) method. This method is used to analyse the environmental impact that a certain product has from his cradle to his grave. The environmental impact of our apples was calculated from the moment that they are cultivated at the farm stage until they reach the supermarket shelf. The analysis was performed according to the ISO 14044 framework (ISO,2006). The four typical steps of an LCA that are described in this framework were followed: goal and scope of the study, life cycle inventory, impact assessment and interpretation of the results. Four indicators were calculated in this way: greenhouse gas emissions; Pesticide hazard; Acidification and Eutrophication.
Data related to the farm stage was obtained through the FADN database. The different pollution indicators were calculated at this stage for the 291 observations of the integrated group (97 orchards, growing seasons 2010-2012) and 15 observations of the organic group (5 orchards, growing seasons 2010-2012). Data related to the other stages of the chain were obtained through interviews.

Greenhouse gas emissions

Greenhouse gases are emitted in the chain mainly due to energy use and fertilizer use. Energy is used for machinery, for cooling and for transport. Indirect energy use for the production and supply of fertilizers and pesticides is also taken into account. Fertilizers are contributing to greenhouse gas emissions at the farm stage. A major contribution is made through nitrogen application through which N_2O is emitted, an important greenhouse gas.
For the farm stage we calculated greenhouse gas emissions based on the FADN database. This database includes energy, fertilizer and pesticide inputs used in the organic and integrated orchards. Emissions related to these inputs were calculated by using characterisation factors. These factors were taken from IPCC (2006). Factors for the calculation of indirect emissions were taken from Lal et al. (2004).
We calculated greenhouse gas emissions for each of our observations and then built average values for the organic and integrated group.
Greenhouse gas emissions related to the other stages are mainly due to energy use during cooling, sorting and transport. Data on these inputs, gathered through interviews with actors, was also converted into greenhouse gas emissions by using factors from IPCC (2006).
The Greenhouse gas emissions are expressed as CO2 equivalents per kilogram of apples.

Pesticide hazard

Pesticide hazard refers to the toxicity impact on the environment caused by pesticides. The indicator is only referring to the farm stage. Data on the type and amount of pesticides used in the integrated and organic farms were taken from the FADN database for the growing seasons 2010-2012 (see section 4.2). For every orchard we multiplied

the active ingredients of the different pesticides with toxicity factors. These factors were taken from Kovach et al. (1992). They are constructed based on the toxicity that active ingredients cause on farmworkers, consumers and the local ecosystem. The toxicity is expressed as an environmental impact quotient which can only be used for relative comparisons. The absolute values do not have a useful meaning.
Toxicity is expressed as environmental impact quotient per per kilogram of apples.

Acidification

Acidification of the environment is mainly caused through fuel use (during field operations and transport) and fertilizer use. Fuel combustion emits sulphur oxides and nitrogen oxide. Fertilizers are emitting ammonia. Emitting factors were taken from FAO (2001). Data on fuel use and, fertilizer use were obtained through the FADN database and interviews.
Acidification potential is expressed in SO_2 equivalents per kilogram of apples.

Eutrophication

Eutrophication is the ecosystem response to the addition of artificial or natural substances, mainly phosphates, through detergents, fertilizers, or sewage, to an aquatic system (Shindler, 2004). It stems mainly from emissions related to fertilizer use (e.g. losses of phosphor and leaching and volatilization of nitrogen). Characterisation factors were taken from FAO (2001), IPCC (2006) and Jensen et al. (1997).
Eutrophication potential is expressed in PO_4 equivalents per kilogram of apples.

4.2.5 Labour relations

The indicators that are related to the attribute ‘labour relations’ were adapted from SAFA (FAO, 2012).
SAFA provides a holistic framework for the sustainability assessment of food and agricultural supply chains. Within the SAFA framework, a set of 118 indicators related to four broad dimensions of sustainability (good governance, environmental integrity, economic resilience, social wellbeing) were developed. These four broad dimensions are subdivided into 4-6 universal themes per dimension and furthermore detailed into sub-themes with associated sustainability objectives. For example, in the dimension “social wellbeing”, one theme is called “decent livelihood” and the sub-theme “quality of live”. We have adapted two SAFA indicators from the dimension “social wellbeing” to study the labour relations in the two chains.

Work contracts

The indicator work contracts is defined as ‘the share of workers who have a legally binding work contract and no vulnerable employment’ (FAO, 2013).

Working hours

The indicator working hours is defined in SAFA as 'the percentage of workforce whose working time arrangements are fully compliant to the standards of the international labour organisation (ILO)'. Studying labour relations in apple farms is especially relevant in relation to seasonal work. We did interviews with farmers and one farmer union representative to understand how seasonal work on apple farms is organized and regulated in Flanders.

5. Results and discussion

In this paragraph we present the results of the performance indicator calculation. Values were calculated for the local and the global apple supply chain, respectively. The values of the two chains are compared to each other and discussed. The results of the different indicators are presented in table 5. They are further discussed in the section below this table.

The findings are summarized in table 5.

Table 5: Results of performance for the local and global chain.

	Local chain	Global chain
Contribution to economic development		
➢ Added value	743 €/ t	293 €/ t
➢ Work	29 h/t	17 h/t
Fair trade		
➢ Distribution of revenues	90 %	20 %
Resource use		
➢ Land productivity	36.7 t/ha	44.6 t/ha
➢ Labour productivity	34 kg/h	59 kg/h
➢ Fossil energy efficiency	1.69 MJ/kg	1.37 MJ/kg
➢ Fossil energy intensity	23.75 GJ/ha	30.01 GJ/ha
Pollution		
➢ GHG emissions	146.25 g CO2eq./kg	84.7 g CO2 eq./kg
➢ Pesticide hazard	34.9 EIQ/kg	26.1 EIQ/kg
➢ Acidification potential	1.09 g SO2 eq./kg	0.75 g SO2 eq./kg

➢ Eutrophication potential	0.21 g/kg	0.38 g/kg
Labour relations		
➢ Work contracts	99 %	99 %
➢ Working hours	99 %	99 %

5.1 Contribution to economic development

Added value

In the global chain we calculated added value at three different supply chain stages in the year 2008. First, the added value at the farm stage is 209 Euros per tonne of apples. The integrated farmers have an average sales revenue of 13,601 Euros per hectare and an average operational cost of 2,641 Euros per hectare (costs for energy, machinery maintenance, fertilizers and pesticides) (Van Broekhoven et al., 2010). Second, the added value created at the auction stage is 4.5 Euros per tonne. It makes sense that this added value is low because the auction redistributes a part of its profit to the farmers (these revenues are thus included at the farm stage). The main objective of the auction is to share operational costs rather than making profit. Third, at the retail stage we estimate an added value of 100 Euros per tonne of apples. This is calculated by multiplying the average price for Jonagold apples in 2008 (1408 Euro per tonne) with the profit margin of Colruyt being 7.1 %. The strategy of the retailer is to sell a large amount of products at low prices. The added value per product unit is hence low (0.1 euro per kilogram of apples). If we sum the added values of the three stages of the global apple chain we find a total added value of 314.5 Euros per tonne.
In the local chain added value is created mainly at the farm stage because the main cultivation and distribution steps occur at this stage). The added value is 743 Euro per tonne of apples. Our local farm had in 2008 a revenue of 31,930 Euros per hectare and total operational costs of 1,653 Euros per hectare.
When comparing the two chains we see that the added value of the local chain is higher than the added value of the global chain. A main reason is that higher prices are paid to the farmer in the local chain.

Work created

The total labour hours that are needed to produce one tonne of apples is calculated as a proxy for the number of jobs generated in each chain.
In the global chain on average 15 hours of labour are needed to produce one tonne of apples. Most of this labour is needed at the farm stage: 13 hours per tonne. We found

this value by taking the average total amount of hours worked per hectare in the integrated farms of our FADN sample (591 hours) and by dividing this by the average harvest of 44.6 tonnes per hectare. Based on our interviews we assume that one more hour is needed per tonne at the auction to control the apples. Transport and sorting are on the other hand very efficient and hence not many labour is needed for these processes. For example, transport from the auction to the distribution centre of the retailer happens in one hour with trucks with a load capacity of 27 tonnes of apples. Another example of labour efficiency is sorting at the auction. This happens with machines that can sort 15 tonnes of apples per hour.

In the local chain more labour is needed, on average 20 working hours per tonne of apples. The three local farms in the FADN sample need on average 674 hours of work per tonne of apples. Their average yield is 37 tonnes per hectare. Hence, to produce one tonne of apples in these local farms 18 hours of work are needed. Distribution and transport is also less efficient than in the global chains so more labour is needed. This is especially the case for the preparation of the fruit and vegetable baskets. Based on the interviews we estimate that on average 30 minutes are needed to sort one tonne of apples and to put them in baskets.

We saw earlier that around 5,300 hectares are covered with orchards in Flanders. If all this area was covered with farms of the local type, one would have a total harvest of 196,100 tonnes (37 tonnes per hectare x 5300 hectare) and 3,922,000 labor hours would be needed. If one person works 2,080 hours a year (40h x 52 weeks), work would be created for 1,886 persons. If these 5,300 hectares would be covered only with farms from the global type work would be created for only 1,705 persons.

Thus, the global chain is more labour efficient but more work could be created through the local chain.

5.2 Fair trade

Distribution of revenues

Farmers received on average 0.28 Euros per kilogram of apples that they produced in 2008 (van Broekhoven et al., 2008). The average consumer price for apples was 1.408 Euro per kilogram in that same year. Hence, around one fifth of the price paid by the consumer in the supermarket is received by the farmer.

The farmer in the local chain sells directly to consumers. He gives 10 percent of his revenues to the umbrella organisation 'food teams' in order to be part of their network. Hence, 0.90 percent of the price paid by the consumer is received by the farmer. The price paid by the consumer was 0.55 Euros per kilogram (Van Eykeren, personal communication, 2014), so the farmer received 0.5 Euros per kilogram.

5.3 Resource Use

Fossil energy intensity

Fossil energy intensity refers to the fossil energy use at the farm stage per unit of land. It demonstrates how energy intense a farmer is cultivating on a certain area. Fossil energy is mainly consumed through fuel use for tractors and machinery. Indirect fossil energy needed to produce and supply pesticides and fertilizers are also taken into account. Fossil energy intensity is larger for the global chain than for the local chain. The main reason for that is that global farmers are using larger quantities of inorganic fertilizers and hence larger amounts of indirect energy. The local farms had on average a larger direct energy consumption during field operations than the farmers in the global chain but because of lower inorganic fertilizer use the total amount of energy depletion resulted to be higher in the global chain. Our calculations resulted in a fossil fuel consumption of 30 GJ per hectare in the global while the local chain consumes 24 GJ per hectare.

Fossil energy efficiency

The global chain is more energy efficient than the local chain. The difference between the chains is especially due to higher yields in the global chain. Transport is also more efficient in the global chain than in the local chain but apples travel a longer distance. Most energy is being consumed at the farm stage. The global chain consumes on average 0.70 MJ per kilogram apples at the farm stage and 0.67 MJ per kilogram apples at the distribution stage. Cooling is responsible for 0.4 MJ fossil fuel consumption. The local farms consumes on average 1.69 MJ/kg of fossil fuels. 1.16 MJ/kg is consumed at the farm stage. In addition, 0.53 MJ per kilogram is needed to cool and transport the apples.

Land Productivity

Land productivity refers only to the farm stage of the two chains. We calculated the average value in the FADN database for the 50 integrated fruit farmers and the three organic fruit farmers. The global integrated fruit farms have an average land productivity of 44.6 tonnes per hectare. The local organic farms on the other hand have an average land productivity of 36.7 tonnes per hectare. The land productivity of the integrated fruit farms in the global chain is hence larger than that in the local chain. In other words, the global chain produces more Jonagold apples per unit of land that is used. One reason for the lower land productivity of organic farms is that these use less fertilizers.

Labour productivity

Labour is also an important resource for the production of apples. In the global chain, more apples can be produced with an input of 1 hour of labour compared to the local chain. This is in a first place because the global chain is more mechanized than the local chain. Sorting happens for example with high tech sorting machines, while the sorting and preparation of fruit baskets in the local chain is happening with manual labour. Hence, one needs less human labour in the global chain to produce and supply a certain amount of apples.

5.4 Pollution

Greenhouse gas emissions

The global chain emits 85 grams of CO_2 equivalents per kilogram of apples. The chain is more efficient in terms of greenhouse gas emissions compared to the local chain. The latter emits 146 grams of CO_2 per kilogram of apples. The main reason for this difference is that in the local chain, lower average yields are produced for a certain rate of mechanization at the farm stage and transport and cooling is less efficient. Most greenhouse gasses are emitted at the farm stage, 54 g CO_2 equivalents for the global chain and 130 g CO_2 equivalents for the local chain. These emissions stem mainly from fuel use and fertilizer use (in particular nitrogen use resulting in nitrous oxide emissions).

Pesticide hazard

Farmers from both integrated and organic production systems use pesticides so both systems have toxic effects on the environment. The organic farms had according to our calculations on average a higher toxic effect compared to the integrated farmers. However, we tested if the results of the sample of organic plots were significantly different from the integrated plot and no significant difference was found (based on the Kolmogorov-smirnov test ($p<0.1$). Therefore, there is no significant difference in PH per kg between the organic production system in the local chain and the integrated system in the global chain. This might be surprising because organic farmers are not allowed to use herbicides. They do, however, use fungicides and insecticides, which have a higher toxicity impact than herbicides. Consequently, the overall toxicity of organic production is similar to that of integrated production. Especially the use of sulphur in organic farms resulted in a high toxic effect.

Acidification

The global chain has an average value of 0.75 g SO_2 equivalents per kilogram. Acidification is mainly caused through the emissions of NOx and SOx related to the use of machinery and emissions of ammonia through the use of nitrogen for fertilization. The local chain emits 1.09 g SO_2 equivalents per kilogram. This is in particular because more direct energy was consumed during field operations at the farm stage and because of lower yields.

Eutrophication

The global chain emits on average 0.38 g PO_4 equivalents per kilogram of apples. Eutrophication is mainly caused through emissions related to the use of nitrogen and phosphor for fertilization. The eutrophication efficiency differs significantly among the two chains. The organic system has a lower average value, 0.21 g PO_4 equivalents /kg. This makes sense because the organic farmers apply a lower amount of fertilizers than farmers that use integrated production methods.

5.5 Labour relations

We do not find differences in labour conditions between the global and the local chain. Seasonal work at the farm is strictly regulated in Flanders. Farmers need to register every worker and need to respect the wages and working hours that are fixed by the government. Compliance with labour regulation is controlled at least once a year. Hence, we assume that farmers in the chains respect the law (we assume 99 % of them respecting the law). This means that workers in both chains have a legally binding work contract and no vulnerable employment and that working time arrangements are fully compliant with ILO standards.

5.6 Data quality check

In order to check the quality of the data used to calculate the indicators, the pedigree matrix approach is used (Ciroth, 2013; Lewandowska, 2004). Table 6 shows five criteria of evaluation of the data quality: reliability of source, completeness of data, temporal correlation, geographical correlation, further technological correlation. For the first criterion, two types of reliable sources are specified, but only one is to be selected depending on the qualitative or quantitative nature of the analysed data. For each criterion, there is an ideal requirement that is called “data quality goal” (DQG), and four other categories called “data quality indicators” (DQI) from 1 to 4 that represent a lower quality of data than the DQG. The DQG is associated to the score 1, and the DQI are successively associated to the scores 0.8, 0.6, 0.4 and 0.2. The higher the score, the better the data. Every single data is reviewed following the five criteria: for each criterion, a “data quality distance” (DQD) is calculated:

So, the lower the DQD, the better the data. Then for one data point, the five DQD (one for each criterion) are summed up to give a total DQD. This number is then interpreted with the pedigree matrix: the total DQD is associated to a letter representing the data quality class. Letter A is for the best data quality (total DQD between 0 and 0.2), and letter E is for the worst data quality (total DQD between 3.2 and 4).

Table 6: Data quality check

Attribute	Indicator		Data source	Reliability	Completeness	Temporal correlation	Geographical Correlation	Further technological correlation	Total DQD	Quality Class
Contribution to economic development	**Added value**	**local**	Company accountings; Company year reports; FADN; Interviews	0	0.6	0.2	0	0	**0.8**	**A**
		global		0.2	0.4	0.2	0	0	**0.8**	**A**
	Work	**local**	FADN; interview with local farmer	0	0.6	0.2	0	0	**0.8**	**A**
		global		0.2	0.4	0.2	0	0	**0.8**	**A**
Resource use	**Land productivity**	**local**	Company accountings	0	0.6	0.2	0	0	**0.8**	**A**
		global		0.2	0.4	0.2	0	0	**0.8**	**A**
	Labour productivity	**local**	Company accountings	0	0.6	0.2	0	0	**0.8**	**A**
		global		0.2	0.4	0.2	0	0	**0.8**	**A**
	Fossil energy intensity	**local**	FADN	0	0.4	0	0	0	**0.4**	**A**
		global	FADN	0	0.4	0	0	0	**0.4**	**A**
	fossil energy efficiency	**local**	FADN; Interview with local farmer	0	0.4	0	0	0	**0.4**	**A**
		global	FADN; Interview with auction representative		0.4	0	0	0	**0.4**	**A**
Pollution	**Pesticide hazard**	**local**	FADN	0	0.4	0	0	0	**0.4**	**A**
		global	FADN	0	0.4	0	0	0	**0.4**	**A**
	Greenhouse gas emissions	**local**	FADN; Interview with local farmers	0	0.4	0	0	0	**0.4**	**A**
		global	FADN; Interview with auction representative	0	0.4	0	0	0	**0.4**	**A**
	Eutrophication potential	**local**	FADN	0	0.4	0	0	0	**0.4**	**A**
		global	FADN	0	0.4	0	0	0	**0.4**	**A**
	Acidiphication potential	**local**	FADN	0	0.4	0	0	0	**0.4**	**A**
		global	FADN	0	0.4	0	0	0	**0.4**	**A**

Fair trade	Distribution of revenues	local	company accountings	0	0.6	0.2	0	0	**0.8**	**A**
		global		0.2	0.4	0.2	0	0	**0.8**	**A**
Labour relations	Seasonal work contracts	local	Interview with farmer union representative	0	0	0	0	0	**0**	**A**
		global		0	0	0	0	0	**0**	**A**
	Working hours	Local		0	0	0	0	0	**0**	**A**
		global		0	0	0	0	0	**0**	**A**

6. Comparing our findings with Apples from New Zealand

In this additional chapter we compare our findings with scientific studies on apples imported to Europe from New Zealand, a global food supply chain. The performance of New Zealand apple chains has previously been assessed mainly in relation to the environmental dimension. We have based the comparison in particular on the work carried out by Mila i Canals (2003), part of which has been published in Mila i Canals et al. (2006). In this study a comprehensive life cycle analysis (LCA) is conducted that addresses all relevant environmental impacts. Other LCA studies only address carbon and energy aspects of apple production systems in New Zealand (Blanke and Burdick, 2005; Saunders et al., 2006; McLaren et al., 2009; Frater, 2010).

6.1 Description of the New Zealand apple chain

Together with Chile and South Africa, New Zealand is a major fruit producer and exporter. Exports of fresh and processed apples account for the third largest export share in horticultural products, only preceded by exports of wine and kiwifruit (Aitken and Hewett, 2012). It is in particular exporting a large amount of apples, accounting for about 5 percent of global apple trade (MPI, 2014). Annual export volumes amounted to $NZ 341.6 million. However, from 2011 to 2012, income from apple exports decreased by $NZ 21.7 million, i.e. a decrease of 6%. Apple varieties exported include the traditional varieties of Braeburn and Royal Gala (60.2% of exports), but increasingly also new varieties such as the Pacific series, Fuji, Jazz, Envy and Pink Lady. Europe is the most important export destination with 51% of total apple exports in 2012. Most of these exports are destined to the UK and Ireland (Aitken and Hewett, 2012).
In 2012, apples in New Zealand have been cultivated on 391 orchards and covered 8,324 ha. The number of orchards has decreased tremendously from 920 in 2005, indicating a decrease by 57.5% between 2005 and 2012. Also, the area planted with apples has decreased from 12, 585 ha in 2004. Most of the orchards are located in the regions of Hawke's Bay and Nelson (60 and 30 % respectively). Like in Flanders, most apples are cultivated with integrated production practices. In 2011 94% of the orchards used

integrated production methods and 6% were certified organic (Aitken and Hewett, 2012). For example, understory management is applied which implies that the tree line is kept vegetation free with herbicides while the alley is planted with a grass/legume mix. After harvest the apples are sold to packers who package, store and export the apples. In 2011, there have been 70 export packhouses. Apples are graded in three classes according to fruit size, colour and storage characteristics: Grade 1 is designated for export, Grade 2 for domestic markets and Grade 3 for processing (Mila i Canals et al., 2006). The main exporting company is ENZA (formerly the New Zealand Apple and Pear Marketing Board) and in total, there have been 90 apple exporters in 2011 (Aitken and Hewett, 2012). Apples that are exported to Belgium are first transported by boat to the harbour of Antwerp. The export company transports the apples from there to the distribution centres of the big retail groups (the most important ones are Carrefour, Colruyt and Delhaize). From the national distribution centres of the retailer the apples are transported to the supermarkets.

6.2 Critical issues

6.2.1 Competitive pressure on small family farms

There has been an increasing tendency towards vertical integration. Vertical integration is mostly backward integration by large growers, packers and shippers: the top 8 packhouse operators account for about two thirds of the traded volume and 25 out of 70 packhouses handle 91% of the export apples. Regarding export companies, 25 out of 90 handle 90% of exports (Aitken and Hewett, 2012). The number of smaller family farms has declined mainly due to competitive pressure. Average farm size has increased steadily. At the same time, there is increasing concentration at the buyer's side. This has resulted in more or less constant income on a per hectare basis, but declining profitability at the whole farm level (MPI, 2014).

6.2.2 Food miles

A concern to decision makers is the long distance that apples have to travel before arriving at their export destination. Apples that travel to Europe, the main export destination, are transported more than 20 000 kilometers before reaching their destination. This transport contributes to greenhouse gas emissions and fossil fuel depletion. A recent study by Mc Laren et al. (2009) has demonstrated that more than 50% of greenhouse gas emissions are due to shipping.

6.3 Comparison of performance

Table 7 presents the indicators that we have compared for the Belgian and the New Zealand case studies. The indicators cover three performance attributes: Contribution to economic development, resource use and pollution. Data come mainly from the ministry of primary industries (MPI) and earlier LCA studies on New Zealand apple exports.

Table 7: main attributes, indicators and data sources to compare the performance of the NZ apple chain and the belgian apple chains

Dimension	Main attribute	Indicators	Data sources
Economic	Contribution to economic development	• Added value	Ministry of Primary Industries (MPI), 2012, Horticulture Monitoring
Economic/ environmenta l	Resource use	• Energy intensity • Energy efficiency • Land productivity	Mila i Canals (2003); Saunders et al. (2009), Frater (2010) Blanke and Burdick (2005) Ministry of Primary Industries (MPI), 2012, Horticulture Monitoring
Environmenta l/health	Pollution	• Greenhouse gas emissions • Acidification	Blanke and Burdick (2005) Mila i Canals (2003)

6.3.1. Contribution to economic development

Added value

The Braeburn apple production sector generated an added value of 143 $/t in 2008 (MPI, 2012). If we multiply this with the average $NZ - EUR conversion rate in 2008 (0.7134) we obtain an added value of 102 EUR/t at the farm stage. This value is much lower than the values we have calculated at the farm stage in the Flemish chains (209 EUR/t for the global chain and 743 EUR/t for the local chain). The Braeburn apple adds hence less value per ton to the New Zealand economy compared to what the Jonagold apple adds to the Flemish economy.

6.3.2 Resource use

Land productivity

The average yield of Braeburn apples in the Hawke's Bay region in New Zealand is 55.1 t/ha. This is more than 10 t more than the average yields in Flanders. The global chain in Flanders had an average yield of 44.6 t/ha and the local chain 36.7 t/ha. The New

Zealand chain is hence the most productive one per ha. This performance is relevant not only in relation to resource use (land use) but also in relation to food security.

Fossil energy intensity

Mila i Canals et al. (2006) assessed the fossil energy intensity at the farm stage in two regions of the New Zealand Braeburn apple chain. The farmers in the region Central Otago consumed 20 GJ/ha of apple production. Farmers in the Hawke's Bay region consumed on average 30 GJ/ha. Our own calculations in Belgium result in 30 GJ/ha for the global chain and 24 GJ/ha for the local chain. We should be carefull with comparing these results because the study of Mila i Canals et al. includes also energy use for machinery and fuel production. This was not included in our calculations which would otherwise be higher. Therefore we conclude that farms in Flanders are slightly more fossil fuel intensive compared to New Zealand farms.

Fossil energy efficiency

Regarding fossil energy use along the whole supply chain we find that the New Zealand chain consumes most fossil energy because of the long distance the apples have to travel. This adds to the energy used at the production stage. According to Blanke and Burdick (2005) 2.5 MJ/kg apples is consumed to ship apples from Nelson in New Zealand to the harbour in Antwerp. This amount alone is already more than the total energy consumption of the Flemish chains (1.4 MJ/kg for the global Flemish chain and 1.7 MJ/kg for the local chain). Based on the study of Blanke and Burdick we assume an energy consumption of 4.5 MJ/kg for the total New Zealand apple chain from cultivation until the national distribution centre of retail groups in Belgium. This amount inludes 28 days of cooling during shipping. In the calculations of the Flemish chains we included 100 days of cooling. New Zealand apples exported to Belgium are hence consuming around 4 times more fossil energy than the Flemish chains.

6.3.3 Pollution

Greenhouse gas (GHG) emissions

GHG emissions of the New Zealand export apple chain have been calculated in previous LCA studies (e.g. Defra et al., 2008; Stadig et al., 1997; Blonke et al., 2011). These studies find that on average the apple export chain is emitting 450 g CO2 eq./kg. This is more than 3 times higher than what we have calculated for the Flemish local chain, 146g CO2 eq./kg. The Flemish global chain emits even less GHG being 85 g CO2 eq./kg. Most GHG are emitted during transportation of the apples.

Acidification potential

The acidification potential at the farm stage of the New Zealand export apple chain is estimated to being 0.8 g SO2 eq./kg (Mila i Canals, 2006). This is similar to what we find for the global chain in Flanders (0.75 g SO2 eq./kg). The farmers in the local Flemish chain are less efficient with an acidiphication potential of AP of 1.09 SO2 eq/kg.

7. General discussion (WP4)

8. Conclusion

We can draw several conclusions from this case study. A first conclusion is that our local chain is contributing more to economic development. As shown in our study the local apple chains can add more value to the economy and they can create more jobs. The latter is in particular because more human labour was needed to produce and distribute a certain amount of apples. The main reason for the difference in added value on the other hand is that local farmers receive higher prices for their products while actors in the global chain tend to produce or distribute large quantities with low profit margins per product and therefore their added value per product is also low. Farmers in the local chain were also receiving a larger share (90 percent) of the price payed by the consumer, compared to farmers in the global chain.

The global chain was on the other more land and labour productive. Apple farms in New Zealand seem to be even more land productive than the Flemish farms. The local farms had on average the lowest yields. Therefore they were also less efficient in terms of energy use or environmental impact per product. However, when expressing energy use or environmental impacts per hectare they are often performing better than the global chains because they are less land intensive. In other words, the global chain has a greater environmental impact on a certain area than the local chain. Decision makers should hence not only focus on efficiency but they should also keep the intensity of the systems in mind.

From the comparisons with studies on New Zealand apple supply chain we can conclude that the NZ chain emits most greenhouse gasses and depletes most fossil fuels because of the long distance that the apples have to travel (more than 20 000 km by boat).

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