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

Case Study: multidimensional comparison of Local, Mixed and Global fresh organic tomato supply chains in Spain

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Case Study: multidimensional comparison of Local, Mixed, and Global fresh organic tomato supply chains (Task 3.5)

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Summary

In the present report, the comparison between a Local, Mixed and Global organic tomato supply chains is presented. The Local supply chain can be described as small size farmers producing a diversity of vegetables that are sold directly to individuals or consumers' groups. The Mixed supply chain is characterized by a medium size farmer, producing 5-6 crops that are sold through an organic wholesale cooperative, of which the farmer is a partner. The wholesale cooperative sales vegetables and some processed products to retailers, supermarkets, and schools canteens among others. In the Global supply chain, tomatoes are grown in greenhouses in the south of Spain. Tomatoes are then transported to the aforementioned organic wholesale cooperative in Barcelona, and finally sold in retail shops to the final consumers.

The comparison is done according to a set of socio-economic and biophysical indicators. The indicators are the technical translation of some of the attributes defined previously in WP2 of the project. The selection of the attributes is based on the relevance to the research questions and the available information to value the indicators.

In the first place, the farms involved in the three supply chains are compared. According to the results, one can say that the Global farmer deals with a higher amount of money than the Local and Mixed farms. However, the Local and Mixed farmers almost double the net income of the Global farm, either per unit of labour or land. Similar results are obtained when analysing the the creation of added value; the Local and Mixed farms produce about 30% more value added, either per unit of labour and land use, than the Global supply chain.

In terms of job creation, the three production systems create similar amount of jobs per square meter of cultivated land. The differences between the farms come from the requirements of labour in the different stages of the production cycle. However, there are further considerations related with the quality of jobs that must be taken into account when assessing jobs creation in the three types of farms.

In terms of productivities, the Global FSC is able to produce a larger amount of tomatoes per square meter of cultivated land and per unit of labour, which is expected given the higher control over the atmosphere in which tomatoes are grown. However, larger productivities are at the expenses of higher consumption in biophysical terms, e.g. consumption of energy carriers.

In a second step, the whole supply chains are compared. According to the results, the Global chain handles larger amounts of tomatoes per square meter and by hour of human activity dedicated to produce and distribute tomatoes. As in the previous comparison, the monetary flows in the Global chain are larger than in the other two chains. But net income per unit of land and per unit of labour is higher for farmers involved in Local supply chains. As well, the contribution to economic development, in terms of creation of *addedvalue,* is higher in Local supply chains. In terms of jobs creation, the Mixed and Global chains present better results basically due to the contribution of activities performed in reduced spaces compared to agricultural land used for production (i.e. wholesaling and retailing). It is important to notice

that when talking about the contribution to keep rural population and dealing with ageing issues, what matters is the creation of jobs in rural areas.

In biophysical terms, the Mixed and Global supply chains present higher consumption of energy carriers in the post-harvest activities: e.g. wholesaling and retailing. This is reflected by the indicator 'consumption of energy carriers per unit of land use'. On the other side, the Local chain is characterized by the use of small trucks to distribute vegetables to final consumers, which increases the consumption of diesel per hour of human activity allocated to this purpose.

As the reader will see, there is no definitive answer regarding the sustainability of food supply chains. Trade-offs between socio-economic and biophysical issues are always present.

1. Introduction

1.1. General Introduction

This case study report describes the results on the performance of three fresh organic tomato supply chains in Spain. In the first case, we analyse a Local tomato supply chain, in which tomatoes are produced by small agro-ecological farmers in the surroundings of Barcelona and sold directly to consumer groups located in Barcelona city. In the second, aMixed tomato supply chain is analysed. This chain considers a medium size farmer producing few crops and selling its production to a wholesale cooperative[1] to which the farmer belongs to. Finally, the third case study is a Global supply chain, in which tomatoes are produced in the south of Spain, distributed through the main organic wholesaler in Barcelona, and sold to supermarkets, school canteens, restaurants, export, producers, and small wholesalers. In our analysis we consider production, transport, and distribution and retail stages, from the production to the point of sale to the consumer.

When approaching the food chains performance, first a set of attributes has been defined to describe and represent the food chains (WP2). Then, the performance of the tomato supply chains has been assessed under a set of multidimensional indicators that are linked to these attributes.

The case study on tomatoes is part of the case study group 'fruits and vegetables', which is one of the five groups defined in the GLAMUR project, namely: wine, pork, grains, dairy and fruits and vegetables. Our direct partner is the National Institute of Agronomic Research (INRA) in France. The work of both teams is streamlined in order to have a common subset of indicators for the Local and Global tomato supply chains. This will enable a comparison between the two countries, which will be carried out in WP4.

The general objective of the case studies is to collect, analyze and compare data on the performance of Global and Local chains for a given product. The data will feed into the comparative analyses of WP4 and the participatory integrated assessment in WP5.

In the following section, we first briefly present how the Spanish tomato sector is embedded in both national and international markets.In the subsequent sectionthe case studies are presented. Also, the differences between the Local, Mixed and Global chains are pointed out. Afterwards, the research framework is presented, developed through specific research questions and objectives, and the selection of corresponding attributes within the common list of 24 attributes of the GLAMUR project (Kirwan et al. 2014). Then, the process of selection and

[1]'Hortec', which is the main organic wholesaler in Catalonia. It was created in 1992 with the aim of increasing the economic viability of its members' farms. Hortec is the oldest distribution platform of fresh and processed organic food in Catalonia and counts with 25 members.

definition of indicators is explained, as well as the data collection process. Finally, the performance of the different food supply chains is evaluated by means of the selected indicators, which are compared with national and sectoral benchmark clues.

1.2. The Spanish fresh tomato sector

During the last lustrum, Spain has produced about 13% of the fresh vegetables produced in Europe (EU28) and about 17-20% of tomatoes[2]. The importance of the Spanish vegetables sector is evident.

Within Spain, and as of 2011, about 90% of fresh vegetables were supplied by domestic production (13.5 thousand tons) and about 10% was imported. Half of that was consumed by households, while the other half of thatis exported. Tomatoes account for about 30% of the total domestic production of vegetables; more than half of the domestic tomato production was exported and about 35% of the domestic production was consumed internally. At the European level, one fifth of the tomatoes are produced in Spainin 10% of the European land allocated to produce tomatoes.

Tomatoes represent 20% of fresh vegetables consumed and producerd in Catalonia. As of 2013, about 52 thousand tons were produced in 1.5 thousand hectares (Generalitat de Catalunya 2014). However, Catalan production is not able to cover domestic consumption. During the low production season (i.e. October-May), tomatoes are brought from Almería and Morrocco, and during high production season (i.e. June-September) the tomatoes produced in Catalonia have to compete with imports from Belgium, France and The Netherlands. Imports from The Netherlands have produced important price declines in the last years, which have had important effects in the production levels. Between 2005 and 2012 Catalan tomato production tomatoes has decreased about 40% and the land allocated to tomato production have decreased in 700 hectáreas (ODG 2014).

Producers and consumers of organic products in Catalonia appeared during the 70's and 80's. The initial ways of commercialization can be characterized as local food supply chains. During the 90's, the organic food sector grew considerably and the Catalan administration recognized its importance by creating, in 1994,the *Consell de Certificació de la ProduccióAgrariaEcològica* – CCPAE, which is in charge of recording and certifying the organic production in Catalonia (Badal et al. 2011).

The production of organic vegetables is still growing in Catalonia: the cultivated land increased 30% from 2000 to 2013. As of 2013, the registered agricultural land for organic production reached about 500 hectares and the prospects are to keep growing.

Unlike the global charachter of the Catalan agricultural and agro-industrial sectors, the organic production in Catalonia has a local scope (Badal et al. 2011). About half of organic production is

[2] Data obtained from FAOSTAT web site.

commercialized within Catalonia, one third is sold to the rest of the Spanish state, and only about 20% of the organic production is exported (CCPAE 2014).

2. Context of the case study

2.1. Distinction of "Local", "Mixed" and "Global" tomato chains

The GLAMUR project has defined the following four criteria to differentiate what is global and what is local:

1. Geographical distance between producers and consumers
2. The type of governance and organization of the supply chain
3. Kind of resources, knowledge and technologies used
4. The way supply chain stakeholders shape product identity with regard to the reference to the territory of production for food plays a relevant role or not

As mentioned in the introduction, the Spanish case study also includes a third category of FSC; namelly, the Mixed chain. The differentiation between Global, Mixed and Local food chain is a complex issue that depends on several aspects. Following the previous criteria, we differentiate them as follows:

Criteria	Global	Mixed	Local
Geographicaldistance	From and to outside Catalonia	Produced in Catalonia, to inside and outside Catalonia	WithinCatalonia
Governance and organization of the supply chain	More than 2 intermediaries (wholesale market and retailers)	Direct sales and more than 2 intermediaries	Direct sales schemes
Resource, knowledge and technologies used	Organic production in greenhouses and hybrid seeds. Dripping systems and (in some cases) cultivation on substrate. Technologyforpackaging and transportation. High energy input agriculture	Organic production outdoors Medium technology Medium energy input agriculture	Local natural resources (e.g. manure) and traditional seeds Low/Traditional technology Low energy input agriculture
Territorial aspects shaping the identity of the product	Hybridvarieties	Local and hybridvarieties	Local varieties

Within these criteria, there are some common issues to all three supply chains. For instance, considering the use of technology, the production stage of the chains depends on agricultural

machinery such as tractors and fossil fuels. It is important to notice that this case study focuses on organic tomato production.

2.2. Presentation of the study case

The Spanish case study considers 3 different tomato supply chains (Local, Mixed, and Global), all of them supplying fresh organic tomatoes. Each of these tomato supply chains are described in the following sections.

2.2.1. Local fresh organic tomato chain

The Local food chain focuses on direct sales schemes (i.e. vegetable basket scheme), in which the farmer sells tomatoes directly to consumers (See Figure 1). In this case, we consider a network of small agro-ecological farmers, whose farms have less than 1 to 4 hectares, with 2 to 5 workers (including the farmer) working in the farm. Farms are usually ceded or rented and mostly irrigated with dripping systems.

Farmers in the network produce seasonal vegetables according to agro-ecological principles defined in a Participatory Warranty System (SPG). The SPG is developed by means of a participatory process with producers and consumers and includes more than mere productive issues, guided bythe aim of developing social transformation projects, promoting fair relations and small farmers' autonomy. As well, most farms are also certified under the official Catalan third party certification system.

Farmers produce as much as 20 different products during the year. Most of the seeds are reproduced within the farm or obtained from an organic seed bank. Production tasks are performed mostly manually or with small machinery. Manure is used as fertilizer, which is obtained locally.

The general characteristics of the farm considered for this case study are the following:

Table 1. Local chain farm characteristics

	TypeLocal
Total land use [m^2]	3.000
Land use tomatoes [m^2]	400
Human activity tomatoes [h/year]	126
Production [Kg/year]	1.385

After production and harvesting, tomatoes are processed on-farm. Processing consists mainly of cleaning the product and preparing individual boxes and/or bulk products. This task is performed one day per week, in the morning just after harvesting and before distribution takes place. Products are then transported by one or two members of the project to the distribution points, which include consumption cooperatives, small retail shops (i.e. organic grocery stores) or school canteens.

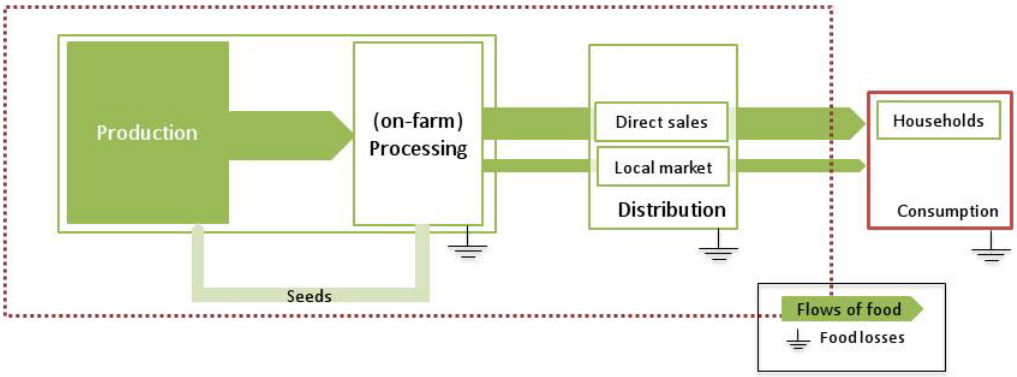

Figure 1.Flow chart of the Localorganic tomato supply chain

2.2.2. Mixed fresh organic tomato chain

This tomato supply chain includes medium size Catalan farms, which produce tomatoes in semi-diversified farms; that is, they produce between 4-5 products in family farms of 2-3 hectares. Production is carried out outdoors, according to organic principles, and some paid labour is hired during the summer. Farmers are members of the Hortec cooperative.

In this case study, the farm size is of 1.8 ha, from which tomatoes occupy about 15% of the farm. Other products occupy about 60% of land use and green fertilizers have a land use of 25%.

The farm producing tomatoes has the following general characteristics:

Table 2. Mixed chain farm characteristics

	TypeMix
Total land use [m^2]	18.000
Land use tomatoes [m^2]	2.600
Human activity tomatoes [h/year]	998
Production [Kg/year]	9.300

Tomatoes are then sold to Hortec, who distributes tomatoes to retailers, small wholesalers, farmers, consumption cooperatives, restaurants, and school canteens. Hortec's members plan their production jointly, and they supply about 20% of the commercialized products. About 10% of the products are supplied by close collaborators, with whom Hortec programmes the supply of products at the beginning of the year. The remaining 70% of products are supplied by non-members.

Eleven people work in Hortec. The 2.000 m^2 premises are located in Mercabarna, the main wholesale market in Catalonia. Hortec's turnover is about 5 million of Euros. Tomatoes represent 2.8% in terms of value with respect to total sales, and 2.5% in terms of volume. About 60% of the tomatoes are supplied from Almeria and the remaining 40% is supplied from

Catalonia. Therefore, tomatoes from the Mixed as well as from the Global supply chains pass through the organic wholesaler (See Figure 2).

About 70% of tomatoes handled by the organic wholesaler are sold to organic shops, about 13% is sold to small wholesalers, 13% is sold to other farmers, and the rest is sold to consumers'cooperatives, restaurants, and school canteens. On the other side, and according to the Catalan government (CEO 2012), 50.7% of organic buyers purchase food in shops specialized in organic products. According to this, we have considered the commercialization in organic shops as the last step in the Mixed supply chain, for both the Mixed and Global chains.

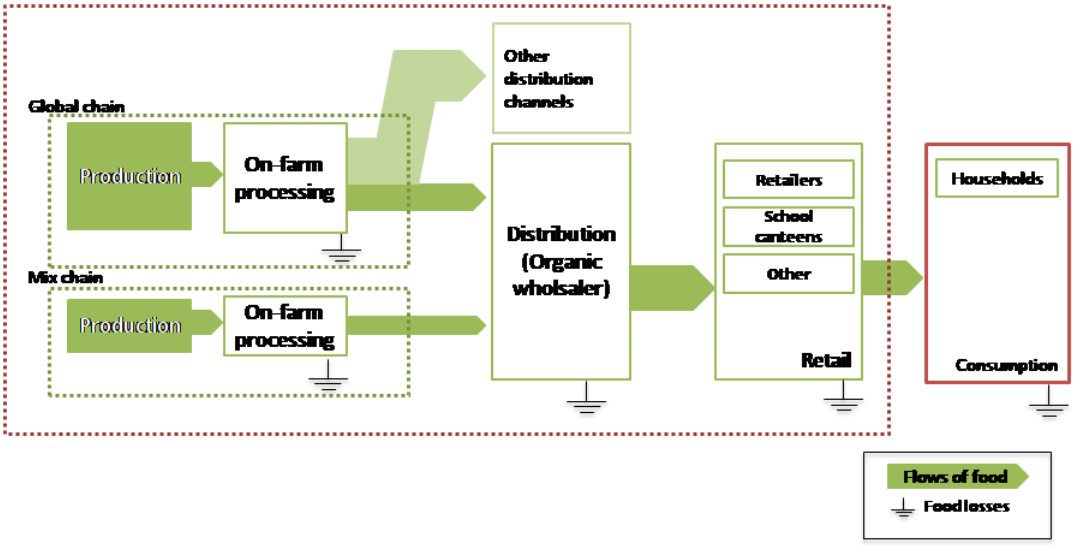

Figure 2. Flow chart of the Mixed and Global tomato supply chain

2.2.3. Global fresh organic tomato chain

The fresh organic tomatoes' Global supply chain has 3 main stages: production, distribution, and retail. A general view of the GSC is presented in Figure 2.

In this supply chain, the production of tomatoes is done in greenhouses in the South of Spain. Greenhouses are 3 hectares in average and equipped with ventilation systems. Cultivation is carried out over substrate and the automated dripping system also delivers nutrients to the plants. Farmers follow organic monoculture production principles according to certification schemes, using inputs purchased in the market. Seeds are mostly commercial hybrids. In most cases, processing takes place on-farm and consists on cleaning and packaging the tomatoes. The average farm has the following characteristics:

Table 3. Global chain average farm characteristics

	TypeMix

Total land use [m^2]	30.000
Human activity tomatoes [h/year]	10.223
Production [Kg/year]	268.000

Source: AdaptedfromMoleres (2009)

For the evaluation of this chain, only asmall fraction of the production is considered (i.e. about 41 tons), which is the fraction sold to the organic wholesaler in Barcelona); the rest of the production is sold through different distribution and commercialization channels. However, the evaluation of the farm's performance considers the all its tomato production and the corresponding use of production factors.

Once produced, tomatoes are transported about 800 kilometres from the production site to the main organic wholesaler in Barcelona. As already mentioned, about 60% of the tomatoes sold in the considered organic wholesaler comes from Almeria province (Andalusia). Then, the wholesaler supplies tomatoes (and other vegetables and processed products) to local supermarkets, retailers, and local distributors.

As a final stage of this chain, we consider sales in small grocery stores specialized in organic products. As mentioned before, more thanthan 50% of organic consumers inCatalonia prefer to buy in these stores rather than in supermarkets, local markets, shops (CEO 2012). In the CEO study data were obtained from 50 organic grocery stores specialized in selling fruits and vegetables in Gracia quarter (Barcelona). For our study case we have collected data from a store run by 2 partners which opened in Gracia in 2012. A small portion of the sold product is packed (preserves, juices, and dried pulses). More than 80% of the fruit and vegetables they sell come from the main organic wholesaler in Barcelona or from another big organic production and distribution company. Only 5% of the product sold in the store is transported by small producers. Currently the two workers (the two partners) do not have regular wages. During 2012-2013 the store grew 30%, and according to their previsions they expect to grow 10% during 2013-2014.

2.3. Main critical issues of the tomato supply chains chains

In the Spanish National report developed in Task 2.5 (WP2), an analysis of the Spanish agricultural sector was presented. Also, the report presents weaknesses and strengths of the Spanish agricultural sector and food system, and the attributes used by different stakeholders to describe the food supply chains. From that discussion, the following critical issues regarding the organic tomato supply chains can be derived.

Pricing mechanisms

Price is the first buying criteria for most consumers. At the global market level there is a strong price competition between Mediterranean producing countries, which would favour consumers'ability to afford food. Local supply schemes base their business model on trust and

commitment between producers and consumers. In most cases, producers offer a diversified box of seasonal products for a fixed price. That is, price keeps constant through the year and products (and their amount) change according to the season.

Distribution of added value

Supporters of direct sales schemes argue that intermediaries have negative effects in pricing mechanisms; reducing sales price of farmers and increasing purchasing prices for consumers[3]. By inter-mediating the exchanges between farmers and consumers they would appropriate the benefits of farmers and consumers, reducing the income of the former and the power capacity of the last. The number of intermediaries and the effect of competition contribute to reduce the level of remuneration of the actors along the supply chain. Wholesale markets impose low prices to farmers, which are even lower when there are intermediaries between the farmer and the market. According to these arguments, downstream distributors are looking to increase their margins and consumers pay three to four times the price paid to producers. In Local supply chains, the added value produced along the chain is kept by farmers, who have to perform tasks of commercialization and distribution.

On the other side, one can also find people supporting the role of intermediaries. According to them, intermediaries would centralize sales and purchases, anticipating excesses and deficits of future supply and demands, managing inventories. By doing so, they would benefit producers and consumers; increasing the sale prices for the former and reducing the purchasing prices for the last. This argument considers that farmers do not get involved in commercialization tasks, which is more a characteristic of Global chains than of Local supply chains.

Models of production

To provide tomatoes all year at competitive prices, agro-industries choose intensive soil-less (i.e. over substrate) mono-cropping systems under greenhouses to maximize yields and control plant nutrition parameters. This model may be presented as environment-friendly as far as inputs are under control, and contact with environment is reduced. However, energy consumption is expected to be higher as well as the flow of matter and waste (e.g. substrate bags over which tomatoes are produced, which end up in landfills).

Producers involved in Local supply chains choose to produce tomatoes in a diversified farm in which crop rotation is put in practice. Irrigation is performed by a dripping system and manure is used as fertilizer. The main material flow is straw or agricultural scrolls, which are used to avoid evaporation and as anti-weeds. This production model is more labour intensive, but is expected to consume less energy carriers.

[3] This opinion is much generalized among the staholdersintervierwed during tasks in WP2 and WP3.

Pollution and environmental impacts

Tomatoes produced within the Global supply chain are transported over a large distance in refrigerated trucks before arrivingat the wholesale market.Greenhouse gasses are emitted during this transport. Tomato production over substrate and under glass requires the use of materials (e.g. aluminium, plastic polymer, rock wool), which must be treated after the end of their use.

Small producers within the Local tomato chain try to reduce the use of agro-chemicals and foster the use of biodegradable materials. However, the use of small trucks to distribute their products may increase the amount of CO_2 emissions. Thus, the Local chain would tend to be more sustainableat the production level, but not when considering the distribution stage.

Working conditions and labour rights

Theprecarious working conditions in Almeria's greenhouses have been denounced elsewhere; including, for instance, low salaries, poor working conditions and lack of social security (Defensordel Pueblo Andaluz n/d). On the other side, Local chains also appear, in some cases, as places with difficult working conditions because of self-exploitation. This means that often small self-employed producers do not have a living wage or social benefits. This would be, in some way, compensated by the feeling of working for one-self, and belonging to a collective project based on trust and cooperation.

3. Research Design

3.1. Research questions

The general objectives of the case studies are the following:

- To examine supply chain arrangements and the relations between the actors involved in the chain
- To analyse key food chain performance from a set of attributes and indicators

In order to meet these objectives, the following research questions have been defined between the Spanish and French teams:

- How and at which stage does each chain create added value and how is this added value distributed among actors?
- How and to what extent do the two chains contribute to national, sectoral, territorial economy, including employment?
- How and to what extent does each chain consume, preserve, deteriorate or reproduce natural resources (air, land, water, and fossil fuels)?

From here, researchers have chosen attributres that are relevant to answer these questions. Attributes are then translated into indicators in order to measure them.

3.2. Attributes' and indicators' selection process

From the GLAMUR grid proposed in the WP2 synthesis, the Spanish team has chosen the attributes which are relevant to their research questions about tomato chains. Attributes have been translated into indicators, which are calculated at farm and chain level.

3.3. Defining indicators

As already mentioned, attributes have been translated into indicators. The number of indicators per each attribute depends mostly on the available information. The number of indicators has been limited to a maximum of 20 in order to enable adequate understanding and analysis of the information. Following Gallopín (1997) indicators are considered as *variables*; an operational representation of an attribute of a system. In other words, an indicator is an image of an attribute defined in terms of a specific measurement or observation procedure. The value (i.e. the state of the variable) gives information on the condition and/or trend of an attribute (or attributes) of the system considered. Indicators provide the means to monitor and evaluate social, economic and environmental conditions and trends of a system (OCDE 1999). In sum, indicators would be useful to measure achievement, monitor changes or evaluate the performance of a system.

Table 4presents the set of indicators considered in the tomato case study performed by the Spanish team.

Table 4. Attributes and indicators for the evaluation of the Global, Mixed and Local tomato supply chains

Related Attributes from WP2 Report	Indicators	Indicator Description
Fair trade	Distribution of addedvalue	Added value generated in each stage of the chain (obtained by the corresponding actor) with respect to the added value generated in the whole chain
Contribution to economic development	Gross income per unit of land	Gross income of farmers, per unit of land use. It is calculated by multiplying the volume of sales by the price; that is, the turnover related to the sales of products. The result is divided by the land used to perform production, distribution and retail activities.
	Net income per unit of land	Net income of farmers, per unit of land use. It is calculated by substracting the costs of production and the taxes to the gross income. The result is divided by the land used to perform production, distribution and retail activities.
	Gross income per unit of labour	Gross income of farmers, per unit of labour It is calculated by multiplying the volume of sales by the price; that is, the turnover related to the sales of products. The result is divided by the total amount of hours used to perform production, distribution and retail activities.
	Net income per unit of labour	Net income of farmers, per unit of labour. It is calculated by substracting the costs of

		production and the taxes to the gross income. The result is divided by the total amount of hours used to perform production, distribution and retail activities.
	Number of jobs per unit of land	Number of jobs per unit of land use, in each stage of the chain and in the whole chain. It is calculated by dividing the total amount of hours required to produce, distribute and retail, divided by the land use.
	Number of jobs per production	Number of jobs per one hundred tons of production, in each stage of the chain and in the whole chain. It is calculated by dividing the total amount of hours required to produce, distribute and retail, divided by the total amount of tomatoes.
Affordability	Price (Ability to provide food at acceptable price)	Sale prices to consumers with respect to household budget allocated to food
Biodiversity	Agro-biodiversity	Number of crops present in the farm
Pollution	CO_2equivalent per land use	Tons of CO_2equivalent directly emitted, per unit of land use, in each stage of the chain and in the whole chain. It is calculated by multiplying the amount of burned fossil fuels by the corresponding emission factor, and divided by the total land use allocated to produce, distribute and retail.
	CO_2 equivalent per labour	Tons of CO_2equivalent directly emitted, per labour, in each stage of the chain and in the whole chain. It is calculated by multiplying the amount of burned fossil fuels by the corresponding emission factor, and divided by the total human activity allocated to produce, distribute and retail.
Resource use	Consumption of energy carriers per land use (Energyconsumption)	Direct consumption of electricity, natural gas and liquid fuels, per unit of land use, in each stage of the chain and in the whole chain
	Consumption of energycarriers per labour (Energy consumption)	Direct consumption of electricity, natural gas and liquid fuels, per unit of labour, in each stage of the chain and in the whole chain
Creation and distribution of added value	Economiclabourproductivity	Added value per hour of human activity in each step of the chain and for the whole chain. It is calculated in each stage of the chain bysumming the salaries, the net income of the farmer/wholesaler/retailer and the taxes. The added value of the chais is calculated by aggregating hte added value of the chain stages. The results are divided by the human activity allocated to each stage of the chain.
	Added value per unit of land	The sum of the profit, the depreciation cost and the labour cost, both in absolute terms, per unit of land use. Added value is calculated considering the same method than in the calculation of the Economic Labour Productivity, bu the results are divided by the land use required is each stage of the chain

		and in the whole chain.
Labour relations	Wageslevel	Average salary of workers in each stage of the chain
Efficiency	Landproductivity	Amount of product obtained per unit of land use
	Labourproductivity	Amount of product obtained per unit of labour
Foodsecurity	Foodavailability	Availability of food in the market (e.g. number of months per year)

4. Methods

4.1. Metabolic Analysis, MUSIASEM

The definition of performance indicators have been guided by the MuSIASEM approach (Giampietro et al. 2009), which is an operationalization of the fund-flow model developed by Georgescu-Roegen (1971). According to him, any metabolic system can be represented by using *fund* and *flow* categories. On the time scale of the representation, *fund* categories transform *inflows* into *outflows*, and *flows* are either consumed or generated in order to reproduce the *funds*. Therefore, *fund* categories remain "the same" over the duration of the representation (e.g. capital, people, Ricardian land). *Flow* categories refer to elements appearing and/or disappearing over the duration of the representation (e.g. added value, water, energy, matter). What we call production is in reality a transformation process of resources into useful products and waste products: a transformation of some materials into others (the flow elements) by some agents (the fund elements).

Then, an analysis based on the MuSIASEM approach differentiates those categories that have to be reproduced, from those that are used for the reproduction of the system and its compartments; that is, the fund and flow categories.

One can combine fund and flow categories in order to characterize the system in quantitative terms. As a result, we can define extensive and intensive indicators:

Extensive indicators are those that can be added. They characterize the size of the system and its compartments in terms of either fund categories representing *what the system is*, or flow categories representing *what the system does*. Extensive indicators are calculated by aggregating and dis-aggregating figures across levels.

Intensive indicators are those that represent a ratio. They describe *how the system does what it does.* When these ratios are constructed with funds or flows categories referring to different levels, these $fund_{k-1}/fund_k$ and $flow_{k-1}/flow_k$ shares represent the relative sizes of lower-level fund elements compared to upper-levels fund elements. They provide information on the structural relation between the functional parts (e.g. the size of the Agricultural sector – level *k-1* – with respect to the Agriculture, fishing and forestry sector – level *k* –, in terms of land uses, human activity or flow of electricity or CO_2 emissions).

When the ratios are constructed with fund and flow categories referring to the same level, a $flow_k/fund_k$ ratio represents the speed and intensity of the system's metabolic processes; i.e.

the speed to which flows are consumed or produced per unit of fund category (e.g. flow of electricity per square meter, measured in kW·h/m^2·year, or the flow of added value created per hour of human activity, measured in €/h)).

4.2. Data collection

4.2.1. Primary data collection

Primary data collection encompasses two main methods to record time and resource allocation: (i) activity log, and (ii) in-depth interviews.

Activity log

The activity log has been applied to one small farm involved in the Local supply chain. Data collection took place from April to November 2013. Farmers were asked to record all activities related to tomato production, including time and resources (e.g. land, machinery, equipment) allocated to the activity. For instance, when applying agricultural treatments to the plants, farmers had to record the time spent in preparing and applying treatments, the amount of chemical compounds and their cost.

The information collected by means of the activity log encompasses the following issues:

- Time allocated to tomato production, differentiating between preparation and agricultural tasks, and labour costs
- Amount of seedling and their cost
- Amount of organic agrochemicals applied and their costs
- Use of machinery and equipment: time and cost
- Land allocated for tomatoes cultivation and its productivity
- Time allocated to prepare boxes of vegetables, and amount of vegetables and tomatoes per type of box
- Distance and time used to distribute vegetable boxes

After collecting the information, some production parameters were calculated (e.g. land productivity, direct and indirect costs) and compared with figures in the literature in order to check the reliability of the gathered data.

In-depth interviews

Interviews were carried out with two farmers (Local and Mixed), two wholesalers and one retailer involved in the different tomato supply chains. A common objective of the interviews was to describe the operation of the different stages in which actors participate. The main aspects considered in the interview encompass the following issues:

- Description of productive, distribution and retail activities (depending on the actor interviewed)
- Description of operational aspects of the enterprise. Advantages and obstacles of the supply chain in which they participate

- Relations with other actors of the chain
- Perception of other supply chains and actors

Interviews also served to complement data collected by means of the time and resource allocation questionnaire. Interviewees were asked about salaries, purchase and sale prices, and amount of product produced/distributed/sold, among other issues.

In the case of wholesalers, they were asked to provide the following information (per year):

- Labourcosts and labourrequirements
- Costs of equipment, machinery and transport
- Cost of rentingthepremises
- Costs of energy carriers consumption (electricity, natural gas and diesel)
- Total turnover in monetary (i.e. €) and mass terms (i.e. Kg)
- Turnover of fruits and vegetables, in monetary (i.e. €) and mass terms (i.e. Kg)
- Turnover of salad tomatoes, in monetary (i.e. €) and mass terms (i.e. Kg)
- Share of total sales, in monetary (i.e. €) and mass terms (i.e. Kg), to different customers (e.g. retail shops, school canteens, small distributors)
- Share of vegetable sales, in monetary (i.e. €) and mass terms (i.e. Kg), to different customers (e.g. retail shops, school canteens, small distributors)
- Share of salad tomato sales, in monetary (i.e. €) and mass terms (i.e. Kg), to different customers (e.g. retail shops, school canteens, small distributors)
- Origin of products, in monetary (i.e. €) and mass terms (i.e. Kg)
- Origin of vegetables, in monetary (i.e. €) and mass terms (i.e. Kg)
- Origin of salad tomatoes, in monetary (i.e. €) and mass terms (i.e. Kg)

In the case of the medium size farmer involved in the Mixed supply chain, data correspond to 2014. The information given by the organic wholesaler corresponds to the period between July 2013 and June 2014.

4.2.2. Secondary data sources

Secondary data sources have been used to both check the quality of data obtained by primary data collection techniques and to complement that information. The main sources of secondary data sources are presented in the following table:

Table 5. Secondary data sources

Task	Spain
Quality check and secondary data for the production stage	● Guzmán G., García A., Alonso A., Perea J. 2010. Producción Ecológica: Influencia en el Desarrollo Rural. Ministerio de Medio Ambiente y Medio Rural y Marino Secretaría General Técnica. Centro de Publicaciones

	● Montero J., Antón M., Torrellas M., Ruijs M., Vermeulen P. 2011. Environmental and economic profile of present Greenhouse production systems in Europe. Deliverable 5, EUPHOROS project. ● Sanyé-Mengual et al. 2013. Environmental analysis of the logistics of agricultural products from roof top greenhouses in Mediterranean urban areas. Journal of Science of Food and Agriculture 93, 100-109 ● Moleres J. 2009. Estudio y análisis de costes de producción de explotaciones de tomate ecológico bajo invernaderos en Almería. Final degree project, Technical School of Agricultural Engineers. Public University of Navarra.
Quality check and complementary data for the distribution stage	● Sanyé at al. 2012. Life cycle assessment of energy flow and packaging use in food purchasing. Journal of Cleaner Production 25, 51-59 ● CapgeminiConsulting. 2009. Estudio de la cadena de valor y formación de precios del tomate. Observatorio de precios de los alimentos, Ministerio de Medio Ambiente y Medio Rural y Marino

4.3. Methodological observations and key performance distinctions

In this section we present themethodological assumptions and decisions made, as well as the difficulties that we have encounteredduring the study case analytical process (i.e. to calculate indicators and assess the chains' performance).

From an individual farm to a farm typology[4]

It is important to notice that the primary data collected in this case study correspond to particular farms, which (in principle)are not meant to be representative of all farms involved in the Local and Mixed supply chains[5]. Therefore, in order to make the gathered information more representative of the farms involved in Catalan Local and Mixed tomato supply chains we proceeded as follows:

First, some production parameters were calculated (e.g. land productivity, labour productivity, direct and indirect costs) and compared with expected values found in the literature. The aim was to check the reliability of the gathered data. In the case of the farm involved in the Mixed supply chain no major deviations from the expected values were found. Therefore, the

[4]The MuSIASEM approach in based on the use of typologies to represent the system under analysis: in this case, a farm. A **type** is a simplification of real entities. A representation based on a set of expected relations (which lead to an expected performance). The characteristics of a given type are always associated with the possibility of performing a given, expected function (Giampietro 2004).

[5] It is assumed that the farm typology considered in the Global supply chain is representative of the farms producing organic tomatoes under greenhouses in Almeria (See Moleres 2009).

performance of this farm is considered as the usual performance of a medium size farm involved in the specific Mixed supply chain considered for this study.

In the case of the farm involved in the Local supply chain, the major deviation from the expected performance of the farm was the land productivity of the farm. In particular, this farm has an important rate of tomato losses (about 25%) due to birds biting the tomatoes. These tomatoes are also harvested but not sold, and the time and resources use recorded by the farmer correspond to the activities related to the whole tomato production (= production for sale + losses). According to this, the calculation of performance indicators is based on the following assumptions: *a)* time and resources recorded by the farmer correspond to the whole tomato production (= production for sale + losses), and *b)* the amount of tomatoes suitable for sales is equal to all tomato production (= production for sale + losses). In this way, some specificities of the studied farm were disregarded, which entailed to adjust some figures in order to transform this individual farm into a farm typology.

Diversity of products witin the food supply chains

One of the first difficulties when analysing food supply chains is the fact that most producers, wholesalers and retailers handle a diversity of products. Hence, it is very difficult to know and evaluate the performance of the food supply chain of one single product.

Primary data collection was possible only in the case of the Local supply chain. In this case, the use of time and resources specific to tomato production were collected by means of the activities log.

On theother side, thefarmer involved in the Mixed supply chains, and the wholesaler and retailer involved in the Mixed and Global chains handle a diversity of products. The data gathered in those cases correspond to the overall resources used and activities performed by these actors. Then, the allocation of economic and biophysical resurces used is done according to the weight of the different products.That is, for instance, the time (and resources) required to handle one kilogram of tomatoes is equal to the time (and resources) required to handle one kilogram of other product.

Diversity of distribution channels for each actor

Another difficulty we have found when analysing food supply chains is that some actors participate in more than one distribution channel. In order to deal with this issue, the report first presents the comparison of the farms participating in the different supply chains. Then, the report presents the comparison of the supply chains, which is based on the following assumptions regarding the destination of the tomatoes:

- In the case of the Local chain, the whole amount of tomatoes produced by the farmer is sold directly to consumers
- In the Mixed supply chain, all tomatoes produced by the farmer are sold to the wholesaler. This farm typology supplies about 13% of the tomatoes handled by the wholesaler.

- In the case of the farm typology participating in the Global chain, 15% of the production is sold to the wholesaler considered in this study. In this way, this farm typology supplies about 60% of the tomatoes handled by the wholesaler.

Then, for the purpose of this evaluation, it has been considered that the wholesaler sells all these tomatoes to organic shops, which are responsible for about 70% of the tomatoes boughtto the wholesaler.

Human activity

As the reader can see, labour required by tomato supply chains is evaluated in terms of hours of human activity. In the case of the farmers participating in the Local and Mixed supply chains, human activity allocated to tomato production was obtained directly from farmers. In the case of the farmer of the Global supply chain, the human activity was calculated fromthe labour costs reported in Moleres (2009). In order to do so, a workload of 45 hours/week and a net salary of 1.000 €/month have been considered.

In the case of the wholesaler (11 workers), a workload of 40 hours/week and 48 weeks/year is assumed. In the case of the retailer (2 workers), the workload is of 30 hours/week and 51.5 weeks/year. Then, in both cases, the time allocation is based on the weight of tomatoes with respect to the total amount of products sold.

To calculate the indicator'number of jobs', the total amount of hours required in each chain is calculated by assuming that one worker works 172 h/week, during 11 months.

Transport

Economic and biophysical resources used for transport is allocated to actors assuming the transport of tomatoes. In the Mixed and Global chains, the farmer pays the transport to the wholesaler and the retailers pay the transport from the wholesaler to the shop.

4.4. Data quality check

The following Table 6 presents the quality check of the data used for the evaluation of the tomato supply chains. In order to do so, we have used the pedigree matrix approach presented in Lewandowska (2004). As the reader can see, the information used in this case study presents a high quality score mainly due to the use of either primary data sources, whose reliability has been checked against expected values found inthe literature, or secondary data sources highly related to the cases under study.

Table 6. Data quality check

Item	Local	Mixed	Global
Reliability of thesource	0,8	0,8	0,8
Completeness	0,6	0,6	0,8
Temporal correlation	1	1	0,8
Geographicalcorrelation	1	1	1
Furthertechnologicalcorrelation	0,8	0,8	1
Quality score	**A**	**A**	**A**

4.5. Contextualizing and benchmarking of the indicators

As of 2012, the following figures characterized the agricultural sector in Spain:

Table 7. Characterization of the agriculture sector in Spain

Indicator	Benchmark
Land productivity	Organictomatoes 2012: 5,4 Kgs/m^2
Labour productivity	
Gross income per unit of land	Vegetables and pulses 2012: 1,81 €/m2 tomatoes 2009: 4,16 €/m2
Net income per unit of land	
Gross income per unit of labour	
Net income per unit of labour	
Value added per unit of land	Agricultural sector 2012: 0,19 €/m2
Economic labour productivity	Agricultural sector 2012: 17,7 €/h
Number of jobs per unit of land	total organic production 2009: 0,1 jobs/ha
Number of jobs per production	
Consumption of energy carrier per land use	Agriculture 2012 Diesel: 0,13 kWh/m2 Agriculture 2012 Electricity: 0,03 kWh/m2
Consumption of energy carrier per labour	Agriculture 2012 Diesel: 12,4 kWh/h Agriculture 2012 Electricity: 2,7 kWh/h
CO_2 per land use	Agriculture 2012: 35 gr CO_2/m2
CO_2 per labour	Agriculture 2012 3.235 gr CO_2/h
Agro-biodiversity	

5. Results and discussion

In this section, we present the preliminary results of the performance evaluation of the analysed food chains, in comparative terms. We also suggest some further considerations related with some of the previously stated main critical issues which we think are necessary to take into consideration when assessing the performance of food chains (i.e. the interpretation of the results).

First, we present the performance of the farms (i.e. productive systems) involved in the three food supply chains (Local, Mixed, and Global). Then, we focus on the comparison between the complete supply chains (i.e. production and distribution).

5.1. Comparative evaluation of production systems (farms)

This section presents the characteristics and the performance of the farms involved in each supply chain.

Farms participating in the Global chain are larger than the other two types of farms, either in terms of land use (measured in square meters) or human activity (measured in hours of labour). The difference in the size of the Local and Global supply chains is considerable. This reflects the rationality behind the different business models. That is, the Global FSC is based on larger surfaces of land allocated to produce tomatoes under greenhouses, pursuing higher productivity in order (see below) to compensate lower prices. In turn, the farmers involved in Mixed supply chains cultivate medium size farms with a medium-low diversity of crops. This can be considered an attempt to find a balance between economic viability and use of resources, land, and human time.

For comparison purposes, we have considered that the Local farmers sell their production at an average of 1.6 €/Kg. However, this is not the case, as they produce and distribute these tomatoes. Thus, this price is the price agreed by the farmers of the network for sales between members of the network.

Table 8. Characteristics and performance of farms in the Local, Mixed, and Global chains

	Local	Mixed	Global	Units
Total land use	3.000	18.000	30.000	m^2
Land use	400	2.600	30.000	m^2
Human activity	126	998	10.485	H
Production	1.385	9.300	268.000	Kg
Sales price	1,60	1,59	0,55	€/Kg
Sales price to organic wholesaler		1,59	1,59	€/Kg
Tomato sold to organic wholesaler	1.385	9.300	41.039	Kg
Costs				
Agricultural inputs	499	1.593	46.350	€
Cost machinery	39	555	3.801	€
Labour costs	846	4.623	42.300	€
Familiar labour	0	2.081	28.200	€
Transport	0	804	12.060	€

	Local	Mixed	Global	Units
Direct costs	**1.385**	**9.388**	**120.651**	**€**
Land rent	34	332	4.770	€
Interests	0	0	1.650	€
Other indirect costs	6	589	2.280	€
Amortization	0	919	31.080	€
Indirect costs	**40**	**1.840**	**39.780**	**€**
Total costs	**1.425**	**11.228**	**160.431**	**€**
Income & Valueadded				
Gross income	2.216	14.787	190.326	€
Taxes	34	264	1.164	
Net income	757	3.295	28.731	€
Value added	1.638	10.263	100.395	**€**
Salaries	6,72	6,72	6,72	€/h
Consumption of energy carriers & CO_2 emissions				
Diesel consumption	10	70	160	lts/year
Energy consumption Diesel	103	1.045	5.591	kWh/year
Electricity consumption	48	1.167	24.000	kWh/year
CO_2 emissions	27	272	420	Kg CO_2eq/year

Regarding the costs of production, the farms of the Local and Mixed supply chains present their greater costs in labour, which contributes to 60-70% of the total costs. In the case of the farm involved in the Global supply chain, labour is also an important component of the costs, but the amortization of the greenhouses and the equipment (e.g. irrigation and ventilation systems) accounts for about 20% of the costs, which gives an indication of the investment required to perform this type of production.

The preceding Table 8 also presents information on the biophysical flows of the farm; that is, *what the system does* in terms of production, purchases and sales, consumption of energy carriers and CO_2 emissions. In the case of the Mixed and Global FSC, energy consumption and CO_2 emissions due to transport from the farm to the wholesaler are allocated to production: that is, the producer affords the cost of transport from the farm to the wholesale market. As the size of the Global FSC is larger than the size of the Mixed and Local FSCs, the amount of biophysical flows is also higher. Therefore, in order to assess the pace of metabolism (i.e. intensity of energy consumption, creation of value added, rate of CO_2 emissions), intensive indicators are required. However, one can see that the production of tomatoes in greenhouses requires much larger inputs of electricity in comparison to diesel fuel. In the Local and Mixed farms the situation is the opposite: the share of diesel fuel consumption is higher than the share of electricity with respect to the total amount of energy carriers consumed.

The following table presents a set of indicators representing the performance of the productive systems; that is, variables indicating *how the system does what it does.*

Table 9. Performance of the Local, Mixed, and Global productive systems

Attributes	Indicators	Local	Mixed	Global	Units
Contribution to economic development	Gross income per unit of land	5,5	5,7	6,3	€/m^2
	Net income per unit of land	1,9	1,3	1,0	€/m^2

	Gross income per unit of labour	17,6	14,8	18,2	€/h
	Net income per unit of labour	6,0	3,3	2,7	€/h
	Number of jobs per unit of land	1,7	2,0	1,8	Worker/ha
	Number of jobs per production	4,8	5,7	2,1	Worker/100 Ton
	Taxes per labour				
	Taxes per land use				
Biodiversity	Agro-biodiversity	20	5	1	Number of crops
Pollution	CO_2 per land use	67	105	48	gr CO_2/ha
	CO_2 per labour	213	272	139	gr CO_2/h
Resource use	Consumption of energy carrier per land use	0,38	0,72	0,85	kWh/m^2
	Consumption of energy carrier per labour	1,20	1,88	2,44	kWh/h
Creation and distribution of added value	Value added per unit of land	4,1	3,9	3,3	€/m^2
	Economic labour productivity	13,0	10,3	9,6	€/h
Labour relations	Wages level				
Efficiency	Land productivity	3,5	3,6	8,9	Kg/m^2
	Labour productivity	11,0	9,3	25,6	Kg/h
Food security	Food availability	4	6	12	Months

According to the results, the Local and Mixed farmers almost double the net income of the Global farm, either per unit of labour or land. This means that the Global farmer deals with higher amounts of money than the other two farmers, but the net income available per cultivated square meter is lower.

The creation of jobs is also related to the contribution to economic development. In this case, the three production systems create similar amount of jobs per square meter of cultivated land. The differences between the farms come from the requirements of labour in the different stages of the production cycle. On the one hand, the Local and Mixed farms require more labour in tasks related to production (e.g. prepare the land, seedling and/or weeding) than the Global farm. On the contrary, and due to higher productivities, the Global farm requires more labor during the period of harvesting than the Local and Mixed farms.

However, there are further considerations related with the quality of jobs that must be taken into account when assessing jobs creation related indicators (see Box 1).

Box 1. Working conditions

Intensive agriculture in Almeria is heavily dependent upon migrant workforce to maintain the levels of productivity and profitability upon which the economy of the region has been built. According to the Ombudsman in Andalusia, only 1% of seasonal workers are Spanish. The work is irregular and arduous, with temperatures reaching 40C-45C. Unattractive to the local population, the work is taken by thousands of illegal workers, originally from Morocco, at present also from Eastern Europe and sub-Saharan Africa. Their working conditions have been described as ‘inhuman’ and ‘modern slavery’ by the Red Cross and Anti-slavery International.

Wages are routinely less than half the legal minimum wage.

The number of migrants working in Almeria is different according to the source. Official administrative sources talk about 50000 migrant workers. University studies talk about 80000-90000 people working in the greenhouses. The Andalusian Ombudsman in a special report has highlighted the highly deficient living conditions of this population, which lives in the surroundings of the same place they work (from warehouses to simple shacks and slums). From 60% to 80% of the migrants live in conditions of 'substandard housing', with subsequent health-related problems. Within this context, women are in even greater vulnerability conditions, often suffering sex-related violence (during their migration, and once they get to Almeria) (Women's Link Worldwide n/d).

Local chains also appear, in some cases, as places with difficult working conditions because of self-exploitation. This means that often small self-employed producers do not have a living wage or social benefits. This would be, in some way, compensated by the feeling of working for one-self, and belonging to a collective project based on trust and cooperation.

Regarding the creation of added value, the Local and Mixed farms produce about 30% more value added, either per unit of labour and land use, than the Global supply chain. Sales prices, which in average much lower in the Global chain, play an important role in this regard. See Box 2 for more information on the pricing mechanisms in the different chains.

In all cases, the creation of added value per unit of land use is much higher than the average of the Spanish agricultural sector (0.19 €/m^2). However, the average Economic Labour productivity of the Spanish agricultural sector (17.7 €/h) is higher than the three farm typologies analysed. These differences are the result of the fact that the Spanish agricultural sector uses, in average, more land and less labour (0.1 jobs/ha) than the organic production of tomatoes. This higher mechanization of the Spanish agricultural sector related to higher surfaces of land use is evident when looking at the consumption of energy carriers per unit of labour and land use.

Box 2. Pricing mechanisms

In the Global chain, market dynamics have a key role in defining prices. During the last years, tomatoes coming from Morrocco and The Netherlands have increasing competition based on low prices, which forced Spanish producers to sell to even lower prices. This reinforces the effects of the main business strategy of retail shops to attract customers, which is to offer a diversified portfolio of products at low prices.

In the case of Local supply chains considered in this case study (i.e. direct sales through vegetable box schemes or to consumer groups), price is a matter of agreement between producers and consumers, and market prices are considered as reference values to define prices.

In general, it can be said that prices of organic tomatoesare not as fluctuant as conventional tomatoes. However, the price of organic tomato in the Mixed and Global chains varies annually depending on the seasonality of the product: from 1.5 euros in summer (season) to 3.5 euros in winter (out season). As for organic tomato in the Local chain, prices can be more easily controlled, because small producers usually know each other, and quantities of product in the market are smaller. The price in the Local chain (sales price for consumers, and exchange price between producers) is defined by producers in the small agroecological producers' network, taking as reference the market price for organic tomato. However, given the fact that tomatoes are sold together with other vegetables (in the box), the price negotiated with consumers (consumption cooperatives) is per kg of vegetables, including tomato, and product diversity in the box.

There is a non-written commitment so that producers and consumers find a fair price for both (this is, not to increase much the price if there is some out of season production, and not to lower it much during productive season). In the Mixed and Global chains the wholesaler can control the tomato prices so that they don't fluctuate and are as fair as possible both for producers and consumers.

In terms of productivities, the Global FSC is able to produce a larger amount of tomatoes per square meter of cultivated land, which is expected given the higher control over the atmosphere in which tomatoes are grown. In fact, the Global farm is the only one that has higher productivity than the Spanish average of organic tomato production: 5.4 Kg/m^2. As well, productivity per unit of labour is higher in the Global FSC. But these larger productivities are at the expenses of higher consumption in biophysical terms. That is, the consumption of energy carriers per unit of land use and per hour of human activity is higher in the Global FSC than in the other two cases. This is because greenhouses require larger amounts of electricity to maintain "optimal" conditions to grow tomatoes. The intensity in the use of energy carriers of the Local farm is less than half of the Global farm one, and the Mixed farm use is in between both.

The higher rates of CO_2 emissions, either per unit of labour or land use, of the Local and Mixed farms may be surprising to the reader. However, this evaluation considers direct CO_2 emissions only, i.e. emissions generated by the combustion of fossil fuels. In the case of the Global farm, indirect CO_2 emissions are produced in the energy sector when electricity is generated[6].

Finally, agro-biodiversity is much higher in the Local farm, which is based on a diversified system of production. Here, farmers cultivate as much as 20 different crops during the year to supply

[6]The MuSIASEM approach does not allocate the CO_2 emissions from electricity consumptionto the FSC. These emissions are generated in the energy sector and, as such, its evaluation is an evaluation of the energy sector and not of the FSC.

consumption groups, school canteens or the local market with their own production. In the case of the farmers participating in the Mixed supply chain, agro-biodiversity is medium: they produce between 5-6 different crops. This is a result of belonging to the cooperative that commercializes their products: the members of the cooperative have reached an agreement to reduce the number of crops to simplify the work in the farm, but covering a wide range of products between all members of the cooperative. Also, farmers are not dependent on one product, avoiding economic shocks due to crop failures.

5.2. Comparative evaluation of chains (production, distribution and retail)

In this section, an evaluation of the complete tomato supply chains is presented. As mentioned before, the Global supply chain only considers the tomatoes sold from producers to the organic wholesaler in Barcelona. That is, the chain commercializing about 41 tones of tomatoes.

The last stage in the Mixed and Global supply chain is retail. In order to evaluate this step, it has been considered that the tomatoes are sold in small organic stores, specialized in fruits and vegetables.

5.2.1. Local organic tomato supply chain

The following Table 10presents the characteristics of the Local tomato supply chain. This supply chain is based on direct sales to consumers, in which farmers produce most of the products delivered to customers. In this case, more than 60% of the tomatoes are produced by the farmers and the remaining 40% of the tomatoes are bought from other farmers.

Table 10. Characteristics of the Local tomato supply chain

	Production	Distribution	Local chain	Units
Total land use	3.000	80	3.080	m^2
Land use	400	4,9	404,9	m^2
Human activity	126	55	181	H
Production/Distribution	1.385	1.385	1.385	Kg
Sales price	1,6	2,5	2,5	€/Kg
Tomatoes bought to other farmers		808	808	Kg
Costs				
Agricultural inputs/Tomatoes bought to other farmers	499	0	1.791	€
Cost machinery	39	2	42	€
Labour costs	423	232	791	€
Familiar labour	423		423	€
Transport	0	62	98	€
Direct costs	1.385	296	3.146	€
Rent	34	10	44	€
Other indirect costs	6		6	€
Indirec tcots	40	10	50	€
Total costs	**1.425**	**306**	**3.196**	**€**
Income & Taxes				

	Production	Distribution	Local chain	Units
Gross income		3.462	3.462	€
Taxes	-24	132	108	€
Net income	-1.401	3.024	1.623	€
Value added	-578	3.388	2.810	€
Salaries	6,72	6,72	6,72	€/h
Energy consumption & CO_2 emissions				
Diesel consumption	10	30	40	lts/year
Energy consumption (diesel)	103	295	399	kWh
Electricity consumption	48	12	60	kWh
CO_2 emissions	27	77	104	gr CO_2/year

5.2.2. Mixed and Global organic tomato supply chains

The nextTable 11 and Table 12 present the characteristics of the Mixed and Global supply chains. In the case of the Gobal supply chain, it is assumed that all the production from Almeria is done in a farm typology like the one considered for this case study[7].

Table 11. Characteristics of the Mixed food supply chain

	Farm	Wholesaler	Retail	Chain	Units
Total land use	18.000	2.000	475	20.475	m2
Land use tomatoes	2.600	7	30	2.636	m2
Human activity	998	69	1.069	2.136	h
Purchases wholesaler/retail	9.300	9.300	8.197	9.300	Kg
Sales wholesaler/Retail		8.197	7.958	7.958	Kg
Sales price wholesaler/Retail		2,2	3,4	3,4	€/Kg
Sales price farmer/wholesaler	1,59	1,59	2,2	1,59	€/Kg
Costs					
Direct costs	1.593	14.817	18.033	34.443	€
Cost machinery	288			288	€
Labourc osts	4.623	1.772	4.348	10.743	€
Familiar labour	2.081			2.081	€
Transport	804	424	820	2.048	€
Direct costs	9.388	17.013	23.200	49.602	€
Rent	332	323	2.866	3.521	€
Other indirect costs	589	503	728	1.820	€
Amortization	919			919	€
Indirect costs	1.840	826	3.594	6.260	€
Total costs	**11.228**	**17.839**	**26.795**	**55.862**	**€**
Income & Taxes					

[7] As mentioned in the description of the chains, about 60% of the tomatoes purchased by the Global wholesaler are produced in Almeria. The data for the Global farmer were obtained from Moleres (2009), who presents the results of a sample of 42 organic farms producing different varieties of tomatoes in greenhouses.

Gross income	14.787	18.037	26.765	59.589	€
Taxes	323	86	3.258	3.667	€
Net income	3.236	112	0	3.347	€
Value added	10.263	1.970	7.606	19.839	€/h
Salaries	6,7	25,6			€/h
Energy consumption & CO_2 emissions					
Diesel consumption	70	125	253	447	lts/year
Energy consumption (diesel)	707	1.255	16	2.317	kWh/year
Electricity consumption	1.167	79	3.619	4.864	kWh/year
CO_2 emissions	272	326	7	605	Kg CO_2 eq/year

Table 12. Characteristics of the Global food supply chain

	Farm	Wholesaler	Retail	Chain	Units
Total land use	4.606	2.000	2.103	8.709	m2
Land use tomatoes	4.606	29	132	4.767	m2
Human activity	1.610	306	4.729	6.645	h
Purchases wholesaler/retail	41.147	41.147	36.265	41.147	Kg
Sales wholesaler/Retail		36.265	35.209	35.209	Kg
Sales price wholesaler/Retail		2,2	3,4	3,4	€/Kg
Sales price farmer/wholesaler	1,59	1,59	2,2	1,59	€/Kg
Costs					
Directcosts	7.116	65.557	79.783	152.456	€
Cost machinery	584			584	€
Labour costs	6.494	7.838	19.239	33.571	€
Familiar labour	4.330			4.330	€
Transport	1.852	1.878	3.627	7.356	€
Direct costs	20.375	75.273	102.648	198.296	€
Rent	732	1.431	12.680	14.843	€
Other indirect costs	350	2.224	3.223	5.797	€
Amortization	4.772			4.772	€
Indirect cots	5.854	3.655	15.903	25.411	€
Total costs	**26.230**	**78.927**	**118.551**	**223.708**	**€**
Income&Taxes					
Gross income	29.221	79.804	118.417	227.443	€
Taxes	214	382	14.414	15.010	€
Net income	4.376	494	0	4.870	€
Value added	15.414	8.715	33.653	57.782	€/h
Salaries	6,7	25,6			€/h
Energy consumption & CO_2 emissions					
Diesel consumption	25	551	1.117	1.693	lts/year
Energy consumption (diesel)	248	5.554	73	6.485	kWh/year
Electricity consumption	3.685	348	16.011	20.043	kWh/year
CO_2 emissions	223	1.444	31	1.699	Kg CO_2 eq/year

5.3. Performance indicators: key findings

The following Table 13 presents the performance indicators of the three organic tomato supply chains.

Table 13. Performance indicators of the Local, Mixed, and Global organic tomato supply chains

Attributes	Indicators	Local chain	Mixedchain	Global chain	Units
Fairtrade	Distribution of added value farmer	100%	51%	27%	%
	Distribution of added value wholesaler	n.a.	10%	15%	%
	Distribution of added value retailer	n.a.	38%	58%	%
Contribution to economic development	Gross income per unit of land	8,6	22,6	47,7	€/m^2
	Net income per unit of land	4,0	1,3	1,0	€/m^2
	Gross income per unit of labour	22	29	34	€/h
	Net income per unit of labour	10,1	1,6	0,7	€/h
	Number of jobs per unit of land	2,1	4,3	7,4	Worker/ha*
	Number of jobs per production	6,1	14,2	10,0	Worker/100 Ton
Affordability	Price (Ability to provide food at acceptable price)	2,5	3,4	3,4	€/Kg
Biodiversity	Agro-biodiversity	20	5	1	Number of crops
Pollution	CO_2 per land use	257	230	356	gr CO_2/ha
	CO_2 per labour	645	283	256	gr CO_2/h
Resource use	Consumption of energy carrier per land use	1,1	2,7	5,6	kWh/m2
	Consumption of energy carrier per labour	6,1	3,4	4,0	kWh/h
Creation and distribution of added value	Value added per unit of land	7	7,5	12,1	€/m^2
	Economic labour productivity	17,5	9,4	8,7	€/h
Labourrelations	Wages level				
Efficiency	Land productivity	3,4	3,0	7,4	Kg/m^2
	Labour productivity	8,6	3,8	5,3	Kg/h
Food security	Food availability	4	6	12	Months

The indicator of *land productivity* makes reference, in the case of the whole chain, to the amount of tomatoes handled by the chain. In this sense, the Global chain is able to handle larger amounts of tomatoes per square meter and by hour of human activity dedicated to produce and distribute tomatoes.

It is worth noticing that land productivities of the whole chains considers the tomatoes sold by the chain with respect to the total land uses in the chain. Also, the amount of tomatoes sold by the chain is lower than the tomatoes produced due to the losses within the chain. Therefore, land productivities of the chain tend to decrease with respect to land productivities of the farm due to two main reasons: a) land use increases, and b) the amount of tomatoes decreases. The increase of land use is not very relevant since the land use of the wholesaler and the retailer are

small in comparison with the agricultural land use. Losses have been considered after the production stage. This information has been provided by the wholesaler and the retailer.

In the case on *income* indicators, the monetary flows of the Global chain are larger than in the other two chains. But net income per unit of land and per unit of labour is higher for farmers involved in Local supply chain. As well, the contribution to economic development, in terms of creation of *addedvalue,* is higher in the Local supply chain.

The *creation of jobs* per unit of land use is much higher in the Mixed and Global chains. This is basically due to the contribution of activities performed in reduced spaces compared to agricultural land used for production (i.e. wholesaling and retailing).However, all the jobs created by the Local supply chain are located in rural areas, since production and distribution is performed by the same people who are living and working in rural areas (except by the distribution tasks). In contrast, the Mixed and Global chains create jobs in rural areas only in the production stage of the chain. Therefore, when talking about the contribution to keep rural population and dealing with ageing issues, the Local supply chains seems to perform better than the Mixed and Global chains (See Table 14).

Table 14. Creation of jobs in rural areas

Indicator	Local chain	Farm in Mixed chain	Farm in Global chain	
Number of jobs per unit of land	2,1	2,0	1,8	Worker/ha
Number of jobs per production	6,1	5,7	2,1	Worker/100 Ton

On the other hand, *economic labour productivity* is almost 2 times higher in the Local case than in the other two cases. That is, this chain creates more added value per unit of labour than the Mixed and Global chains. This is because in the Local chain most of the added value is created in the distribution stage, which requires lower amount of labour with respect to the amount of tomatoes sold. On the other side, the Global chain creates more added value per unit of land use than the Mixed and Local chains. This is because in the Global chain the added value is created in the retail stage, in which land use is smaller in relation to the amount of tomatoes sold.

Regading the *distribution of added value*, the Local supply chain performs better from the point of view of the farmer, who retains 100% of the created added value. In the case of the Mixed chain, most of the added value is retained also by the farmer. Recall that this farmer is member of the wholesale cooperative, and that the former objective of the cooperative was to facilitate the commercialization of products to the farmers and make their business more profitable. In the case of the Global chain, the wholesaler increases the share of added value and the farmer decreases its share. However, it is the retailer who retains most of the added value created along the chain.

Finally, in biophysical terms, the *consumption of energy carriers* per unit of land use is lower in the Localchain. This is due mainly to the fact that the Local supply chain delivers fresh products

one day after harvesting them, which makes the use of cooling chamber unnecessary. In the case of the Mixed and Global supply chains, the consumption of energy carriers in the wholesale center and the retail shops increases the energy consumption of electricity per unit of land use. On the other side, the Local chain consumes more fossil fuels than the Mixed and Global chains. This may seem counterintuitive to the reader considering the lower degree of mechanizationin the Local farm. However, transport plays an important role in this regard. The Local chain is characterized by the use of a small truck to distribute the tomatoes to the final consumers, which increases the consumption of diesel per hour of human activity allocated to this purpose.

6. Conclusions

In this report we have addressed a performance evaluation of three different food supply chains for organic tomato in Spain: Global, Mixed, and Local.

In the Local case tomatoes are produced by a network of small (i.e. less than 1 to 4 hectares) agro-ecological Catalan farmers who distribute their production to consumers through a direct sales scheme. Products then are transported by one or two members of the project to the distribution points, mainly consumption cooperatives. In the Mixed case tomatoes are produced by medium size Catalan farmers, who sell their product through an organic wholesaler cooperative of which they are members. The wholesaler mainly sells the product to organic shops. Finally, in the Global chain, the production of tomatoes is done in greenhouses in the South of Spain. Once produced, tomatoes are transported about 800 kilometres to the main organic wholesaler in Barcelona. The wholesaler then supplies tomatoes to local supermarkets, retailers, and local distributors.

Our results show that the Global chain is the most productive of the three, both per unit of land and per unit of labor, meaning that it is able to handle a larger amount of tomatoes both during production and distribution stages. As for economic development, the Local chain is significantly contributing most, as it is able to retain a greater amount of added value. Also, the Local chain is the one generating higher net income. In terms of jobs creation, the Mixed and Global chainsare the most labour intensive. However, as previously stated, we think that quantitative results should be complemented with qualitative information related to the quality of the created jobs (i.e. working conditions) in order to have a more accurate evaluation, particularly in the Global case.On the other hand, economic labour productivity is much higher in the Local case, so its productive potential is the highest of the three. Our results for energy consumption are not yet conclusive, as we have yet to consider the wholesaler to final consumer step. The same must be highlighted concerning CO_2 emissions.

Finally, we would like to point out two important methodological reflections:

- Assuming a chain approach may not be the most suitable frame when analysing different food supply systems. Indeed, it is suitable for Global food supply chains but not necessarily for other chains. In our case study, Local and Mixed chains involve diversified

actors (i.e. producers who are also distributors), so links (stages) in the chain are not independent.

- Also, focusing in one product to assess the performance of a chain is an important limitation when considering diversified productive systems.

In order to overcome these limitations, we suggest revising the Local/Global categories used in the GLAMUR project. For what we have observed in the organic tomato case, food systems could be instead characterized according to their identity, or their openness. We think in this way our cases could be better evaluated and compared to most productive chains in Catalonia, as well as with other countries. Thinking about next steps, we are working on an alternative categorization to be shared with partners.

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