CASE STUDY

PROCESSING TOMATO OF NORTHERN ITALY (ITALY)

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1 Introduction: What is the case study about?

The "processed tomato supply chain of northern Italy" is a market-driven case study, characterized by an innovative governance system (Inter-branch Organisation) guaranteeing both vertical and horizontal cooperation and coordination within the supply chain and production and processing adaption to environmental and economic sustainability requirements. Main ESBOs investigated are healthy functioning soil and water quality and quantity, whose provision is driven mainly by increasing demand for sustainable food products and for quality, social and environmental certifications but also supported by policies with indirect and direct focus.

The whole processed tomato supply chain of northern Italy covers four Regions (Emilia-Romagna, Lombardy, Piedmont, Veneto) and an autonomous Province (Bolzano), accounts for 39,000 hectares under tomato, comprises 2,000 producers grouped in 15 Producers Organisations (PO) and 24 processing companies operating in 29 plants, processes almost 3 million tons of tomatoes into concentrate, pulp and paste that represent 50% of the overall Italian processing tomato, 25% of the European production and 6.5% of world production.

Three quarters of the total area belongs to Emilia Romagna (provinces of Parma, Piacenza and Ferrara) and our analysis is limited to 37 municipalities belonging to the Provinces of Parma and Piacenza where historical roots and core business are mainly located.

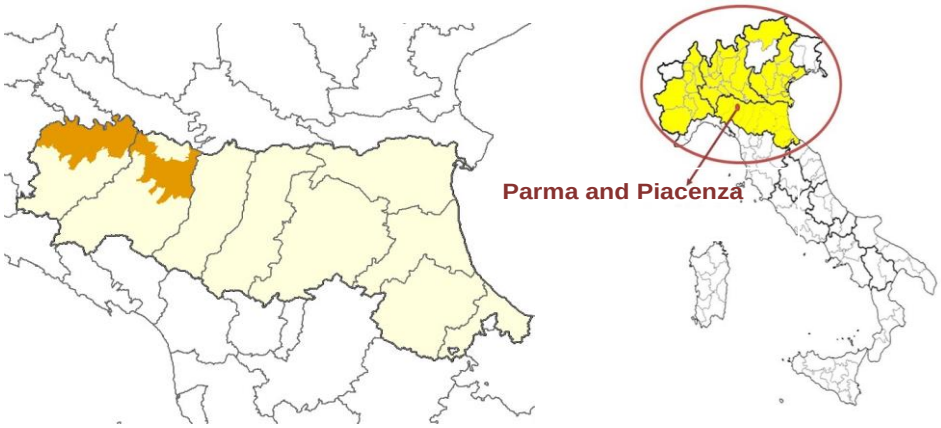

Figure 1: The case study area (in orange) and the supply chain area (in yellow)

The Po Valley suffers from very high environmental pressure from agricultural activities and livestock manure, but also from industrial and human activities. And open field processing tomato production is no exception since it requires highly intensive soil and water management, since plant growth and tomato quality and yield depend both on the soil structure for physical support and anchorage and on nutrients and water supply.

However, in the northern Italy supply chain a favourable convergence of attitudes, policies and market conditions occurred and allowed over time fruitful interactions between main private stakeholders and public authorities aiming, initially, at maintaining soil and water quality by minimising degradation and maintaining good biological and chemical conditions and, at a later stage, at reducing the quantity of water employed for production and processing, thus

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combining the need for adequate water supply for irrigation and processing and minimum volume and flow of streams.

This course of events is characterised by the introduction of relevant innovation in agricultural practices and processing techniques that created the necessary conditions to reduce soil depletion and water consumption while paying due attention to economic sustainability.

In particular, faced with the pressing need to tackle the challenges of environmental, economic and social sustainability, the supply chain found a collective response marked by two major turning points in **farming and technological innovation**: the introduction and the widespread application of integrated production in the early '90s and microirrigation in the early 2000s. And also **organisational innovation** ensued: the standardisation of criteria and procedures among the Regions involved favoured increased attention to reduced impacts on the environment at supply chain level and changes in markets and policies required progressive organisational adjustments which led to the establishment in 2007 of the association "District of industrial tomato" between Producers Organisation, processing firms and their representative associations, local institutions and local research centres and in 2011 of the Inter-branch Organisation (IO) recognised by the Region and the European Union.

Therefore, in the tomato supply chain of northern Italy innovation has always gone hand in hand with organisation and social cohesion and more and more its essential feature is the commitment to support long-term economic growth while safeguarding environmental and social sustainability and market stability.

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Table 1: Key features of the case study on processing tomato of northern Italy

Region or locality	Region Emilia Romagna, focused on 37 municipalities belonging to the Provinces of Parma and Piacenza.
Main Farming/ forestry system	Agriculture, mostly arable crops (tomato, wheat, maize) and forage. But also significant livestock farming.
Area (ha) of initiative (& Case Study)	The whole northern Italian supply chain accounts for 39,000 hectares under tomato, whereas the case study is focused on 37 municipalities of the Provinces of Parma and Piacenza (Emilia Romagna Region) with 14,000 hectares under tomato (nearly 40% of the supply chain).
Key ESBOs covered	Soil protection and functionality and water quality and availability
Total no. of farmers/ foresters involved	About 600 tomato farms based in the case study area
Other key stakeholders involved	Producers Organisations and Cooperatives, Processing Farmers Cooperatives, Processing firms; support from local institutions (Provinces, Chambers of Commerce, Region) and from key professional organisations in the sector (confederations of farmers and of industries); involvement of local research centres (Experimental Farms, Experimental Station for the Food Preserving Industry, local university).
Source(s) of funding	Public support through Common Market Organisation (CMO) and regional funds (Rural Development Plans, Regional laws)
Main steps of the processing tomato supply chain	Mid/End-1800s: start of open field tomato cultivation (parallel rows of tomato plants tied up to stakes stuck in the ground) and of tomato industrial processing From 1970s: widespread use of bush varieties of tomatoes and mechanization From 1970s: association of tomato producers in Producers Organisations From early '90s: shift from conventional farming to integrated production From early 2000s: widespread use of microirrigation From 2007: association "District of industrial tomato" between Producers Organisation, processing firms and their representative associations, local institutions and local research centres and then, in 2011, Inter-branch Organisation recognised by the Region and the European Union

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2 Definition of the social-ecological system (SES) studied

2.1 Figure of the SES

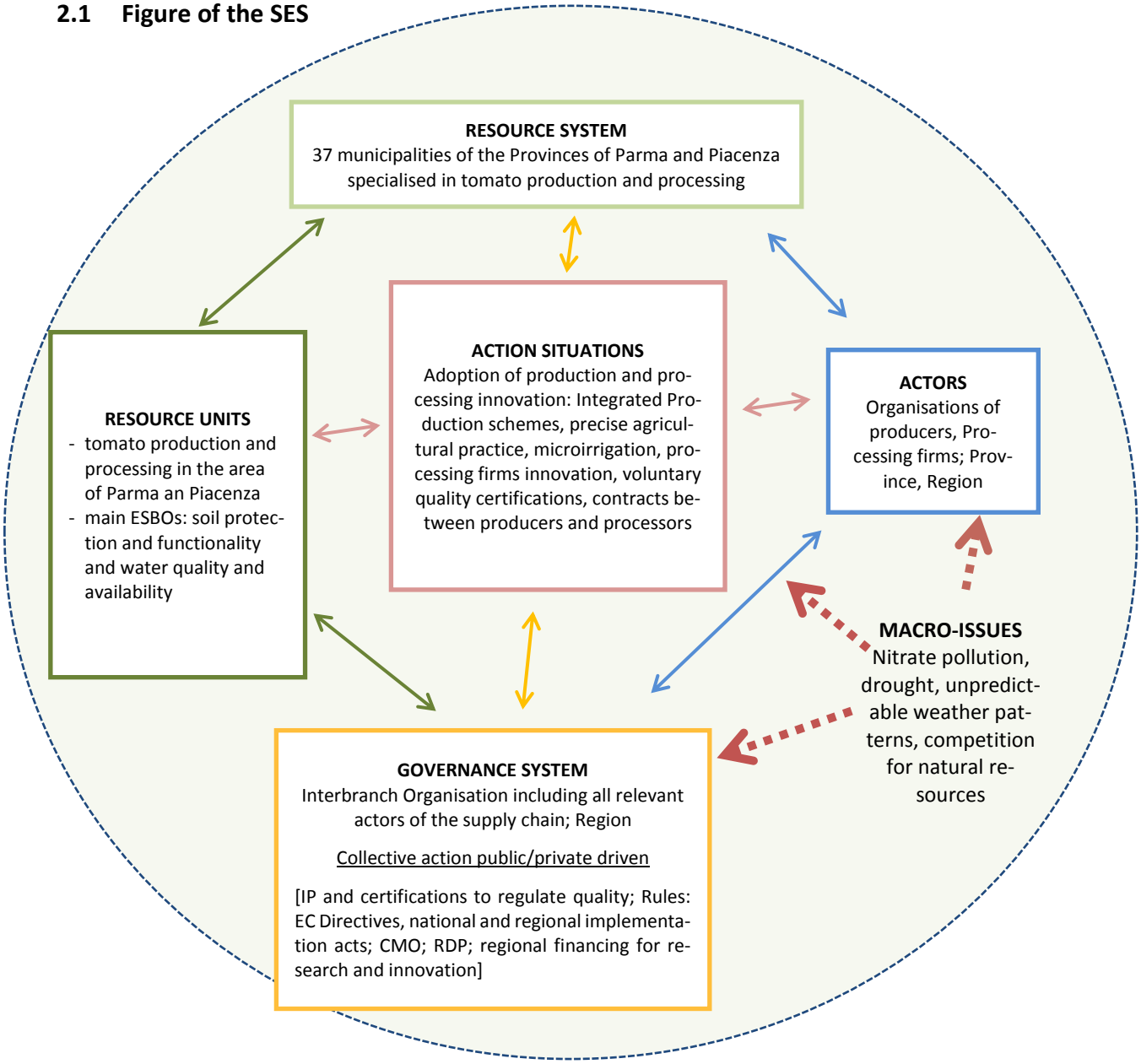

Figure 2:
Tomato supply chain SES framework
(adapted from Ostrom and Cox 2010; McGinniss and Ostrom 2014)

2.2 Description of the SES

Soil protection and functionality and water quality and availability are the main ESBOs in the processing tomato chain and they cannot be dealt with separately, since soil structure and conditions are fundamental for decisions concerning water management, water saving and irrigation infrastructures. Moreover, tomato is a high-input crop (nutrients but also water) and

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irrigation water levels are strictly related not only to irrigation methods but also to the needs of the crop.
The provision of ESBOs related to water and soil is indirectly delivered through productive and investment choices of the supply chain actors. Producers and processors were urged to guarantee production and processing viability by dealing with severe emergencies related to soil and water (mainly nitrate pollution, drought, floods, competition for natural resources) and to gain competitive advantage by meeting new consumers' demand (certified quality food, environmental-friendly productions).

Widespread use of innovation initially depended primarily on economic decisions of private actors, lured by the savings that could be made by reducing pesticides, water and energy consumption, rather than on a general focus on environmental concerns. However, fortunately, anticipating critical issues affecting the whole tomato supply chain, private needs coincided with increasing attention to reducing pressure on natural resources and environmental impact. Furthermore, the increasing national and international demand for high environmental performance products entailed a willingness to reward farmers and processing firms for their role in safeguarding the environment by paying higher prices for foods produced/processed under stringent rules: among other recommendations, the Statute of the Inter-branch Organisation commits all producers to follow, promote and guarantee regional integrated or organic production specifications and all processors to reduce the impact on the environment and to reuse by-products and waste water, also for energy purposes.

In particular, considering that soil and water are the natural resources more susceptible to effects associated to the tomato supply chain, two major innovations can be identified.

As for soil functionality and water quality, the adoption as of early '90s of **integrated production** (and other services related to it) brought a reduction of pesticides which meant lower costs for treatment but also lower residues in tomato and lower impact on soil and water.

As far as water saving is concerned, instead, from the '90s onwards, industries started to introduce techniques aimed at reducing water consumption levels, such as recycling and reuse of waste water, aseptic filling, capture of evaporation water. But it was the adoption of **microirrigation** in the early 2000s to bring a breakthrough. The benefit for tomato producers has been twofold since the reduction in quantity of water used to irrigate not only meant lower costs for water but also lower moisture near the tomato plant, lower possibility of mildew development and lower plant protection treatments (and costs).

2.3 Levels of ESBO provision, trends and determinants

Tomato production and processing is highly resource-intensive: outdoor tomato production typically calls for ploughing to a depth of 40 to 50 cm before sowing and on average, in order to obtain yields around 80-100 tons per hectare, there is a need of nutrients supply of 180-200 kg per hectare of nitrogen (N), 100-120 kg per hectare of phosphorus (P_2O_5) and 150-200 kg per hectare of potassium (K_2O), and of seasonal water supply of 4000-5000 m^3 per hectare depending on rainfalls and temperature.

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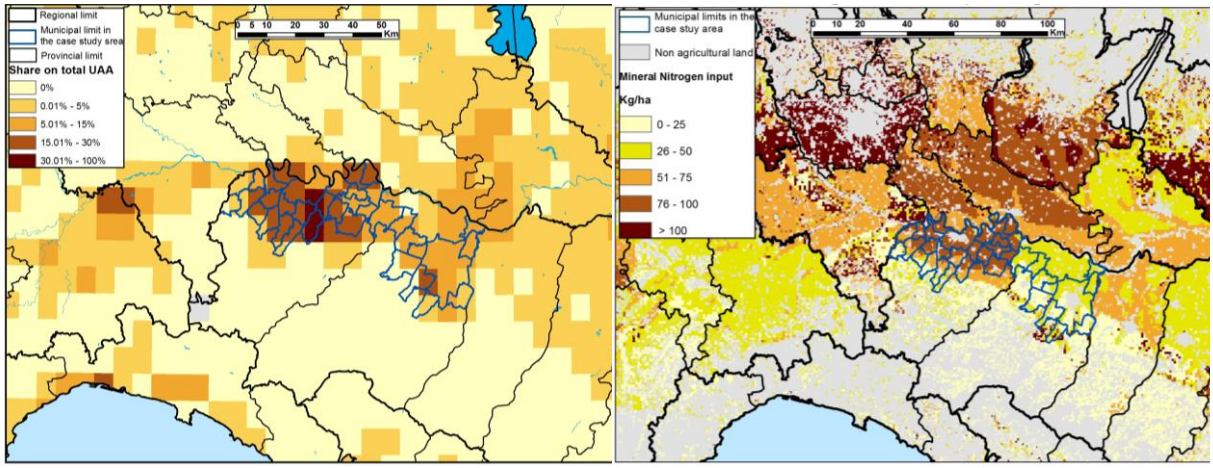
But soil and water are under increasing pressure also driven by a large number of other human activities, such as industry and urban development, and nitrogen pollution and water footprint of animal husbandry is considerable (mostly in Parma area).

It is therefore hard to assess the contribution of the tomato sector to local concentration of pollutants (see Figure 3 for comparison between distribution of outdoor fresh vegetables and nitrogen inputs in the study area) and to environmental pressure since the study area is located in the Po Valley, which is one of the most important industrial and agricultural areas in Italy and has a population density among the highest in Europe.



** mineral nitrogen fertiliser input (Kg of nitrogen per hectare of UAA) is elaborated from data of the Common Agricultural Policy Regionalised Impact model (CAPRI), baseline 2008*

Figure 3: Outdoor fresh vegetables UAA on Total UAA (left) and mineral nitrogen fertiliser input in agricultural land* (right)

Source: Elaborations of the European Commission Joint Research Centre, ISPRA Italy

However, soil quality and functions and water quality and quantity are strictly interconnected and the supply chain of northern Italy has as a long-standing commitment in this regard, with the aim of maximising yield, reduce waste, increase productivity and quality while reducing the impact on the environment.

Priority has long since been given to cultivation and processing methods respectful of the environment and to investing in research and innovation not only to enhance wealth by producing more (granting of a better balance between input cost and output value and at avoiding fluctuations of output prices and increase productivity and profitability) but also to enhance human health and the environment by means of practices and technologies aimed at minimising the impact on human health and making the most of natural resources and at improving soil fertility and water quality (Table 23 in 9.4).

Producers Organisations played the most relevant role in promoting and implementing environmental-friendly practices, however the beneficial outcomes provided are linked not only to agriculture, but to the whole supply chain. Initially it was a rational technical and economic choice, but since good soil and water conditions are essential for granting good crop yields, farming methods have more and more been aimed at balancing environmental protection and

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competitiveness and agricultural production has started to pay particular attention to protection from erosion, minimisation of the use of pesticides and fertilisers, incorporation of organic matter to the soil, crop rotation, progressive reduction of water quantity to give to crops.

The first major turning point in the provision of beneficial outcomes on soil and water was with the adoption of **integrated production** in the 90s and of **microirrigation** in the years 2000. And public policies fostered and supported the change of attitude already begun.
Whereas the European framework directive on the sustainable use of pesticides and the mandatory application of integrated pest management in all European farms came into force in Italy just in 2014 with an Inter-ministerial Decree approving the National Action Plan on the sustainable use of pesticides, in Emilia Romagna Region the transition from conventional agriculture to sustainable agriculture had already started in the 1980s with pest management provisions, and went through successive steps that resulted in integrated crop management schemes aimed not only to reduce the use of chemicals and to respect the environment and human health, but also to minimise water and energy consumption without undermining product quality and competiveness.

In the 90s, regional technical standards for integrated production in industrial tomato cultivation were defined in cooperation with research centres and producers organisations and from then on updated every year, in order to guarantee the best possible use of all the most advanced farming practices with a view to both ensuring competitiveness and to providing sounder guarantees of the quality of product to consumers while respecting the environment. In 2006, already 60% of the tomato was produced according integrated production rules. At present in Emilia Romagna overall Utilised Agricultural Area of integrated production for vegetables is 64 thousand hectares (Figure 8 in Annex), of which 20% for tomato cultivated in Parma and Piacenza.

There is evidence that integrated production proved to have positive environmental results, even if not referred to tomato (whose integrated production is financed mainly through CMO Operational Programmes). The Regional Rural Development Plan 2000-2006 Mid-term and Final assessment data reported in the technical implementation fiche for Actions 1, 2, 5, 6 and 9 of Measure 214 “Agri-environmental payments" of the Regional development Plan 2007-2013 show that in mid 2000s with integrated production, compared to the “Good Agricultural Practice” usually adopted, there was an average reduction of pesticides of 20-30%, a lower impact on human health (of producers, first of all) and on the environment due to minor use of high and medium acute and chronic toxicity products, and an average reduction of fertilisers of 30-45% referred to the quantity of macro-elements (nitrogen N, phosphorous P, potassium K) thanks to new methods and different application period that determined minor releases in groundwater (-40% for nitrogen, -60% for phosphorous), making a positive contribution to the downward N-P-K trend registered at regional level (Figure 9 in Annex). And this is true also as far as technical standards for outdoor tomato under integrated production is concerned: in comparison to conventional farming the inputs admitted for an yield of 65-95 tons per hectare at present have been fixed at: 130 kg per hectare of nitrogen, 80-130-190 kg per hectare of phosphorus (plots with high-normal-low amount) and 120-200-250 kg per hectare of potassium (plots with high-normal-low amount).

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Also concerning irrigation systems Producers Organisations held a key position in the adoption of water-saving practices. The development of optimal water management strategies is, in fact, one of the main concerns of the tomato supply chain. First of all, yield and quality of tomato (brix level) depends on water (and nutrients) inputs. Secondly, only appropriate irrigation management can preserve soil and water quality by avoiding nitrate leaching and groundwater pollution. Furthermore, water management is fundamental also for soil and water quantity, since groundwater extraction higher than natural reload is causing depressurization of the aquifer and a consequent serious and irreversible land subsidence problem (Figure 10 in Annex).

In this respect, the main turning point was the diffusion of microirrigation starting from the year 2000, when farmers started to adopt high efficiency irrigation systems better suited to new environmental conditions (+65% between 2000 and 2010 in Emilia Romagna, see Figure 11 in Annex). In the last years irrigation water needs grew by 20-30% due to higher temperature and heatwaves that extended irrigation season and increased evapotranspiration, whereas effective rainfalls and water level in rivers, lakes and reservoirs decreased, and consequently water saving has become fundamental (particularly for the Piacenza area, where average temperature rise and average rainfall decrease are worse and where tomato production is mainly concentrated; Figure 12 in Annex). Moreover, as for water quality and quantity, besides water sources and irrigation systems used, also tomato varieties chosen and its hydro-nutritional needs according to soil structure and temperatures have to be considered (Tables 22 and 23 in 9.4). But water saving is hard to manage at the farm level, because surface water and groundwater are influenced not only by the plant physiology but also by their geological characteristics, anthropic activities, atmospheric conditions.

Parma and Piacenza have always been characterised by the adoption of the most efficient agricultural practices available and focus was always both on the beneficial effect on the environment and on increasing profitability. However, from the point of view of the measurement of the reduction the negative impacts of an intensive crop as tomato, it is very hard to discriminate impacts from agriculture, processing and other human activities and to indicate, on a case-by-case basis, what is the final output of each technical and organizational innovations introduced for tomato growing and processing in the past 40 years.

The productive phase of the tomato supply chain is not fragmented. Tomato farms have quite a big size: 40% of the tomato area is cultivated by 15% of the farms. Average farm size is more than 20 hectares and 40% of farms exceed 20 hectares, while just 28% are of less than 10 hectares (Table 2). Value of tomato production per farm is relevant also for smaller farms, where the contribution to family income is adequate to employ one full time working unit and the value is more and more remarkable as farm dimension increases.

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Table 2: Tomato farms in the study area

Farm size (hectares of tomato)	Nr. of farms	%	Utilised Agricultural Area (hectares)	%	Tomato cultivated area (hectares)	%	Value of tomato production €	Value of tomato production per farm €
<=10	171	28%	5,113	13%	1,041	7%	5,852,589	34,226
<=20	190	32%	9,625	25%	2,888	21%	16,228,716	85,414
<=40	150	25%	12,204	32%	4,390	31%	24,674,044	164,494
>40	90	15%	11,694	30%	5,721	41%	32,154,057	357,267
Total	601	100%	38,636	100%	14,040	100%	78,909,407	131,297

Source: our elaborations from Agricultural Census data (2010)

More than half of the 600 tomato farms and are in Piacenza area, where we find 80% of the farms belonging to the class of 40 hectares or more. And, the bigger is the farm size, the less differentiated are the crops (Table 3). In firms with 10 or lesser hectares, instead, tomato is not very relevant and accounts just for 1/5 of their cultivated land: the smaller the farms are, the less significant is the amount of land under tomato compared to other arable crops, mainly compared to forage (31%). Piacenza is the leading tomato producer in Emilia Romagna and in the whole northern Italy, however if we consider all arable crops, tomato represents a small portion of them (15%); more common crops are wheat and forage (both 27%) and maize (16%). In Parma, instead, which is the third tomato producer in Emilia Romagna and the north, forage is the first arable crop (56% of total) and wheat the second (19%), whereas tomato accounts just for 8%.

Table 3: Arable crops in farms located in the study area (hectares, %)

Farm size (hectares)	Arable crops	Tomato	%	Wheat	%	Maize	%	Other cereals	%	Forage	%	Other	%
no tomato	80,015	0	0%	17,797	22%	11,109	14%	3,631	5%	40,044	50%	7,433	9%
<=10	4,846	1,041	21%	1,226	25%	458	9%	132	3%	1,506	31%	483	10%
<=20	9,412	2,888	31%	2,524	27%	1,013	11%	155	2%	1,749	19%	1,084	12%
<=40	11,858	4,390	37%	3,287	28%	1,252	11%	218	2%	1,926	16%	785	7%
>40	11,544	5,721	50%	3,195	28%	739	6%	70	1%	1,121	10%	698	6%
Total	117,676	14,040	12%	28,030	24%	14,571	12%	4,205	4%	46,346	39%	10,483	9%

Source: our elaborations from Agricultural Census data (2010)

This composition reflects in part the specialisation of the two areas and in part the adoption of crop rotation plans, mandatory for cultivation produced according the integrated production regional guidelines. And tomato is 94% integrated production and 6% biologic. In the two provinces, half or more of the arable land in the tomato farms follows a crop rotation plan. This reflects the great attention given to maintain the soil clean and fertile, to reduce the risk of pests and diseases, to improve soil mineralisation and to enhance yield quality and quantity. Once again, the bigger the farms are, the higher the percentage of arable land under rotation plan is (almost 60%).

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Table 4: Crop rotation (hectares, %)

Farm size (hectares)	Arable crops	Monocolture	%	Free crop rotation	%	Crop rotation plan	%	No answer	%
no tomato	80,015	1,298	2%	15,078	19%	21,700	27%	41,939	52%
<=10	4,846	1	0%	1,019	21%	2,186	45%	1,640	34%
<=20	9,412	107	1%	2,293	24%	4,950	53%	2,062	22%
<=40	11,858	188	2%	3,224	27%	6,234	53%	2,212	19%
>40	11,544	60	1%	3,439	30%	6,723	58%	1,323	11%
Total	117,676	1,654	1%	25,053	21%	41,793	36%	49,176	42%

Source: our elaborations from Agricultural Census data (2010)

As for soil management (table 5), arable land is mainly conventionally sowed: an average of 80% of tomato farms arable land, ranging from 74% in smaller farms to 86% in farms with more than 40 hectares. This reflects the widespread utilisation of Integrated Production schemes that require conventional sowing at 40-50 cm and then a second soil working (grubbing, vibration).

Table 5: Soil management (hectares, %)

Farm size (hectares)	Arable crops	Conventional sowing	Surface ploughing	No tillage	No answer
no tomato	80,015	61%	2%	4%	33%
<=10	4,846	74%	2%	2%	21%
<=20	9,412	82%	3%	2%	14%
<=40	11,858	82%	4%	3%	10%
>40	11,544	86%	5%	1%	8%
Total	117,676	68%	2%	3%	26%

Source: our elaborations from Agricultural Census data (2010)

Most of the fertilisation of tomato farms is not organic (table 6). Standard procedures of Integrated production envisages specific requirements for organic fertilisers but it is mainly used controlled chemical fertilisation based on quantification of crop absorptions and additions to compensate losses and calculated with a specific free software and/or suggested from technical advisors of the Producers Organisations and of processing firms or from technical means suppliers.

Table 6: Organic manure (hectares, %)

Farm size (hectares)	Arable crops	Solid dung	Slurry	No organic manuring
no tomato	80,015	24%	21%	55%
<=10	4,846	22%	25%	52%
<=20	9,412	14%	13%	73%
<=40	11,858	16%	12%	72%
>40	11,544	17%	13%	70%
Total	117,676	22%	19%	60%

Source: our elaborations from Agricultural Census data (2010)

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Tomato is a highly water demanding crop and correct irrigation is essential to grant yield and quality, since tomato suffers from water stress in every period of its growth. Most of the irrigation of tomato farms comes from groundwater and in much smaller part from water consortium (on turn or demand basis). Other sources, such as farm reservoirs and surface water, are of minor relevance.

Table 7: Sources of water for irrigation by farm size (% of farms)

Farm size (hectares)	Groundwater	Farm reservoirs	Lakes, rivers, streams	Water consortium (collective use)	Other source	No answer	Total
no tomato	32.7	3.6	6.1	17.0	5.1	35.4	100.0
<=10	62.0	4.1	6.4	25.1	1.2	1.2	100.0
<=20	66.8	3.2	5.8	22.6	1.6	-	100.0
<=40	65.3	2.7	4.7	25.3	1.3	0.7	100.0
>40	63.3	5.6	7.8	21.1	1.1	1.1	100.0
Total	36.5	3.6	6.1	17.8	4.7	31.3	100.0

Source: our elaborations from Agricultural Census data (2010)

It is worth noticing that the percentage of farms irrigating with groundwater is equal in bigger and smaller size tomato farms, as equal but to a lesser extent is the use of collective water sources. However, not necessarily high use of groundwater means high water consumption, since this depends from irrigations systems adopted.

Irrigation water quantity is a critical point for tomato. The Po Valley has a great irrigation potential, but competition on the use of water, higher temperatures and reduction in effective rainfalls make it difficult to balance tomato cultivation water needs and respect of minimum levels of surface and groundwater. Moreover, as mentioned before, a very serious problem is land subsidence, which is due to high groundwater abstraction.

It takes therefore particular importance how water-efficient irrigation systems are. Tomato farms adopt almost exclusively sprinklers and microirrigation, with which they tailor irrigation to soil and seasonal weather conditions, control disease and reduce drastically the use of pesticides, ensure the right level of humidity of the root structure, and enhance yield and quality of tomato. The use of sprinklers is almost evenly widespread among all tomato farm size, but it is more used in smaller farms than in bigger farms; microirrigation is instead much less adopted by small farms and remains reserved to bigger size farms.

Table 8: Irrigation system by farm size (% of farms)

Farm size (hectares)	Surface irrigation	Sprinklers	Micro-irrigation	Other systems	No answer	Farms
no tomato	0.5	4.1	1.3	0.1	94.0	100.0
<=10	5.3	65.5	19.3	1.2	8.8	100.0
<=20	4.7	58.4	31.1	1.1	4.7	100.0
<=40	4.0	54.0	36.7	1.3	4.0	100.0
>40	4.4	43.3	48.9	2.2	1.1	100.0
Total	1.0	10.4	4.9	0.2	83.5	100.0

Source: our elaborations from Agricultural Census data (2010)

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Therefore, evidence shows that intensification of tomato production favours the adoption of more sustainable agronomic practices and precision technology techniques which reduce the need for plant protection products and for irrigation and consequently reduce costs.

It has also to be noticed that bigger tomato farms pay more attention than smaller ones to conserve and/or restore the non-productive features of local rural landscapes, such as hedges and rows, which are also important for wild flora and fauna.

Table 9: Landscape (% of farms)

Farm size (hectares)	Farms with hedges	Farms with rows	Farms with dry stone walls	No elements of landscape	Farms
no tomato	12.6	14.0	1.2	72.3	100.0
<=10	16.4	15.2	4.1	64.3	100.0
<=20	16.8	22.6	0.5	60.0	100.0
<=40	20.0	28.0	1.3	50.7	100.0
>40	30.0	32.2	2.2	35.6	100.0
Total	13.4	15.1	1.3	70.3	100.0

Source: our elaborations from Agricultural Census data (2010)

Even in this case, it is the biggest firms that mostly improve biodiversity in agricultural land: they have twice the hedges and rows the smallest have and the number of tomato firms with no elements of landscape shows exactly the inverse proportion.
As a conclusion, it seems that intensification of tomato farms favours major sustainability of agricultural activities, since large farms invest more in environmental-friendly agronomical practices and in innovative water-saving technologies and methods (Figure 4). In percentage, it emerges that bigger farms:

- adopt crop rotation plans more (from 45% of the <= 10 hectares farms to 58% of the > 40 hectares farms),
- make lesser use of underground water (67% of the <= 20 hectares farms, 63% of the > 40 hectares farms) and of water from public consortia (25% of the <= 10 hectares farms, 21% of the > 40 hectares farms),
- use less irrigation with sprinklers (from 65% of the <= 10 hectares farms to 43% of the > 40 hectares farms),
- invest more in innovative irrigation systems (microirrigation ranges from 19% in <= 10 hectares farms to > 40 hectares 49% in farms),
- show a higher percentage of hedges and hedgerows and stone walls (from a total of 36% of the <= 10 hectares farms to a total of 64% of the > 40 hectares farms).

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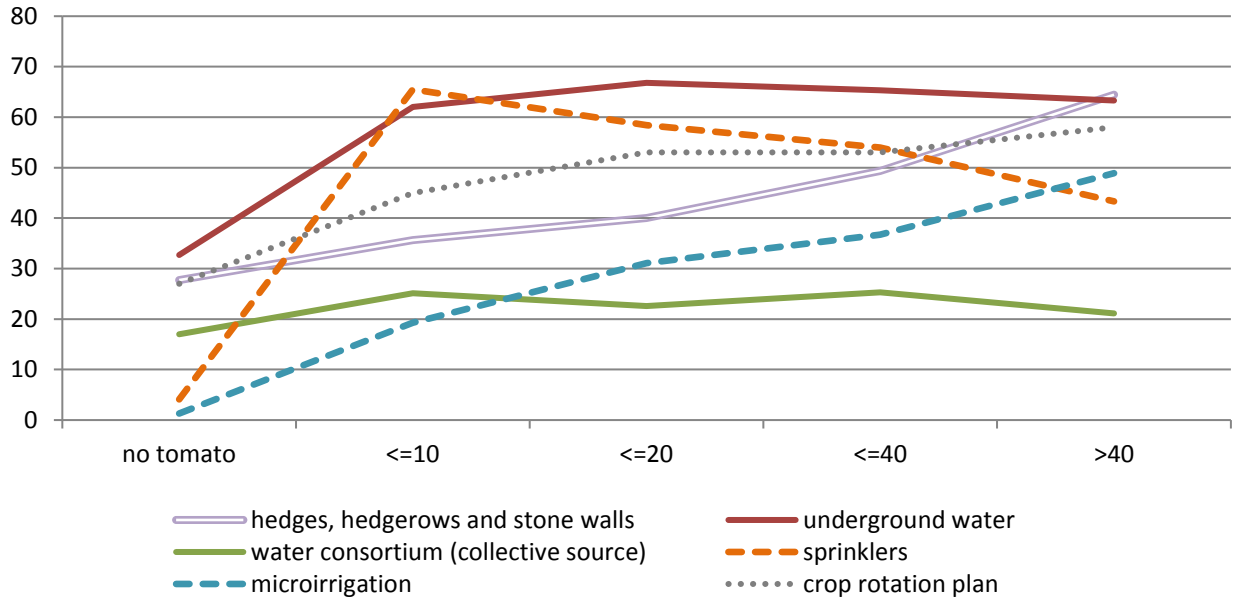
Figure 4: Key indicators of ESBOs by tomato farm size (% of farms; crop rotation=% of hectares)



Source: our elaborations from Agricultural Census data (2010)

2.4 Ancillary economic and social benefits provided 'on the back' of ESBOs

Investments in research and experimentation, introduction of innovative practices aimed at product quality, soil protection and water saving and respect of additional quality/quantity requirements set by producers and processing firms in tomato contracts resulted in higher costs and lower productivity compared to the other tomato producer countries.
However, notwithstanding global competition and a structural downward trend of tomato price, cohesion of the stakeholders and coordination of the Inter-branch Organisation grant the conditions and the context for matching tomato supply and demand entirely within their own geographical area.

Table 10: Comparison on costs and productivity in main tomato world producer countries

	Raw material cost (€)	Productivity (t/ha)	Gross agricultural production per hectare (€)
Northern Italy	95	72	6,840
Portugal	81	85	6,885
Spain	76	93	7,068
California	70	105	7,350
China	64	94	6,016

Source: Conforti G. - AIIPA, in Martelli G. (2015)

California and China are specialised in different products and address different markets. The direct competitors of Italian tomato are Spain and Portugal, whose productivity is favoured by more suitable soil and weather conditions and less restrictive agro-environmental conditions required (more active substances and soil sterilization admitted, etc.) despite acting under the same European framework.

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Higher costs of northern Italian tomato depend on pedoclimatic and regulatory conditions and on deliberate quality choices. At present the challenge is to guarantee more profitability in a world context of volatility of prices. But the supply chain manages to withstand competition by keeping up with practice, product and process innovation, by putting emphasis on safety, quality and environmental and social commitment and by differentiating products, progressively shifting from the commodities segment (concentrate and pulp, more exposed to competition) to the retail one (where profit margins are higher).

The economic dynamic of the tomato supply chain is remarkable. It is composed by large and very large producing and processing companies with a substantial workforce and a high turnover.
Most of the tomato farms are highly capital, labour and technology intensive and the employment generated is of crucial importance. Average working days per year in the area are very high (329) and, except for the smallest tomato farm class (whose average, anyway, is more than one full-time working unit per year), annual working days in all other classes are well above average, ranging from 339 up to 432.

In general, family labour is prevalent in all farms, but it is indirectly related to size (more than 80% in smallest farms, 60% in the biggest) mainly due to higher capital intensity and to the use of other typologies of labour (seasonal) as sizes increase.

In overall terms, hired labour becomes more relevant as farm size is greater, however while in the smaller farms permanent hired labour prevails on seasonal hired, the opposite occurs in bigger ones. This implies a major necessity for large highly mechanized tomato farms to fulfil labour need just for short periods, in line with the programming of production phases.

Table 11: Farm labour working days in the study area and distribution among family and hired labour

Farm size	Total agricultural working days	Annual working days per farm	Annual working days/UAA	% Family labour	% Permanent hired labour	% Seasonal hired labour
no tomato	1,470,133	327	16.7	78.2	17.3	4.6
<=10	49,974	292	9.8	83.9	12.3	3.8
<=20	64,340	339	6.7	69.00	21.2	9.8
<=40	54,008	360	4.4	65.7	18.7	15.6
>40	38,854	432	3.3	60.3	16.6	23.2
Total	1,677,309	329	13.2	77.2	17.3	5.5

Source: our elaborations from Agricultural Census data (2010)

But employment generated in the tomato production is even more relevant if also services to farms through contract labour and outsourcing are considered. Both of them are supplied partly by producers associations, partly by processing industries, partly by specialized firms.

The most part of contract labour inside/outside farms is hired by farms between 10 and 40 hectares, whereas large farms make wider use of seasonal contracts, as noticed also before. But most of the contract labour is seasonal and it increases as the size of the farms goes up, especially in comparison with contract labour inside the farm.

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Table 12: Contract labour used by different farm sizes (annual working days)

Farm size	Contract labour outside farm (A)	Contract labour inside farm (B)	Contract seasonal labour (C)	A/C	B/C
no tomato	6.624	16.406	67.288	10%	24%
<=10	556	1.280	1.914	29%	67%
<=20	788	1.867	6.295	13%	30%
<=40	774	1.529	8.417	9%	18%
>40	228	766	8.998	3%	9%
Total	8.970	21.848	92.912	10%	24%

Source: our elaborations from Agricultural Census data (2010)

Also outsourcing is frequently used, but especially from farms between 10 and 40 hectares. 30-40% of all tomato farms utilise outsourcing for mechanical harvesting and first processing of tomato, few utilise it instead for ploughing (except for the 10-40 hectares ones), and even less the sowing or fertilization.

Table 13: Outsourcing by farm size (% on arable land)

Farm size (hectares)	Arable land	Complete outsourcing	Ploughing	Fertilisation	Sowing	Mechanical harvesting and first processing	Other operation on the land	Other operation not on the land	No outsourcing
no tomato	80,015	4.4	10.8	3.8	6.5	34.6	5.2	0.1	34.5
<=10	4,846	4.8	8.1	1.7	4.9	34.0	4.0	0.1	42.4
<=20	9,412	1.9	12.1	1.5	6.2	38.4	4.2	0.04	35.8
<=40	11,858	1.4	13.2	2.7	4.1	28.7	6.0	0.02	44.0
>40	11,544	1.0	7.1	0.6	3.2	27.4	5.1	0.02	55.7
Total	117,676	3.6	10.7	3.1	5.9	33.5	5.1	0.1	38.0

Source: our elaborations from Agricultural Census data (2010)

The impact of tomato production on employment is therefore highly relevant, but while direct impact is mainly due to smaller farms, the increase in size of farms implies wider mechanization, major economies of scale and major use of seasonal labour (directly hired or under contract). Therefore, the increase in size of the farms less than 10 hectares could contribute to boost permanent (and seasonal) labour, and also contract labour. In fact, in bigger tomato farms only family labour plunges, whereas permanent hired labour and contract labour inside farm remain more or less constant and there is an increase in seasonal hired work (Figure 5).

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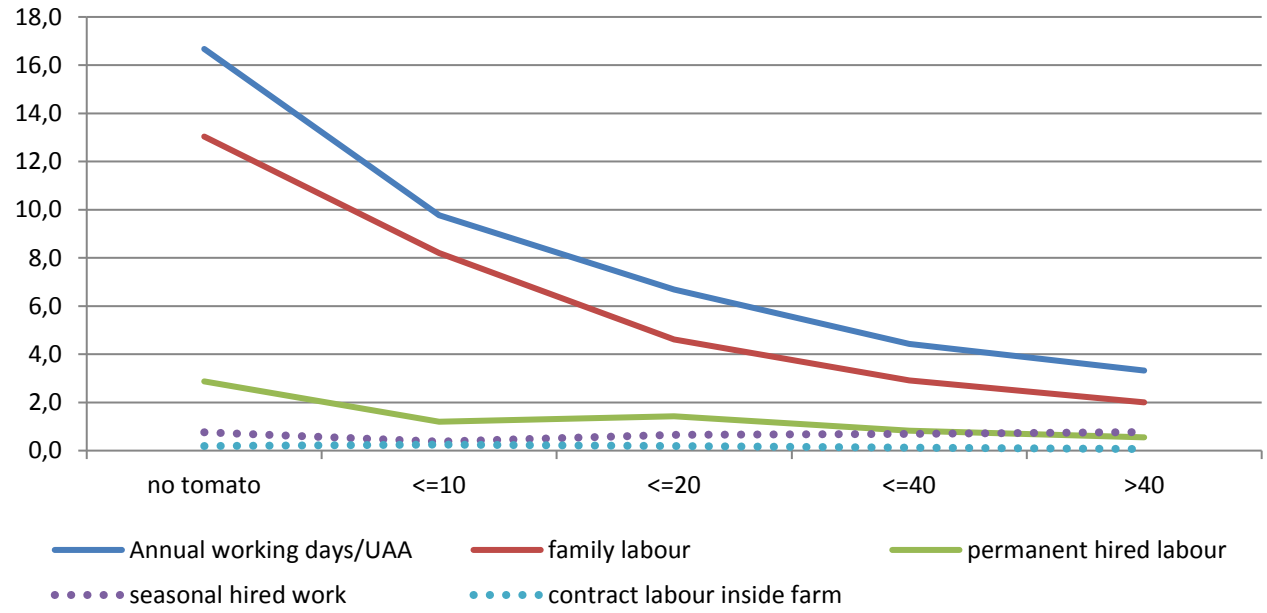
Figure 5: Employment effects by UAA of tomato farms



Source: our elaborations from Agricultural Census data (2010)

Positive effects of the lively economic trends of the tomato supply chain are also found in **exports**. In fact, the promotion of Mediterranean diet and of made in Italy products together with the high quality and hygiene standards of northern Italian processed tomato (60% of which in the study area) boosted exports.
There is, in fact, a significant upward trend in Emilia Romagna processed tomato exports, whose value increased of 40% between 2009 and 2015 and which represent 18-20% of the whole regional made-in-Italy exports and 8-10% of national agri-food ones.

Particularly relevant was the rise in 2015, when Emilia Romagna processed tomato accounted for 25% of national exports (424 million Euros on 1.7 billion), for 16% of all regional processed products and for 10% of the regional exports; tomato exports registered an increase of 3% in value, of 2% in volume and of 1.3% in price compared to 2014 (Emilia Romagna Region-Unioncamere, 2016).

Exports are the new frontier. The challenge that producers and processors are taking at present is to strengthen the position in the existing markets and to enter new markets where processed tomato consumption is still low. And the supply chain is already well equipped with the standards required as to respect of quality and safety of products and national and international quality certifications, as we will deepen further on in the text.

3 Shifting societal norms, collective learning and voluntary actions

Decades of key stakeholders interconnections within the supply chain tomato supply chain led to a success story of economic growth and attention to a new balance between agro-industry and environment, for the benefit of producers/processors, consumers, and natural resources.

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Profitability strategies inevitably imply intensification of farming in order to maximise profit levels per hectare. The keywords are: to produce less, to have better prices, and to use less agricultural land for tomato production in order to reduce unit price. However, in the tomato supply chain intensification does not necessarily conflict with regulatory and social requirements in support of sustainability.

The success of the tomato supply chain is based on investments in organizational and technical innovation geared to support long-term economic growth. But particular emphasis is put on environmental and social responsibility.

Profit margins are squeezed between pressing competition that pushes world prices down and compliance with public safety and environmental parameters that leads to ever-increasing adaptation costs. But, the supply chain found a collective motivation that could grant profitability and at the same time reward producers and processors for attention paid to safeguarding the environment: differentiation based on quality.

Reputation and attention to quality represent the cornerstone of the supply chain, as emerged in the interviews:

“The supply chain has a cascade of safeguards that in the long run pays back”;

“It is thanks to quality that northern Italian tomato has gained a good position on the market and is always a step up the other competitors”;

“Everyone’s attention to sustainability is a guarantee for everyone else since this makes the entire supply chain unassailable on a whole series of issues, including food scandals”.
Producers and processing firms of the supply chain collectively learnt that reliability and quality are highly appreciated by the market, and intend to further ensure so by moving, as we will see in detail in paragraph 5, from an approach founded on holding-based schemes to an ecological system approach.

Behind organisational and technical innovation there is not only competitiveness but also ethic, sense of identity, common aim: competitiveness based on reputation and high quality rather than on price erosion. The collective action that is behind the Inter-branch Organisation (IO) is rooted in the tradition of cooperation and conflicts mediation practices of Emilia-Romagna agro-industrial sector. This tradition has produced a sort of contractual economy where the different interests at stake try to find co-decision processes.

Main objective of farmers and agro-industrial entrepreneurs is conciliating intensification with cost-reduction and quality requisites of the processed tomato. A satisfactory trade-off between these objectives is not easy to find. IO represents the “neutral” institutional place where this trade off was possible over time. Farmers push towards more and more intensification, while industrial sector tries to strengthen quality features of the processed tomato.

The fundamental instrument for conciliating these conflicting parties is the quantitative and qualitative programming and control of production, in relation to the market demand. As we

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will see in the next paragraph, this collective action based on dialogue and setting common general rules was under serious crisis. Global competition on the European and international market implied a reduction of the bargaining margins in the annual contracts. This can be considered a transition period where the IO action is becoming more and more hard to carry out.

4 Mechanisms, (collective) actions and governance arrangements to enhance the level of ESBO provision

4.1 Organisational capacities, leadership, networking and communication

With a production of 5,4 million tons of tomatoes for processing in 2015 and a 13% share of the global market, Italy is the third world tomato producer after California (31%) and China (14%) and the first in Europe (50% of the market), far ahead Spain and Portugal (44% altogether).

As already mentioned above, half of the Italian tomato is produced and processed in northern Italy and mainly in Emilia Romagna, where industrial tomato is the major horticultural crop.

Parma and Piacenza (together with Ferrara) are the leading producing provinces in the north and account for almost 40% of the whole northern Italian tomato cultivations, and include most of the processing firms of the supply chain, representing more than 60% of processed tomato.

Tomato production and processing shows a steady upward path, even if following a cyclical pattern partly due to the strong influence of weather conditions on yield and partly due to fluctuations in the consumption levels and consequent agreed choice between producers and processing firms to reduce tomato cultivation, as happened during the last years in the 2012 and 2013 campaigns and as reportedly is going to happen for the upcoming one.

Table 14: Tomato production and processing in northern Italy (hectares, tons)

	2011	2012	2013	2014	2015	2016
Tomato cultivated area (hectares), *of which*:	35,975	33,464	29,175	35,681	38,948	38,594
Emilia Romagna	*24,403*	*22,144*	*20,015*	*24,534*	*26,195*	*26,504*
Parma and Piacenza	*13,909*	*12,837*	*11,065*	*13,905*	*14,610*	*14,507*
Tomato production (tons)	2,562,828	2,370,917	1,889,374	2,322,065	2,623,514	2,773,146
Yield per hectare (tons/hectares)	71.24	70.85	64.76	65.08	67.36	71.85
Tomato processed (tons), *of which:*	2,491,878	2,289,368	1,883,434	2,357,939	2,651,045	2,813,638
Parma and Piacenza	*1,548,455*	*1,469,329*	*1,185,700*	*1,429,671*	*1,610,889*	*1,740,656*

Source: our elaborations on Inter-branch Organisation of processing tomato of northern Italy

The supply chain groups more than 2,000 producers, organised in Producers Organisations and cooperatives, and 24 processing companies and it is traditionally characterised by spatial concentration of tomato fields and processing premises, which are mainly located very near

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(maximum 60 km) in order to contain costs and to guarantee the freshness of the product (tomato is usually processed within few hours after harvesting). Processing firms, anyway, obtain also small tomato supplies from outside Parma and Piacenza, so to avoid the risk of local adverse climatic events.

The study area accounts for almost 40% of the entire supply chain production and for more than 60% of the tomato processing of northern Italy. The most involved area in the tomato production is Piacenza (around 9 thousand hectares, that is 25% of the supply chain and 37% of the regional tomato) while in Parma (specialized also in the dairy sector) the hectares under tomato remain around 4.5 thousand, accounting for 12% of the chain and 18% of the region. However, in both areas production is constantly growing and reached the highest production peak ever in 2016.

Tomato processing, is instead concentrated in the area of Parma, where are located more than half of the private processing firms and half of the processing producers cooperatives.

Moreover, in the area there is also a relevant presence of all the upstream and downstream phases of the supply chain, such as an advanced mechanical engineering industry, specialized in agricultural machineries, food processing lines, and packaging lines, services (research and experimentation, but also transports and logistics) and international promotion events specialized in agri-food (the international food exhibition CIBUS, the international food processing and packaging technologies CIBUS TECH).

Although initially the development of the tomato supply chain depended on a favourable combination geographical, historical and economic reasons, recent attainments result from pioneering choices of producers and processors made in order to anticipate specific relevant issues unsafe for market stability and competitiveness, such as fragmentation, out-of-date structures, and unsuitable quality of production.

The cooperative culture characterizing the Emilia Romagna area, the expertise and long-sightedness of the supply chain stakeholders and the financial support of European and regional funds (CMO, RDP, other funds) consolidated collaboration, coordination and organizational and technical innovation. Step by step, producers and processors passed from direct agreements between them, to formalised written contracts concluded through Producers Organizations in advance containing basic elements of the tomato supply (required for accessing coupled aid envisaged in the 1996 CAP reform).

From the 80s, the pivotal role was played by Producers Organisations. Although European agricultural policies required the grouping of tomato supply to have access to CMO aid, in the tomato area the grouping in POs corresponded to real needs of the supply chain, since the POs strengthened the position of producers in the market and in negotiations with the processing industry, organized collective purchases of production inputs, offering tailored-made consultancy services and technical support. Further on, in order to tackle in advance the new CAP reform and the decoupling of aids from actual tomato production and world competition, the stakeholders agreed on the need to guarantee coordination of the entire tomato supply chain and in 2007 decided to set up the association “District of industrial tomato” between

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Producers Organisation, processing firms and their representative associations, local institutions and local research centres.

Founder members of the association were the Provinces and the Chambers of Commerce of Parma, Piacenza and Cremona, the Union of processing firms of Parma (UPI), the provincial organizations of farmers (Coldiretti), local Producers Organisations and Association of Producers Organisations (AINPO, ASIPO, CIO), the local research centres (Experimental Farm Stuard, Experimental conserve production industry SSICA). But soon afterwards, the association enlarged its borders to include also other tomato areas in the nearby Regions (Lombardia, Piedmont, Veneto, Province of Bolzano) and finally, in view of new framework and market challenges to meet, in 2011 evolved into the present Inter-branch Organisation (IO) of processing tomato on northern Italy, soon afterwards recognized by the Region and the European Union.

The present set-up of the supply chain of northern Italy is very comprehensive and is characterized by a complex system of functional, technological and organizational relationships between the various players representing the production and processing stages and between them and institutions, research centres and provider of technical means and the intermediate/final market.

The Inter-branch Organisation is composed 50% by producers, all associated in PO and APO, and 50% by processing firms, partly private and partly cooperatives, all of them associated as well. It involves 62 members representing all the key actors of the tomato supply chain.

Advisory members (Provinces, Chamber of Commerce, professional agricultural organizations-Coldiretti, and representatives of processing firms - UPI, CONFAPI, and AIIPA) do not have the right to vote but have the right to issue opinions. Ordinary members are all the private processing industries (some of which with a centennial history, such as Mutti, Rodolfi, Greci, Manzella, etc.), the cooperatives of producers processing their own tomato (COPADOR, Conserve Italia, the recently merged ARP and Consorzio Casalasco, ect.), the Producers Organisations (ASIPO and AINPO), the association of Producers Organisations (the Interregional Fruit and Vegetables Consortium - CIO) and all the other processing firms and POs located outside our study area (AFE, CICO, APO CONERPO, APOFRTUIT, Ferrara Food, Conserve Italia, Tomato Farm, etc.).

Decisions are adopted by a majority of three-quarters of the ordinary members, but decision-taking power is allocated 50% to producers and 50% to processors and each single member's vote has a weight proportional to its productive weight.
As illustrated in Figure 6 the local system where relevant trade relationships occur (in green) is much wider than the supply chain (in blue) and the Inter-branch Organisation (in pink), and is characterized by both vertical and horizontal relations and processes, including also second level processing firms.

In the Parma and Piacenza study area, tomato producers are members of local and/or interregional Producers Organisations (AINPO, ASIPO, CIO) or of cooperatives that produce and process tomato by themselves, through which they make collective purchase of means of production, receive agronomic and technical assistance, sell to processing industries.

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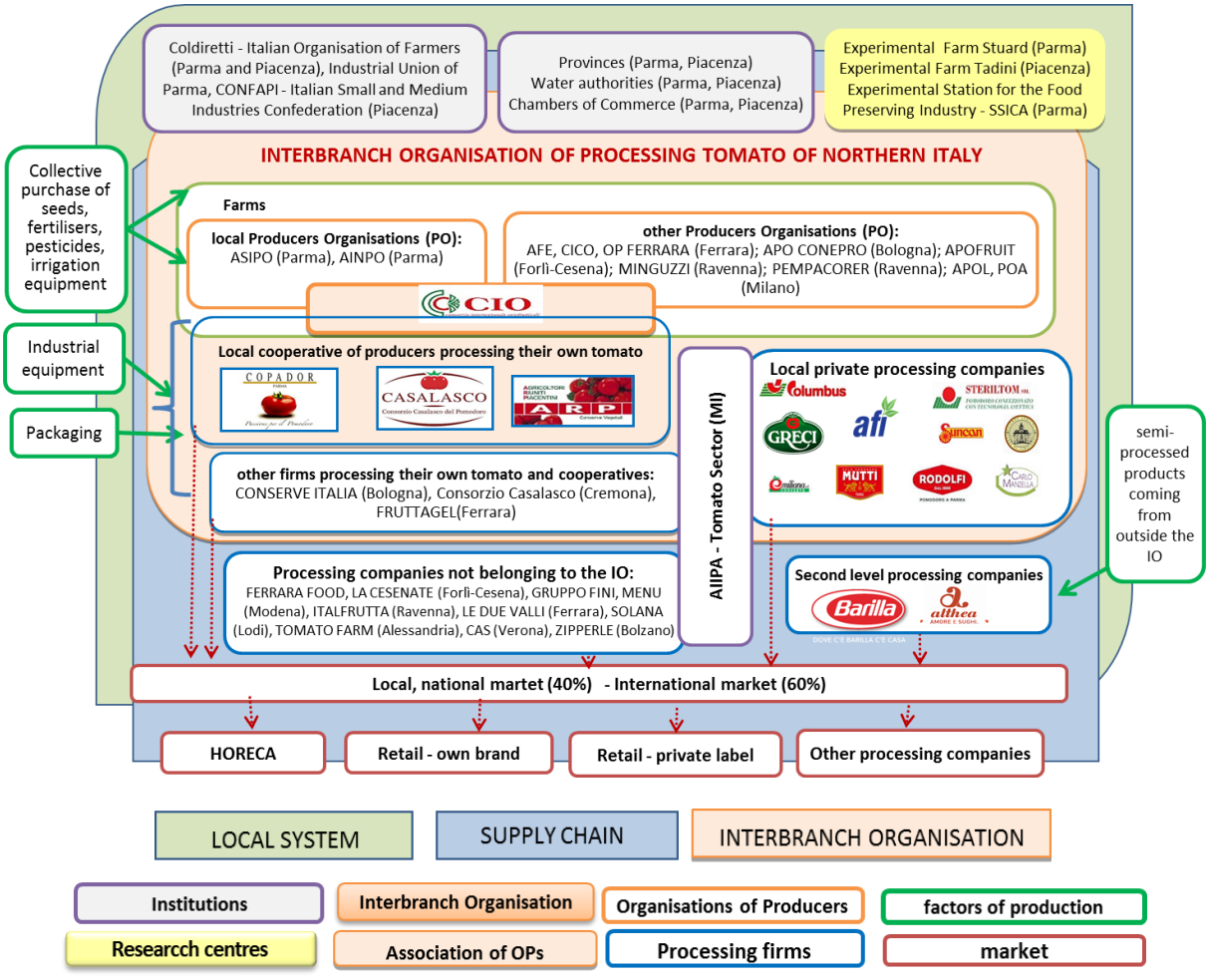
AINPO and ASIPO started as producers' cooperatives in the middle 70s and were recognized as POs by the Region in 1997. *AINPO* associates more than 400 tomato producers (single producers and two cooperatives) located mainly in Parma and Piacenza, but also in Lombardia, Piemonte, Veneto, Marche and Abruzzo; its members cultivate 100% integrated production tomato on 6,200 hectares with a productive capacity of 400,000 tons per year of industrial tomato. Also *ASIPO* associates tomato producers are mainly located in Parma and Piacenza, and cultivate tomato on 5,600 hectares producing almost 400,000 tons of fresh products.

The CIO, instead, is a second-level Producers Organization formed in the 2000 on the initiative of by four tomato producers and processing organisations (AINPO, *ARP-Agricoltori Riuniti Piacentini*; *Consorzio Casalasco del pomodoro*, Cremona; *COPADOR*, Parma) and recently recognized as Association of Producer Organisations (APO); it gathers 650 producers cultivating on 12,000 hectares (that account for 30-35% of northern Italy cultivated land), producing 830,000 tons of fruit and vegetables (tomato, peas, beans, onion, garlic, melon, watermelon, pumpkins and spinach) with an average yield of 69 tons per hectare and transforming by themselves 480,000 tons of final products.

Figure 6: Governance structure of the processing tomato of northern Italy



Source: adapted from Daraio, 2014

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As already mentioned in advanced, in the study area is concentrated 60% the processing phase of the whole tomato supply chain. Processing is made partly in private firms and partly in producers cooperatives, some of them are specialised in semi-finished products, some others in processing fresh tomato and/or semi-finished tomato in finished products to be sold under own private label or for third parties, and some others just process semi-finished products.

Big producers cooperatives processing their own tomato (Consorzio Casalasco del Pomodoro, COPADOR, ARP) account for 40% of the processing of the supply chain. *ConsorzioCasalasco del Pomodoro* in 2007 purchased the brands of Parmalat Group (Cirio, Pomì) and in 2015 merged by incorporation ARP (a cooperative operating in Piacenza since 1958 in cultivation, processing and distribution of tomato), thus becoming the first industrial tomato producer and processor in Italy and the third in Europe: it now associates 370 farms located mainly in the Provinces of Piacenza, Cremona, Parma and Mantova, cultivating tomato on 7,000 hectares and producing more than 550,000 tons of tomato, and it has more than 50 processing lines (formerly belonging to ARP) occupying nearly 1,300 workers (permanent and seasonal) and generating a turnover of 270 million euros. *COPADOR*, instead, is a processing producers' cooperative set up in 1987; its members cultivate 4,000 hectares with tomato and process around 300 thousand tons of fresh tomato every year.
The biggest private processing firms (turnover of more than 50 billion Euros and more than 100 permanent employees) are located in Parma and Piacenza and most of them still belong to the founder families, even when publicly traded, such as Mutti, Rodolfi, Greci Alimentari, Emiliana Conserve. They represent nearly half of the entire processing of the supply chain. For example, *Mutti Ltd*, set up in 1899, is the Italian retail market leader: it processes almost 200 thousand tons of tomato provided by 400 tomato farms, it employs around 700 people (150 permanent), it has 30% of Italian market share, it has a turnover amounting to 234 million Euros in 2015 (+178% in comparison to 2003), 1/3 of which in export, and it is very proactive in product and process innovation and keen to pay higher prices for tomato produced under more stringent rules in order to achieve required quality. *Rodolfi Ltd*, instead, was set up in 1896 and in 2013 merged the processing firm E&O Von Felten. It processes almost 150 thousand tons of tomato and employs around 200 people. Its productions are addressed to the retail market and to second level producers and 1/4 of its turnover is on exports.

Relevant are also the medium and little processing firms, with less than 100 employees, among which we find well-structure old family business (Columbus, Steriltom, Carlo Manzella), small tomato processing businesses (Terre di San Giorgio), businesses that process mainly other fruit and vegetables than tomato (Suncan). *Columbus* was established in 1983 and belongs to the group Romano Freddi of Mantova owned by the same family, but processes tomato in a plant in activity under different owners from 1912. It employs more than 70 people; it processes up to 150 thousand tons of tomato (mostly for third parties) and exports 65% of its production. *Steriltom* was established in 1934 and still belongs to the Squeri family, which is also a tomato producer. It employs 25 people, processes around 150 thousand tons of tomato and itis leader in pulp production for Horeca and industries, with a turnover of around 45 million Euros, 55% of which in export.

Although already mentioned in advance, the research system deserves a particular mention. In the northern Italian tomato context, a fundamental role for both producers and processors

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has always been played by research and experimentation on varieties and cultivation techniques. Therefore, the Experimental Station for the Food Preserving Industry (SSICA) and the experimental farms Tadini and Stuard are vital members of the IO. They carry on targeted research projects and experimentation in individual farms and make a valuable contribution to competitiveness of food production and preserving and to supporting the implementation of regional guidelines for integrated production.

The Inter-branch Organisation does not intervene in trade within the supply chain, nevertheless it exert a key influence on competitiveness and market stabilization by managing vertical relationships between producers and processing firms, acting as a guarantor of the respect of the agreed rules set and endorsed by both producers and processors, monitoring the obligation to use only tomato produced in the area, supporting producers and processors to manage in a transparent way the general framework contract and the reference price agreed, facilitating the implementation and the respect of the single supply/delivery contracts as for price and terms of payment, exchanging of data on the tomato campaign, origin, quantity and quality of tomato.

The strength of the value chain is to be found in the collective action of producers and processor that ensures cohesion and programming and in the interprofessional agreements/contracts that ensure profitability by lowering transactions costs and conciling tomato supply from producers and tomato demand from processing industries and lay the basis for the stability to the tomato market. Through the coordination and supervision of the IO, different motivations and divergent interests of producers, processors and consumers find a fair balance to respond not only to the challenge of global competition but also to the food, energy and environmental challenges.

However, the collective action and the interprofessional agreements/contracts proved to be also its weakness. Lately, the stability of the supply chain, which is linked to timing and respect of contracts, began to waver.

During the campaign 2016, the two crucial elements of programming failed: time limit for contracts and time limit for payments have not been respected. Producers found themselves in weaker negotiating positions, since, due to unsold surplus of previous years, processing firms required to reduce tomato cultivations in order to avoid overproduction crisis and keep the price level high. Producers and processors couldn't reach a timely agreement and contracts were signed only in June, when the tomato was almost ready for harvest. Therefore, since tomato production exceeded tomato under contract, a programming penalty of 2.25 Euros per tons was applied on the reference price agreed. Moreover, one of the biggest producing and processing cooperatives set in Parma (4,000 hectares under tomato) incurred in severe financial setbacks and paid to member farms only 35% of the sums due for the tomato of 2015 and hasn't paid at all the tomato of 2016. And another processing firm based in Ferrara (1500 hectares under tomato, 20% of the Ferrara area) paid tomato producers just the deliveries made in June and not the more consistent ones of July and August (11 million Euros).

Under such circumstances, the starting 2017 campaign is getting off to an inauspicious start. All this can damage the stability and the reputation of the whole supply chain since it could

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have a domino effect throughout the area. In first place, a big number of tomato producers cannot pay back investments made to produce high quality tomato required in contracts and cannot therefore plan the production for 2017. Secondly, if no recovery solution is found, there will be fewer processing companies where to deliver tomato and a decrease in producers negotiating power. And all of this could result also in loss of jobs, if the failing companies don't find a way out.

At present, the 2017 contract hasn't yet been signed and the persistence of uncertainty is endangering the programming of the new campaign for the entire supply chain.

4.2 Innovative governance arrangements and mechanisms supporting ESBO provision

Governance arrangements of the tomato supply chain are the key element in the improvement of the provision of environmental and social beneficial outcomes in the area examined. And they are in turn the result of a 40-year-long process in which collective action (discussed in 4.1) and public policy changes (in 4.3) intertwined.
Governance arrangements in the tomato sector ensued (following the approach of North, 1990) from the development of:

- new organisations associating, at an earlier stage, producers (Producers Organisations), and, later on, producers and processing firms (the association District of processing tomato and then the IO);
- new rules and contractual arrangements between producers and processors enforcing the new organisation and the market.

Institutional change and contractual agreements, as confirmed by all participants to the focus groups, have direct and indirect effects on ESBOs (Table 15).

Table 15: Effects of governance on ESBOs in the study area: institutional change and contractual arrangements in the private sector

	Governance arrangements	Indirect effects on ESBOs	Direct effects on ESBOs
Institutional changes	Creation of Producers Organisation / supply chain association / Interprofessional Organisation	Positive effect on farm income via cooperation and better bargaining power of farmers	Soil: limitation of pressure on soil conditions due to reduction of pesticides and sustainable soil management (innovative farming practices) Water: limitation of pressure on water conditions due to innovative farming practices and reduction of irrigation water need due to the introduction of less water-demanding tomato varieties and innovative irrigation systems
Contractual arrangements	Supply contracts between producers and processors	Positive effect on farm income via market programming and stabilisation of tomato prices	

Source: our elaborations

They both have comparable direct effects on soil and water, since direct effects ensue from the adoption of innovative and environmental friendly farming and water-saving practices. As explained in more details further on in the text, the introduction of technical innovation resulted in improved soil and water conditions.

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Indirect effects, instead, converge (higher farm income) but ensue from different processes: inter-professional cooperation in the case of institutional arrangements and market/price stabilisation in the case of the agreed rules and contracts.

The supply chain was initially centred on Producers Organisations that provided support services to their associates, organised tomato offer and guaranteed relationships between producers with processors. But over the past years mutual cooperation agreements and networks among producers and between producers and processing firms evolved in nature and became the basis over which the present Interregional IO has been built.

The IO represents the supply chain by providing assistance, common identity and united voice, by defining and managing fair rules of conduct with regard to exchange of information and cooperation and common research questions and needs.

Transport costs have a limited impact on the value chain, since production and processing take place in contiguous areas, at an average distance of 60 km. Quality, intrinsic environmental characteristics and organisational structure are very positive factors as far as price is concerned. Production is entirely environmentally-friendly (94% integrated production, 6% organic production) and is organized in structured forms of cooperation (Producers Organisations, cooperatives) based both inside and outside Parma and Piacenza area. The processing phase is characterised by horizontal integration and by vertical integration.
All farmers are organised in Producers Organisation and produce for the local processing industry and all Producers Organisations have formalised (and informal) interactions with the processing industry that started with access to CMO support measures but are still well working even after full decoupling.

Producers Organisation have been the driving force of the tomato system: they applied integrated production, organised tomato supply, provided technical services, channelled and guided CMO and RDP funding. They brought about relevant innovation from which benefited both competitiveness and the environment, thus favouring also processing industries and, consequently, real inter-branch logic.

Moreover, transformative practices were also explicitly promoted by fruitful collaboration with institutions. Emilia Romagna Region, in particular, provided technical support relevant for the ESBOs analysed by means of its plant protection service, meteorological service, prediction and early-warning service, monitoring networks etc. and made available RDP resources to foster the adoption of integrated production, to improve processing and commercialisation, to promote new products, processes and technologies and to increase agricultural production value added. Moreover, the Region financed with a specific regional law a great number of research projects on innovative tomato varieties, production methods and irrigation systems.

Together with **organizational innovation**, the tomato supply chain of northern Italy has followed a virtuous 40-year-long **technical innovation** path which has involved producers, processing firms, institutions, universities and research centres and specialized technicians, and

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whose beneficial effects have radically changed relationships between production, environment and consumers.

Environmental concern has always been within the scope of the processing tomato supply chain of northern Italy and appropriate farming practices and technical means have constantly been adopted in order to preserve soil and water natural resources base and to optimise their use while aiming at raising productivity and production.

The engagement of the supply chain worked in conjunction with the commitment of Emilia-Romagna Region for crop protection methods respectful of the environment and of human health, that started with the adoption of Integrated Pest Management, that gradually evolved into Integrated Crop Management and then into the present Integrated Farming. This regional policy is described more in-depth in the next paragraph.

As far as water resources and irrigation are concerned, both producers and processing firms made substantial investments to increase the resource efficiency of water, not only introducing innovative irrigation technologies (microirrigation systems, probes measuring humidity of soil, drones to monitor growth stage and water needs of the crop, etc.) but also using decision support schemes to improve water management practices made available from the POs, the Region, the processing firms. In fact, uniform and timely water distribution does not necessarily mean water saving and reduction in water wastage. Microirrigation is nowadays among the most common irrigation system in use and it can potentially grant an almost complete efficient distribution of irrigation water (85-95%) but if it is not adequately designed, managed and handled, it doesn't give the expected results in terms of water saving and most of all, in terms of tomato production (yield) and quality (brix level).
All this led to an even more stringent implementation of Integrated production within the tomato supply chain since, in pursuance of enhanced environmental, social and economic sustainability and of ethical principles, producers and processors of the IO agreed to define and respect additional rules intended to make the supply chain more efficient. And, from 2015, thanks to the Inter-branch Organisation, the different regional integrated production guidelines have been harmonized to grant the same operating conditions, quality of product and environmental consideration within the entire tomato area.

Tomato trading between the IO partners is totally transparent since it is defined according to **agreed rules and contracts** underpinning the cohesion of the supply chain. Commercial relationships within the IO are regulated by general rules contained in a Framework Contract and by specific contractual conditions set in detailed Supply/Delivery Contracts between producers and processors and between producers and self-processing cooperatives. All the trading takes place within the IO, except for the limit of 10% of the tomato under contract (in order not to hamper risk differentiation). Moreover, non-compliance with the agreed rules in force is penalized in different ways, ranging from fines to exclusion from the IO.

Framework Contract is signed before the tomato campaign starts (January-March) and sets rules and standards on product valorisation, programming (cultivated area and yield), production methods (certifications), quality, safety and wholesomeness of products, contractual conditions. It requires respect of product specifications, lays down criteria for products quality

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assessment, establishes arrangements concerning terms of payment, transport and additional services, penalties and compensations.

Supply/Delivery Contracts, instead, transpose the provisions of the Framework Contract and specify the required quality and quantity of tomato, the scheduled cultivated area and yield, price per unit according to typology of tomato, duration of the contract, terms of payment, guarantees, compensations, programming of deliveries and transport, bonuses/penalties referred to production programming, services from the POs, penalties in case of failures of withdrawal and/or delivery. Moreover they require processing firms to complete delivery forms with data concerning quality, weight and final price of tomato.

The IO monitors the trading by gathering all the contracts signed and all the delivery certificates, by verifying production and quality, by checking the management of eventual contracts for processing, etc.

The biggest advantage of the overall governance arrangements voluntarily set within the processing tomato supplied chain is that they fostered maximum cohesion and accountability between stakeholders, notwithstanding the different interests at stake. And, as stated by local actors, it is cohesion which is unanimously perceived by all stakeholders as the only way to remunerate, defend and promote on the market the high quality of the tomato produced and processed in northern Italy and to protect it from global competition:

"*there are times of the year when the interests of the different stakeholders of the supply chain are in conflict, but the IO tries to lead them to cohesion and pooling*",
"*in comparison with Spain and Portugal and other districts and in a context of world price decrease, thanks to the IO and to the supply chain cohesion northern Italian tomato maintained a higher and more price and high standards of quality and reliability*".

The definition and respect of contracts and of agreed rules bind together producers (linked between them by the principle of mutuality within the POs) and processors (linked to producers through contracts). The respect of quantities and quality agreed in contracts (no pesticide residues or chemical ingredients, brix level, consistency, flaws, etc.) guarantees prices and incomes and a premium/penalty on price is used as an incentive/deterrent against misconduct (Table 16). It is not admitted for single producers to contract directly with the processing industries outside the POs and processing firms interact with producers.

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Table 16: Tomato produced, under contract and delivered within the OI producers and processing firms (tons)

	2011	2012	2013	2014	2015	2016
Tomato production in northern Italy	2,562,828	2,370,917	1,889,374	2,322,065	2,623,514	2,773,146
Tomato under contract	*2,693,390*	*2,488,245*	*2,402,081*	*2,758,800*	*2,951,800*	*2,955,890*
Tomato delivered	2,562,828	2,370,917	1,889,374	2,322,065	2,623,514	*2,773,146*
% delivered/under contract	*95%*	*95%*	*79%*	*84%*	*89%*	*94%*
Yield (t/ha)	71,24	70,85	64,76	65,08	67,36	71,85
Reference price*(€)	88.00	84.00	85.00	92.00	92.00	85.20
Weighted average payment rate	*96.36*	*90.52*	*96.95*	*89.95*	*94.68*	*92.96*
Weighted average final price (€)	*84.80*	*76.04*	*82.41*	*82.75*	*87.11*	*79.20*
Programming bonus/penalty (€)*	-	-	-	*1.00*	-	*-2.25*
Total final price to producer	84.80	76.04	82.41	83.75	87.11	76.95

** CREA survey*
Source: our elaborations on data from Inter-branch Organisation and our survey

As a result of all this, the supply chain manages to preserve the structural balance of the market by trying to avoid overproduction crisis, to produce and process healthy and environmental friendly high quality products, to compensate the attention given to strengthening governance, transparency and environmental protection with a fair and remunerative price.

Organisational and technical innovation, together with attention to health, consumer safety and environmental protection are essential to maintain the leadership thanks to a globally recognised tradition of quality. And quality is essential to compensate tomato high cost/price and to enable the supply chain to compete.

A success story in this respect is the leader processing firm Mutti Ltd, first in Italy for sales in products processed from tomatoes, which greatly contributed to ESBO provision by choosing to bet on its private mark, on quality and on work in close contact with the supply chain. As stated during the focus group:

"*it was necessary to make a choice: follow a price strategy (compete with high volume and low price) or find an alternative path. The approach chosen was to go against the world price trend […] and to place emphasis on product quality and differentiation*".
During its century-old history, Mutti has always maintained a firm commitment to guarantee the best possible quality, functional to market valorisation of its production. But Mutti's quality choice has been a collective quality choice, since it involved substantial investments (increasingly effective research and innovation) not only in tomato processing but also in tomato production. Mutti has introduced constant process and product innovation, has favoured producers innovation in tomato variety choice, and has provided its tomato suppliers with technical devices to measure soil moisture in order to tailor irrigation accordingly. Moreover, it has recently acquired a processing plant in southern Italy to widen the rage of its products with peeled tomatoes and cherries tomato for a better placement on national and international markets.

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Innovation and quality are the core of Mutti's strategy. Tomato is supplied always from the same farms and producers follow agreed farming practices according a premium price mechanism that promotes quality, and the best suppliers are awarded every year a prize in money (*Pomodorino d'oro* in the north, *Targa d'oro* in the south). In the processing plants of northern Italy, tomato comes from very near (maximum 130 km) and every truckload of tomato is strictly controlled according almost 20 parametres. Tomato delivery and processing happen within maximum 24 hours from harvesting and innovative successive lines enable to process the same tomatoes to get the best part of the fruit for every final product (pulp, puree, concentrate).

But quality of products goes together with sustainability and respect for the environment environmental commitment. Mutti is the first firm to obtain in 1999 the regional certification of Integrated Production. In 2001 it obtains the GMO-free certification. In 2010 it starts to collaborate with the WWF and carries on two projects, one on carbon footprint (aimed at reducing CO2 emissions by rationalising energy use, adopting renewable sources and internal organisational procedures to monitor and manage energetic needs) and another on water footprint (reduction of water use during production and during processing obtained with the provision to its farmers of probes hygrometres and the reduction in the use of fertilisers) which resulted in a reduction along the whole supply chain of 27% of the carbon footprint in 5 years (-20,000 tons of CO2 emissions in the period 2010-2015 compared to 2009 baseline levels) and of 4.6% of the water footprint (-1,000,000,000 litres of water in the period 2012-2016 compared to 2010 baseline levels), exceeding by far the initial targets respectively of -19% and of -3%. In 2012 it engaged in a project on traceability of raw materials and, in order to reduce CO2 emissions, installed a solar plant and also a concentration plant. In 2014 it started with HORTA, a spin-off of the University of Piacenza, the project Pomodoro.net, a decision support system that simulates tomato plant growth taking into consideration climate, water needs, diseases, insects, which will be provided to all farms. And, in 2016, completed the certification process for the International standards ISO22005 for agri-food supply chains traceability, BRC and IFS that guarantee legality and food security, and UNI11233 the certification for Integrated production.
The path of quality and sustainability resulted in a collective growth that created turnover and jobs and granted fair working conditions to employees and ethic, trust, stability, continuity in business relationships. Relations with suppliers are based on trust and reciprocity and on support throughout the tomato production; relations with consumers are based on reputation and on immediately recognisable uniqueness and quality of products.

Nowadays Mutti is market leader in Italy and in Europe and is the first Italian tomato processing firm in terms of sales and value:
"*Mutti is constantly going through its whole stock, at the end of each tomato campaign most of the products are no more available because its growing production is not enough to meet market demand [….] and this happens in a sector in crisis where also firms going well manage just to cover costs*".

Notwithstanding the difficulties of the world tomato sector and the world crisis, its turnover increased by 290% between 2003 and 2015, 53% just in the last five years (Figure 7). And it is

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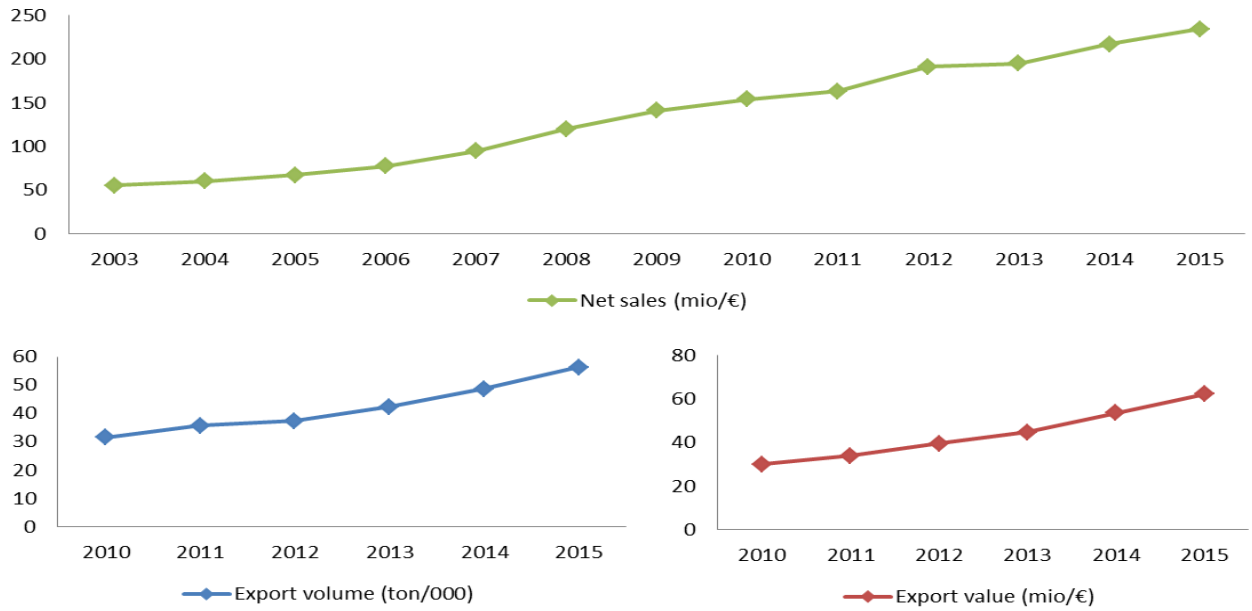
present in more than 80 countries in the world and its exports doubled in volume and value in just six years.
This is a success story not only for Mutti, but also for the whole northern Italy supply chain since this success is distributed between the 400 families of farmers, nearly 150 permanent employees and 550 seasonally hired employees, the dealers of technical means, the researchers, etc.
Innovation leads to input reduction and to environmental benefits. Increased sustainability improves quality. And quality is the mainspring of the supply chain competitiveness.

Figure 7: Mutti: turnover 2003-2015; exports 2010-2015 in volume and in value



Source: Mutti

4.3 The role and impact of policy in ESBO provision

Farmers and processing firms use a broad spectrum of policy instruments to support organizational and technical innovation and to switch to more sustainable production and processing practices and means.

The discussion about the role of policies in ESBO provision is divided in two different parts, since there are two big types of polices which made a relevant contribution in fostering the progressive orientation of the tomato sector towards sustainability:

- The Common Market Organisation reform;
- The agricultural policy of Emilia-Romagna.

Aid granted through agro-environment-climatic measures, in fact, are mainly financed through the CMO (CAP 1st Pillar) and the Rural Development Plans (CAP 2nd Pillar), where environmental objectives are particularly relevant.

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Even if it was not possible to single out all of the financial resources allocated to the tomato sector, from the analysis of some of the payments made to representative CMO and RDP beneficiaries (Producers Organisations, cooperatives and Associations of Producers Organisations) it results that the great majority of resources (97%) come from the CMO (Table 17).

Both policies, however, envisaged financial provisions for investments and for environmental practices, as well as technical assistance, training and advice. And also integrated production had broad-based support from both CMO and RDP, but with differences between the programming periods[1] and paying attention to avoid double financing for the same actions and cultivations.

Table 17: Main resources for the processing tomato sector (payments 2002-2015, €)

	Piacenza	Parma	Total
CMO - Processed fruit and vegetables coupled subsidies	28,966,510	177,375,922	206,342,432
CMO- Fruit and Vegetables Operational Programmes		80,207,559	80,207,559
Total CMO	**28,966,510**	**257,583,481**	**286,549,991**
RDP 2000-2006 - M1g Improvement of processing and commercialisation of agricultural products	4,038,200	1,638,840	5,677,040
RDP 2007-2013 - M123 Increase in value added of agricultural production	4,170,906	2,503,106	6,674,012
RDP 2007-2013 - M133 Support to producers organisations for information and promotion activities concerning products belonging to quality systems		30,800	30,800
RDP 2007-2013 - M214 Promotion of cooperation for the development of new products, processes, technologies	66,500	547,090	613,590
Total RDP	**8,275,606**	**4,689,037**	**12,964,643**
Research Projects financed by Regional Law n, 28/1998			1,957,311
	37,242,116	**262,272,518**	**301,471,945**

Source: our elaboration on data of the regional payment Agency Agrea

Furthermore, even if it is a tiny amount in comparison with CMO and RDP (Table 17), it is important to mention the resources made indirectly available to the tomato supply chain form the regional law for promotion of development services to the agri-food system (Law 28/1998). It financed research projects strategically important for environment and economic sustainability of the supply chain and complementary to RDP measure for the development of new products, processes, technologies. Projects were carried out by local Experimental Farms Tadini and Stuard, Experimental Station for the Food Preserving Industry (S.S.I.C.A.), Crop Production Research Centre (C.R.P.V.) and the Second Level Water Consortium (C.E.R.) and concerned mainly technological and nutritional characteristics of processing tomato, varietal experimentation, sustainable system, tomato traceability management, reuse of processing firms waste.

[1] In the programming period 2007-2013 Integrated Production in the Fruit and Vegetable sector was admeitted only through the CMO Operatinal Programmes.

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The Common Market Organisation

Crucial impulse has not been given by the environmental regulatory framework, but by the reform of the Common Market Organisation of the Fruit and Vegetables sector (at the European level), which forced tomato farmers organizations and processing firms to cooperate in a more effective form: the Inter-branch Organisation (Giacomini and Mancini, 2015).

The CMO reform involved the transition from a top-down spending policy coordinated and managed from the EU to a bottom-up governance model where farmers make autonomous productive choices aimed at reinforcing the role of farmers plus a second-level coordination mechanism (the Inter-branch Organisation) voluntarily set up by all relevant stakeholders of the supply chain to contain market instability.

From 2000 onwards, more than three quarters of the CMO concern coupled subsidies to tomato producers (72%), and another relevant share (28%) is allocated to Operational programmes of Producers Organisations and their Associations for production programming and adaptation to the demand (quantity and quality, mainly through Integrated Production), supply and marketing concentration, cost optimisation and farm gate prices stabilisation (Table 17).

As for support to integrated production, aid concerns both production (agro-environmental measure) and processing, commercialisation and transport (phases outside tomato farms) and is linked to operations additional to standard environmental protection legislation and to the adoption of regional Integrated Production Guidelines.

As for coupled subsidies, instead, with the reform of 2007 aid was decoupled from tomato cultivation and linked to effective sales of tomato from recognised POs to processing firms. As the other European tomato producers, Italy adopted the transitory partially decoupled payments (50% of the national ceiling) for three years (2009-2010) and completely decoupled payments in the fourth (2011). Therefore, “historic” farmers who delivered tomato to processing firms and received CMO aid in the reference period (2004-2006) were entitled to be granted direct decoupled payments but their amount was reduced by 50%. In the transition period, aid was given directly to farmers submitting a single application and modalities and timing of the adjustment to single payment were defined by each member state. In Italy, the amount of coupled aid per hectare for processing tomato was fixed at 1,300 euros for the year 2008, at 1,100 euros for 2009 and at 1,000 for 2010. The effective aid was anyway higher (1,410.18 for the year 2008, 1,177.49 for 2009 and 1,182.15 for 2010). Moreover, transitory coupled aid had to be summed to 50% of the decoupled aid.

From 1 January 2014 the new CMO came into effect and from 2015 tomato could benefit again of coupled aid, but much lower in comparison with the previous one, since direct payments had to converge to a national unitary value. For the present CAP programming period, in particular, an important role was played by the Inter-branch Organisation. Since Italy is the third world producer and industrial tomato is considered to be a strategic sector, the IO presented a common position addressed to the Ministry of Agriculture asking to continue to grant support through integrated production, certification and promotion in the RDP and coupled sup-

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port for processing tomato within the new CMO in order not to penalize the sector's competitiveness, since Spain, Portugal and France were doing so. But coupled support could not bridge the productivity gap: whereas in Italy aid is 160 €/ha, in France is 1,500 €/ha and in Spain and Portugal 250 €/ha.

In conclusion, during the first decade of 2000s CAP subsidies under the 1st Pilar were substantially reduced for the tomato sector, and they have not been compensated by any other form of CAP or regional support. This forced the tomato sector to adapt through a pro-active strategy, more oriented to cost-reduction, sustainability and quality, aggregation and cooperation of actors operating in the sector.

The agricultural policy of Emilia-Romagna

Also regional policy package and investment aid played an important role in supporting adoption, adaptation and promotion of integrated production by compensating consequent reduction in yield and increase in production costs, even if resources available were far below CMO ones. Again, the effect on ESBO provision is indirect, but contributed significantly to the widespread diffusion of environmental friendly attitude of farmers and processing firms.

Initially, in mid 70s, the focus was only on pest, disease, weed and nutrient management and it was the new-born Producers Organisation to assume a pro-active role, supported also by the Region that started to promote integrated pest management systems and low pesticide input in agriculture. After considerable long-term investments in research, sampling and experimentation on new low environmental impact farming practices and in technical assistance and training and the provision of a considerable amount of data gathered within a complex system of research and experimentation, the Region could take a step forward and foster the adoption of more modern methods of cultivation and preservation of products through financial support to farmers and processing firms to extend the use of integrated production.

From the early 90s onward, major emphasis was given in at first to crops and then to crops, soil conservation and irrigation and regional guidelines were introduced to secure the use of production methods and means allowing minimising the use of chemicals and rationalising fertilisation.

Actual integrated production guidelines set mandatory common rules on tomato varieties, crop rotation, fertilisation, irrigation, pest and disease control, ecological and toxicological principles and nevertheless take into account also the guarantee of economic aspects related to qualitative parameters (measured in Brix level, which is sugar content), consistency, and defects. They contain compulsory and voluntary standards aimed at reducing the use of pesticides, optimizing the use of fertilizers according to the soil, supporting crop rotation and water management. Moreover, regional and provincial technical advice and information bulletins, public data base and thematic maps for each soil type, weather forecasts, plant disease monitoring and warning service, research and experimentation, and water management and irrigation support were made available to all farmers.

Integrated production envisages general rules and advice concerning soil preparation for sowing, transplant, planting distances and density, agronomic practices for weed control, use of

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ripening products just for harvesting by middle august (in order to facilitate harvesting planning). Strict mandatory rules are, instead, laid down for agronomic procedures and technical means and serve as a model in all environmental matters relevant for tomato cultivations (crop rotation, plant growth regulators, active substances and fertilizers, fertilization practices, irrigation). Emilia Romagna Region encouraged tomato producers to adopt the regional guidelines on integrated crop management by providing over time full compliance with environmental aid envisaged by the CMO Regulation, with specific measures of the Regional Development Plans, with Regional Act n. n.29/1998 financing research, experimentation, supervision and technical support and with Regional acts n.28/1999 introducing the promotion of agricultural and food products obtained with methods and practices respectful of the environment and of human health and by the establishment of the regional eco-label named *Qualità Controllata – QC* (Controlled Quality), which foresees also mandatory control operations carried out by accredited certification bodies in accordance with standard EN 45011.

The RDP was considered in two last programming periods a strong basis to support the new strategy emerging from the policy change and in both of them environmental-friendly farming practices were highly emphasized. In the programming period 2007-2013, for example, the RDP envisaged:

- agro-environmental aid for farms adopting on their entire area integrated crop management for at least five years and for every year was granted an amount spanning between 77 and 528 Euros per hectare according to crop and to first application or maintenance (Measure 214);
- 70% coverage of control and certification costs, for a maximum of 3,000 Euros per year for five years whether the farm accedes to the control system for at least 3 years after the first concession (Measure 123);
- aid within supply chain projects for promotion of integrated crop management products, since the aggregation of suppliers increases the market power of farmers and the aggregation of processing firms secures production planning, fair terms of payment and dissemination and imitation of best practices (Measure 133).

And a further emphasis on environment is given in the RDP 2014-2020, in line with the new CMO and the integrated production regional and national marks (QC and SQNPI), where particular attention is given to quality productions, to adhesion to certification systems and to the promotion of strict relationship between quality and environmental sustainability.

The effect on ESBO provision

Public resources do represent a key support to change in the tomato supply chain attitude towards sustainability. In general, policies played a very relevant role in promoting and supporting collective actions within producers and between producers and processing firms, in complementing private schemes and in supporting individual actions and fostered the adoption of more environmental friendly practices and innovations and influenced beneficial outcomes on soil and water resources both in a direct and indirect way.

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Table 18: Role of policies and related interventions/measures/tools

Role of policies	Policy interventions/measures/tools	ESBOs involved
Promoting and supporting collective action	- Creation of Producers Organisations - Creation of the Inter-branch Organisation	Soil/water
Complementing private schemes	- Integrated production schemes	Soil/water
Supporting individual actions	- Cross-compliance guidelines	Soil/water
	- Regional measures supporting improvements in agricultural production	Soil/water
	- Investment in technological innovation	Soil/water

Source: Our elaboration

This support was firstly regulatory through the agricultural policy of the region, secondly was of financial type through the different measures of RDP (direct and indirect focus on ESBO provision) and thirdly it was conveyed also with the provision of research and technical advice through specific research programmes and the technical advisory structures and services of the region.

The effect on ESBO provision in the CMO case is indirect, but it is as relevant as direct ones since aggregation of producers in Producers Organisations, initially, and aggregation of producers and processors in the IO, later on, together with framework and supply contracts, consolidated the adoption of Integrated production and fostered quality certifications of producers and processing firms. In the RDP case, instead, the effect on ESBO is both direct and indirect. Agro-environment-climatic measures spurred widespread use of integrated production and measures for investment in tomato food processing promoted the introduction of new products, processes and technologies (also water saving technologies).

All these policies were consistent and complementary with the strategies emerging from the collective action and the attitude change of the private sector towards safety, quality and reliability of production aimed at differentiating northern Italian tomato.

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Table 19: Policy frame impacting on water and soil

	Level of governance		
	EU	**State/Region**	**Local area**
Regulatory framework	- Water Framework Directive* - Groundwater Protection Directive* - Environmental Quality Standards Directive* - Nitrates Directive - Sustainable use of pesticides Directive	- Regional Water Protection Plan* - National guidelines for quantification of irrigation water volumes (and regional implementation guidelines)* - National guidelines on water Environmental and Resource Costs (and regional implementation guidelines)* - National Environmental Legislative Decree 152/2006 - Regional Environmental Action Plan - Regional Action Programme on Nitrates from agricultural sources - National Action Plan for plant protection products sustainable use - National and Regional Integrated agricultural practices guidelines	- Management Plan of the River Po Authority* - Nitrate Vulnerable Zones (NVZs) in Provincial Territorial Planning Programmes (PTCP)
	- Fruit and vegetable CMO - Rural Development Regulation	- Cross-compliance guidelines	
Policies with direct focus		- RDP: Agro-environment climatic measures (Integrated production); Investment in tomato food processing (water saving technologies) - Regional law: Research, Experimentation, Supervision, Technical support in water saving technologies and tomato varieties - Regional Agronomic and Weather Technical services	- Technical advice (Region) - Research and agronomic support (research centres)
Policies with indirect focus		- CMO: Operational Programmes and Direct payments to farmers - National guidelines on precision agriculture - RDP: Information and promotion activities concerning products quality systems and certifications - Regional Law: quality control on products quality systems - Regional Law regulating Interbranch Organisations	- Producers Organisations Operational Programmes - Technical advice and governance support (Province) - Inter-branch Organisation of processing tomato supply chain and system of mutually agreed rules

** only water resources*
Source: our elaboration

4.4 The role of the private sector in ESBO provision and enabling factors

Governance agreements and direct and indirect public policies do not explain all of the relevance of the tomato supply chain as far as ESBOs provision is concerned. They were successful

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in fostering the provision of beneficial outcomes on soil and water since they were consistent with market-driven strategic prospects of local entrepreneurs.
Together with governance arrangements and policies, private schemes form and integral part of the competitive strategy of the supply chain. They all have a common aim: to work for quality products and strengthen the position on markets.

Promotion and implementation of private schemes has been handled by producers' and processing organisations in order to enhance quality and foreign market penetration.

Integrated production and precision farming practices are widely adopted primarily due to economic reasons (lower need for agricultural inputs means lower input costs). But, at the same time, the compliance with specific regulatory constraints and with additional auto-imposed criteria (agreed contractual obligations) determined lower revenues due to reduction in yield and to increased costs involved in adapting to new rules (sprayers calibration, next-generation pesticides and herbicides and/or alternative cultural operations, plant disease monitoring, record keeping, samples collection and analysis, etc.).

The supply chain is strictly controlled from the seed to processed tomato. All producers and processing firms invest suitable human and financial resources to follow and check the entire tomato life cycle from soil management, sowing, transplant, harvest, delivery, processing, and packaging. Production follows the rules of regional Integrated production schemes and of supply/delivery contracts signed within the Inter-branch Organisation concerning pesticides, fertilization, irrigation, etc., whereas in the processing phase physico-chemical and microbiological controls go from the delivery of tomato to the firm exit gate.

The existence of solid regulatory systems introducing standards, bans, controls, certifications and specific procedures and production methods set up can be promoted and exploited by the local system for commercial purposes, guaranteeing quality and origin of products and meeting new consumption trends generated by uncertainties due to global food crises (Lamine, 2006).

Acknowledged reputation and quality are the distinctive feature of the processing tomato supply chain of northern Italy, since it meets certain requirements laid down by regulations to guarantee safety and quality (mandatory/voluntary) or previously agreed rules among partners (voluntary), and everyone involved in the production chain complies with these requirements and maintain high moral standards and business ethics.

Labelling and certifications are the means chosen to derive maximum benefit from attention to quality and to environmental issues. The tomato sector is highly certified to meet different needs: to comply with regulations/laws, to raise market profile, to differentiate from competitors, to grant certified quality, to reduce consumers' uncertainty. However, respect of ethical standard of production and attention to consumer and environment protection does not mean necessarily higher competitiveness, since they result in higher costs and prices.

All producers/POs and processing firms of the tomato supply chain use certifications as a means of promoting the high value of their products on the national and international market. Product and management system certifications are clear and simple measures to encourage

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willingness of consumers to pay more and to promote indirectly greener, more resource-efficient and more ethical production and processing. They are issued by an independent accredited certification body and have a value-creation potential and represent also a guarantee mechanism (mostly in case of food scandals).

Few certifications focus directly on the product and are referred to intrinsic qualities and to conformity to certain verifiable requirements (*100% Italian*, *organic*, *OGM free*).

Some other are referred to entire production processes. The respect of codified production schemes – such as ISO 11233, SQNPI and QC (respectively, international, national and regional certification for integrated production) and the organic farming certification – prove the use of environmentally friendly methods throughout the production phase. In particular, Emilia Romagna Region was the first Italian Region to adopt and promote integrated production schemes and introduced the related collective mark QC awarded to producers and Producers Organisation that throughout the production process attain to the quality standards required by integrated production, whereas only from 2011 there is a National Law setting up a national integrated production certification (SQNPI) for farming practices that entail the use of production inputs and pest management systems that minimize pesticides and rationalize fertilization. The implementation decree was adopted in 2014 and sets the procedure to lay down national guidelines to which all regional guidelines have to conform, thus granting that all the regional marks are equivalent.

Table 20: Main voluntary certifications and standards adopted in the tomato supply chain

	Level*	Product	Process	System	Focus
System Certifications					
European Eco-Management and Audit Scheme (EMAS)	EU			✓	Performance, impact
UNI EN ISO 14001 - Environmental Management System (EMS)	EU			✓	Performance, impact
Supply chain and product certifications					
SA8000 Social Footprint – Product Social Identity (SFP)	EU			✓	Ethic, traceability
UNI EN ISO 22005 - Traceability in the feed and food chain	EU			✓	Traceability
UNI EN ISO 11233 - Integrated production systems in food chains	EU		✓		Method
National Certification SQNPI (Integrated production)	IT		✓		Method
Regional Certification QC (Integrated production)	ER		✓		Method
Product certification100% Italian tomatoes	IT	✓			Traceability
Supply chain with GMO-free seeds	IT	✓			Method
Organic farming Certification	IT	✓			Method
International standards and certifications					
GLOBAL G.A.P. (Good Agricultural Practices)	EU		✓		Method
B.R.C. - British Retail Consortium [UK]	INT		✓		Method
I.F.S. - International Food Standard [Germany and France]	INT		✓		Method
FDA Registration – Certification from the Food And Drug Administration [USA]	INT		✓		Method

** EU: European, IT: national; ER: regional, INT: international*
Source: our elaboration

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System certifications are more numerous and focus on the entire supply chain and demonstrate enhancement in management, environmental, ethical, food security performance. For example, *ISO 22005* gives evidence of the existence of traceability system that allows to trace back not only the product but also the interventions to which it was subjected and its single components and enables to determine the history or origin of the product and to identify all the responsible organizations in the feed and food chain. *EMAS* and *EMS*, instead, are European certifications that witness enhanced environmental performance and achievement of environmental objectives relating to energy, materials, water, waste, biodiversity, emissions (EMAS) or ensuing from an organisational framework that increase compliance to any applicable legal standards (EMS).

Also international standards and certifications are process certifications. Some of them are required to processing firms and retailers from large organised distribution networks for exports in certain countries (B.R.C and I.F.S., nowadays almost equivalent) (F.D.A. for the USA) and are mainly referred to hygiene and food safety requirements (HACCP methodology, Good Manufacturing Practice, Good Laboratory Practice, Good Hygiene Practice, etc.). The GLOBAL G.A.P. (Good Agricultural Practices, that is integrated production), instead, is a business-to-business certification and it is not directly perceived by the consumer; it is required to farms that produce crops for processing and consists of General Rules and Control Points and Compliance Criteria (CPCC) that cover all stages of production, from pre-harvest activities (soil management, plant protection product application) to post-harvest (produce handling, packing and storing) and grants food quality, food security, minimization of environmental impact of cultivations, responsible approach towards security and safety of workers.

While for product certifications the value added is directly associated to the output of major attention to environmental issues of producers, process certifications highlight how the environmental value added is created (good practice, internal controls, traceability, etc.,) and pinpoint both the reputation of the producer/processor and the trust from citizens/consumers.

Safety, quality, reputation, trust are the essential attributes of this articulated framework of private drivers: official recognition of product/process/system quality guarantees trustworthiness of the tomato stakeholders reduces transaction costs, valorises the supply chain and acknowledges its differentiation in the market.

Therefore there is evidence that a virtuous course occurred. Private economic rationale and public policies together favoured the adoption of European, national and regional protection measures, the respect of legislative and quality standard requirements, the adoption of innovative resource-saving farming and irrigation practices, the setting of additional voluntary environmental friendly contractual rules, the accession to standards and certifications guaranteeing quality sustainability, as well as complete traceability. But, at the same time, great attention to quality, traceability, innovation, environmental factors determined strong product differentiation that provided added value for consumers and competitive advantage over other competitors, notwithstanding higher production and processing costs and prices. And, in turn, supply chain integration allowed reducing transaction costs, lowering the threshold for product and process innovation costs, facilitating access to expertise and technology.

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Certifications increase transparency, improve access to information, enable improved protection for citizens and for the environment. And the ensured compliance with quality and safety standards enhances market penetration, including new export opportunities.

5 Potential pathways towards an enhanced provision of ESBOs

Sustainability and ESBO provision is a long-term process and requires a sustained and long-term commitment. Much has been done and a lot has been achieved with the adoption of specific quality-oriented and environmental friendly farming and technical innovations, but the provision of ESBO can be further enhanced.

As far as tomato production is concerned, the integrated production guidelines are annually adapted to agricultural and environmental conditions and, in perspective, its standards will be progressively raised. As for irrigation and plant protection products, instead, main attention has to be paid to the adoption of a crop growth cycle approach through precision agriculture and irrigation.

In northern Italy, the actual level of farming mechanisation is already very high, but is going to be improved in the near future. The tomato supply chain is willing to renovate further agricultural practices and is deeply involved in introducing the innovations of *conservation agriculture* (high-tech seeders, decompactors, etc.) and *precision farming* (variable rate fertilisation and irrigation spreaders, satellite systems, automatic piloting systems, software to collect data and rendering of production maps, monitoring with drones) that enable correct collimation of all working activity in the field and allow low environmental impact and cost saving. Experimentation in variable rate technologies, in particular, is at a very advanced stage and is of great interest since it enables to consider real needs of crops and to tailor all inputs exactly for biochemical and physical characteristics of soil. In addition, the sensors of variable rate machines allow also crop constant monitoring, permanent data acquisition and built up of data series, detection of irregularities and necessary corrections.

As for irrigation practices, instead, many *decision support systems* are and will soon be available, such as the system of irrigation seasonal forecast iColt, the irrigation water management decision support systems based on data organized in a GIS platform (project MOSES) and on integration of weather, soil and aquifer data and also key water parameters for single plots or district (ongoing project FIGARO).

Moreover, there is increasing attention to the assessment of the environmental performance of the whole tomato supply chain, in terms of Product Environmental Footprint within all the phases from the seeds to the end life (life+ project PREFER) and in terms of GHG emissions evaluated with a Life Cycle Assessment approach (life+ project Climate Chang-ER).
Further improvement in ESBO provision could therefore come from widespread adoption of new technical innovation concerning:

- conservation agriculture;
- precision farming;
- irrigation decision support systems.

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6 Suitability of the SES framework and 'action-orientated approach' in the analysis of ESBO provision

Comments raised in the D.4.1 report on the processed tomato about SES are partly valid now. In this report we add some further reflections.

- The idea of S-E-S is already in the minds of our stakeholders, but this way of representing it is meaningless for them. In reality it was not relevant in interviews. Interviews work better when there is a simple scheme showing the main actors playing a role and suggesting possible interpretation of the conflicts and alliances between them.
- The objective of integrating of ecological and social aspects and thus providing a holistic viewpoint is very important, but at the same time is too ambitious and remain a wishful thinking since there is neither a theory nor a model helping to put together all the components of the SES in a coherent and convincing way. Nonetheless it is extremely helpful in forcing the researcher to find some global picture of the system.
- Single Interviews added many elements to our understanding of the system.
- The more useful elements of the SES in this case were motivations and objectives of the playing actors, their governance arrangements and the feed-back effects of the governance arrangements on the objectives and motivations. See the Figure 6 in this report to have a good idea of these elements. This can work very well also in the dialogue with stakeholders because these elements have to do with their feelings about themselves and their behaviour in a given situation.
- The SES framework needs to be further articulated when you have to consider the dynamics of the socio-ecological system.
- The collective and common pool of resource aspects is decisive in understanding the provision of ESBOs and it is clearly understood by some of the actors, in particular those more innovative in environmentally conservative practices.
- In this case action-oriented approach, despite the objective of this research, was unfeasible because of the time needed to develop it with main stakeholders and also because in the supply chain the representatives that were interviewed knew quite well the directions and potentials to be exploited. We simply elicited solutions and ideas that were already boiling in their minds.

7 Main conclusions derived from the Steps 3-4 analysis

7.1 Key findings on the particular SES and the provision of ESBOs

Over-exploitation and drought raised long since alarms for soil functionality and water quality and availability and upcoming public policies introduced solutions responding to the concerns of farmers and processing firms who were already committee to find ways to improve soil and water conditions for the sake of crops and the whole supply chain.

Acknowledging that chronic soil and water pollution by nitrates and pesticides from agricultural sources and water scarcity due to catchment area characteristics represented a pressing

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matter and endangered sustainability of local agro-industrial economy, Emilia Romagna Region has been a precursor in taking adequate protection measures on all these issues.
The Region adopted supervised pest control in the early '70s (national guidelines were adopted only in 1987), formalises integrated production schedules and designed NVZs in 1997 (even before national transposition into national law of Nitrate Directive), financed from 1998 onwards research on water saving systems and varieties, cultivation techniques, product traceability, energy saving production and processing methods, and provided technical assistance, information, dissemination of results, adopted regional implementation acts on water, soil and mines in 1999, on land protection and management, environment and infrastructures in 2000, on Strategic Environmental Assessment in 2008 and made agreements with the Provinces relating sub-regional financial resources and management of local actions.

Within this framework, the tomato supply chain of northern Italy already showed evidence of consolidated positive interdependent relationships between human economic activities and biophysical environment. Strong commitment and efforts of all private and public actors enabled to step down from self-interests and to set in motion the virtuous cycle. The tomato economic system, in fact, was historically strictly entangled with the surrounding institutional, social, cultural and natural setting and even being an intensive production/processing has always been very concerned about environmental and social outcomes and sensitive to new perspectives and new calls for environmentally friendly production methods.

Soil functionality is essential for product quality and integrated production methods ensure food safety while allowing environment protection by means of reduced chemical inputs, as well as improved water quality. Producers, consumers and the environment benefit from farming and pest management systems that enable to limit the use of pesticides and reduce related risks of exposures, thus safeguarding also public health. Therefore, as pointed out during interviews,

"*a major effect of integrated production has been the reduction of the impact on the environment more than on agricultural products*".

Water consumption is concentrated in the stages of tomato cultivation (irrigation) and of manufacturing process (not only for processing but also for cooling or cleaning) and poses relevant problems of competition over the allocation of water resources (agriculture, energy generation, industry and transport, households, natural ecosystems) also in an area rich in water as the Po Valley. But, the use of water within the tomato chain is nowadays reduced by means of measures aimed at reducing water demand, such as water-saving irrigation systems. In relation to water issues, quantity needed is affected not only by agricultural production but also by soil quality and climate. Therefore, in order to save water and maximise both yield and quality, microirrigation (included fertirrigation) is the practice for effective and sustainable water management used within the tomato supply chain. Microirrigation grants uniform distribution of water and allow relevant water saving since water can be precisely regulated and tailored to the soil and plants' needs and to production and quality targets.

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Strong emphasis on the quality and sustainability of cultivation and processing of tomato and adherence to this high quality profile result in lower yields and higher production costs and prices of northern Italian tomato than in the rest of world.

Producers and processing firms made every effort in order to improve their global position by concentrating on competitive advantages based on quality. The supply chain follows integrated production guidelines, acquires **national and international quality standard**, makes thorough controls in all phases, and, more recently, attains also ethical certification. Moreover, producers and processing firms conclude **pre-campaign contracts** containing not only quality and quantity terms of tomato produced/processed but also a binding code of conduct, whose endorsement and respect is rewarded by price (and income) stability within the supply chain and by increasing appreciation of consumers on national and international markets.

Therefore, since the supply chain ensures the highest quality standards and aim at raising the rating of their products by differentiating their products on quality and sustainability, although considered a commodity, northern Italian tomato cannot be considered as a "price-taker".

7.2 Key findings on governance arrangements and institutional frameworks

The scenario where actors, institutions and rules interact and affect soil and water conditions, management and conservation is rather complex.

Competitiveness in the globalised economy was at stake and forward-thinking of producers and processors on one side, and of public institutions on the other side, managed to trigger a process of mutual trust that facilitated collective actions aimed at adapting organisational and entrepreneurial strategies to face the threats posed by world competition, paying special attention to increasing natural resources scarcity and/or pollution and recurrent adverse climatic events.
The response of the supply chain actors is twofold:

- The creation of new organisations associating, at an earlier stage, producers (producers' Organisations), and, later on, producers and processing firms (the association District of processing tomato and then the Inter-branch Organisation);
- The adoption of new rules and contractual arrangements between producers and processors enforcing the new organization and the market (private schemes).

Organisational innovation provides the framework that facilitates a coherent functioning of the market and a rational supply/demand relationship; production rules and contractual arrangements underpin the cohesion and the accountability of the supply chain and are a guarantee for market stability, for remuneration, defence and promotion of the high quality of the tomato produced and processed in northern Italy and for protection from global competition.

The solutions adopted and the cooperative interactions between industry and agriculture are deeply grounded in the historical local context and convergence on agreed rules, transparency in production data and time limits for contracts and payments are the prerequisites for a fairest possible market balance. The positions of agriculture and industry by their very nature

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diverge, but the awareness of the need for a coordinated and cooperative response to the world economic situation favoured a holistic supply chains vision.

7.3 Other enabling or limiting factors

We have seen that a relevant role in ESBO provision is played by public and private certifications and standards guaranteeing sustainable practices and quality of products.

However, during the interviews emerged that in the adoption of sustainable and innovative practices the most important thing is the territorial approach taken by the supply chain. Emphasis is not put on sustainability of crops but on sustainability of the whole territory, of the whole supply chain. And, since consumers make more and more conscious spending, the supply chain needs to have a high quality products according an integrated quality approach "from farm to fork" that can count on codified distinguished rules (contracts, certifications, standards, etc.).

A limiting factor, instead, is that innovation takes a long time to give its fruits; research, development and introduction of new tomato varieties and/or new products on the market take years.

Another limiting factor for worldwide competition is the lack of uniformity in some quality requirements, such as integrated production regulations. At supply chain level this problem has been overcome in the north since lately, thanks to the intermediation of the Inter-branch Organisation, the Regions of the supply chain solved the question with a legislative harmonisation of provision. However, at national and European level this is not true and causes distortions in market exchanges.

7.4 Contributions to EU strategic objectives

The tomato supply chain is based on a seasonal crop and processing, but production/processing volumes generate high employment and coordination within stakeholders lays the basis for long-term stability.

Tomato production requires highly intensive use of capital, labour and natural resources. In the study area tomato farms have relevant size (40% of the tomato area is cultivated by 15% of the farms) and employment generated is of crucial importance.

Average working days per year in the area are very high (329). Family labour is prevalent in all farms but other typologies of labour (permanent and seasonal) are very relevant. Family labour is indirectly proportional to the size, and hired labour increases as farm size is larger since the family cannot follow all the workload needed.

But employment generated in the tomato production implies also numerous services to farms through contract labour and outsourcing are considered, both of which are supplied partly by producers associations, partly by processing industries, partly by specialized firms.

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The impact of tomato production on employment is therefore highly relevant, but while direct impact is mainly due to smaller farms, the increase in size of farms implies wider mechanization, major economies of scale and major use of seasonal labour (directly hired or under contract). Therefore, the increase in size of the farms less than 10 hectares could contribute to boost permanent (and seasonal) labour, and also contract labour.

Moreover, 60% the processing phase of the whole tomato supply chain is concentrated in Parma and Piacenza area and provide employment for thousands people (permanent and seasonal). And thousands more are employed in the upstream and downstream phases of the supply chain (mechanical engineering industry, packaging lines, research and experimentation, transports and logistics, agri-food international promotion events, etc.).

In the supply chain, economic growth is strictly intertwined with increased attention to research and innovation and to environmental issues. Competitiveness and environmental concern, in fact, are interlinked and reinforce each other, since appropriate farming practices and technical means have constantly been adopted in order to preserve soil and water natural resources base and to optimize their use while aiming at raising productivity and production.

And equally important for the whole supply chain is corporate social responsibility and social footprint certification is becoming an increasingly common practice.

7.5 How about the transferability of the approach/mechanism used?

The key driver of the socio-economic and environmental sustainability approach used by the processing tomato supply chain of northern Italy is organisational and technological innovation, which kept price and market stability, notwithstanding the dramatic change in policy support and in global competition.

Although not perfect, as demonstrated in the campaign 2016 (see 4.1), this framework caught the attention of the southern Italy processing tomato district and in June 2015, at the universal exposition Expo 2015, the two productive systems signed a memorandum of understanding aimed at promoting unitarily national traditional tomato production abroad (where 70% of the tomato goes) and at programming quantity and quality of tomato cultivation and processing in order to grant a fair remuneration of tomato at national level and to compete worldwide on quality and product differentiation under the same “made in Italy” brand.

However, the two tomato districts differ in almost everything and it is difficult to imagine whether there could be a transfer of knowledge, best practice and guidance. They have different pedoclimatic characteristics, different product (round tomatoes in the north; oblong and cherry tomatoes in the south) and processing (concentrate, pulp and puree in the north; whole oblong and cherry peeled in the south), and most of all a different structure.

The District of southern Italy was set up only in 2014 and it is very fragmented and uncoordinated: there are almost 50 firms processing more than 90% of the tomato in more than 80 plants located mainly in Campania, 21 Producers Organisations mainly based in Campania but representing 70% of the tomato produced in the south, 30thousand hectares of arable land

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under tomato most of which in Puglia (Foggia) and Basilicata (Potenza) (Figure 13 in 9.4). Moreover, the south often hits the headlines for food scandals, illegal employment and exploitation.

The southern district is just at the beginning and it is therefore lagging behind in every aspect in comparison to the north, most of all as far as transparency and respect of agreed rules is concerned. Already in 2015 there was extreme tension between processors (that didn't respect the framework agreement) and Producers Organisations (which threatened to resign from the District). In 2016, due to stocks and low prices and trade, industries required the reduction of tomato cultivations and price.
For sure, traceability of agri-food products and food security could help to sustain the market of southern tomato, but value of contracts and agreed rules depend on willingness of everyone involved to respect them.

As emerged during our interviews, "the tomato district of southern Italy lags behind as far as market logic is concerned since there is no transparency, and this self-destructive pattern is rooted in people's attitude; it would be unrealistic to imagine changing the southern market by exporting the system adopted in the north". In the southern Italian tomato district "there is no real correlation between producers and processing firms"; and, most of all, it is not possible to secure tomato traceability: "it is not possible to know where the tomato comes from, since also product traceability is not so much an issue of certifications, but of relationships".

Therefore, transferability of the mechanisms adopted in northern Italy should be accompanied by the creation of a climate of trust between the parties involved.

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9 ANNEX: Supporting data and statistics

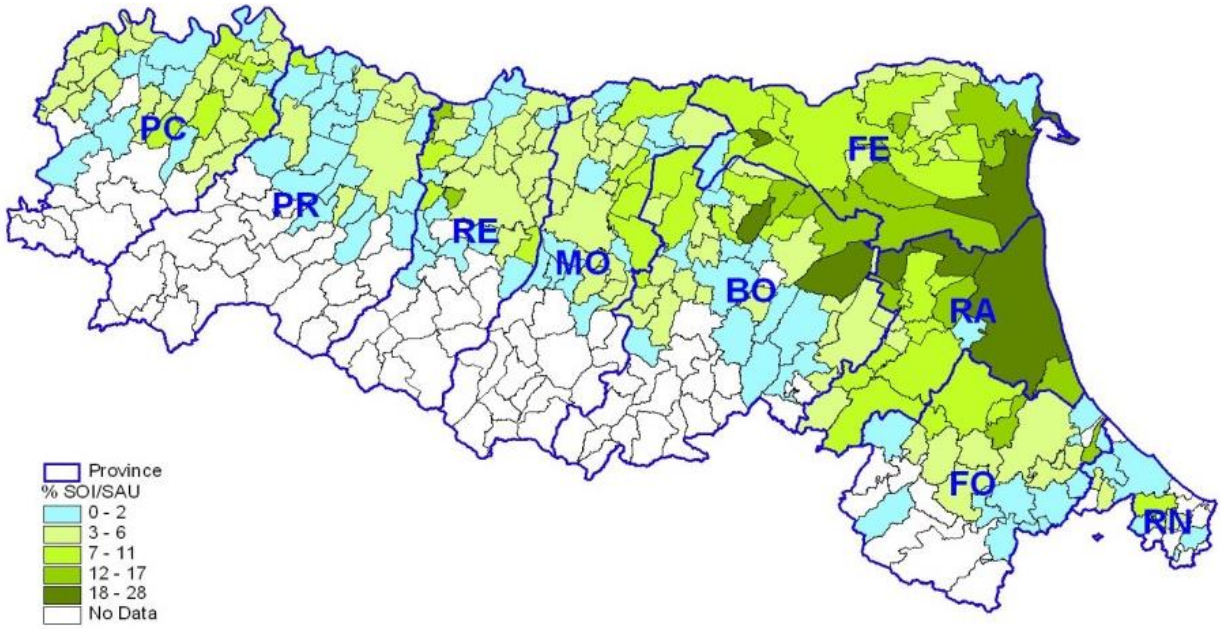

Figure 8: Percentage of regional area under integrated production commitment on Utilised Agricultural Area (UAA)
Source: Regione Emilia Romagna (2016), Il sistema agro-alimentare dell'Emilia-Romagna. Rapporto 2015.

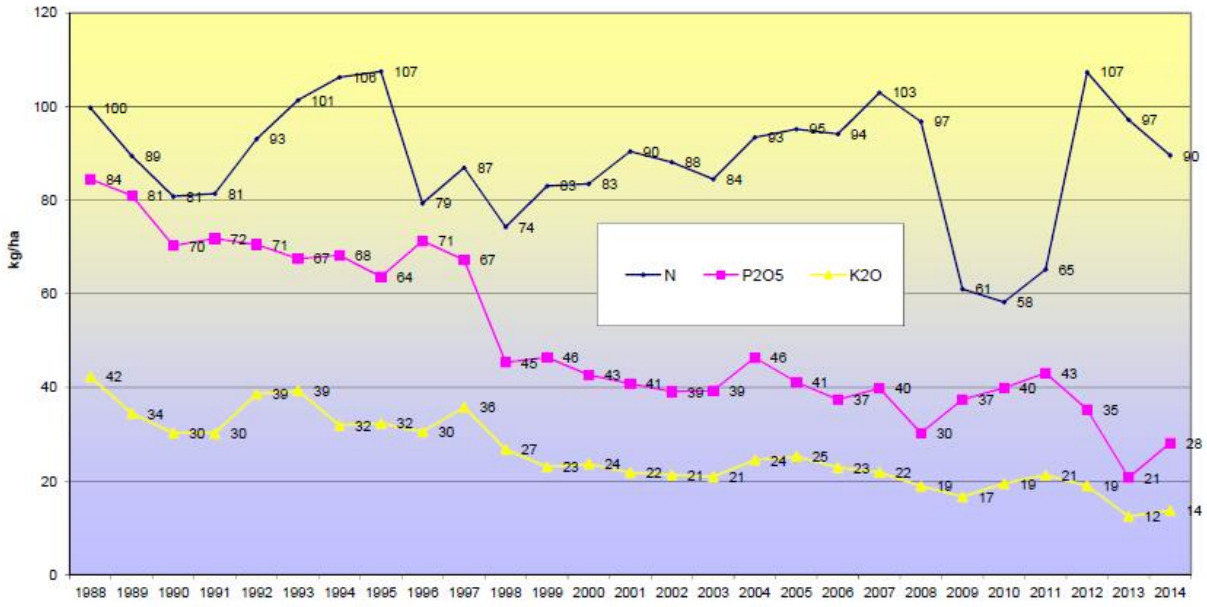

Figure 9: Kg of N, P2O5, K2O per hectare of Utilised Agricultural Area (UAA)
Source: Emilia Romagna Region

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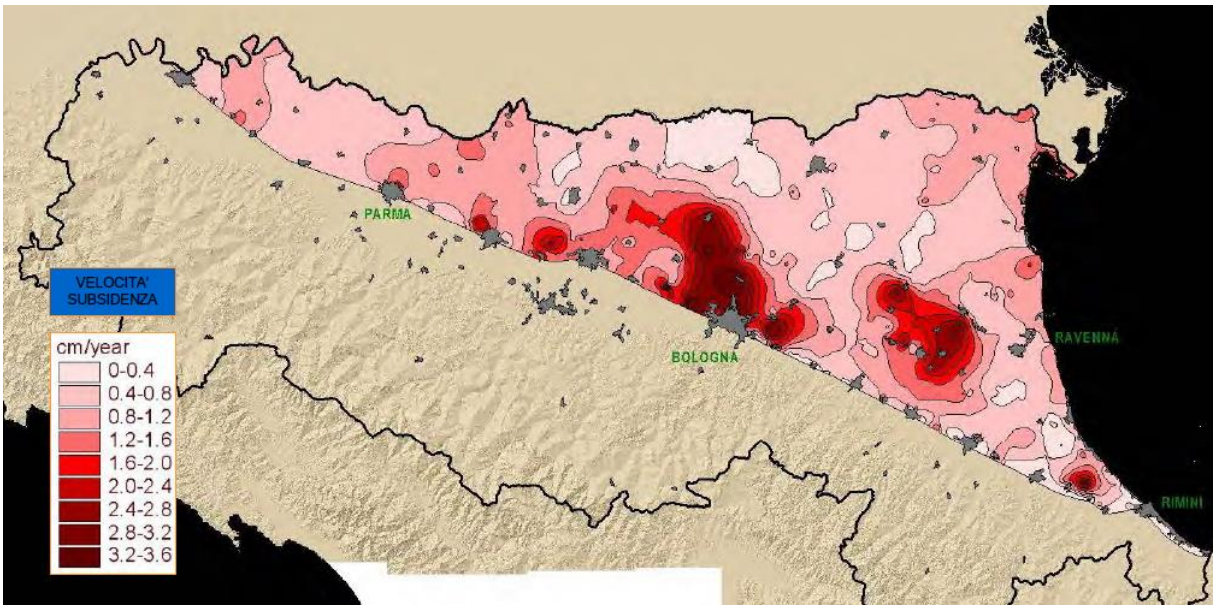

Figure 10: Subsidence rate (cm/year)
Source: Giapponesi A., Mannini P. (2015)

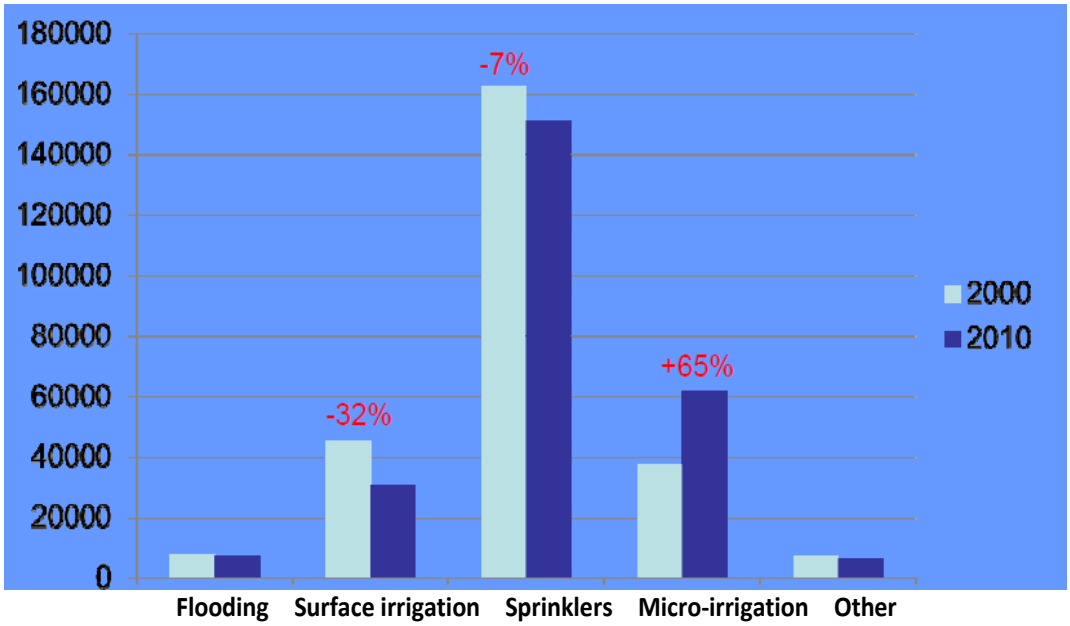

Figure 11: Evolution of irrigation methods between 2000 and 2010 in Emilia Romagna Region
Source: Mannini P., 2016

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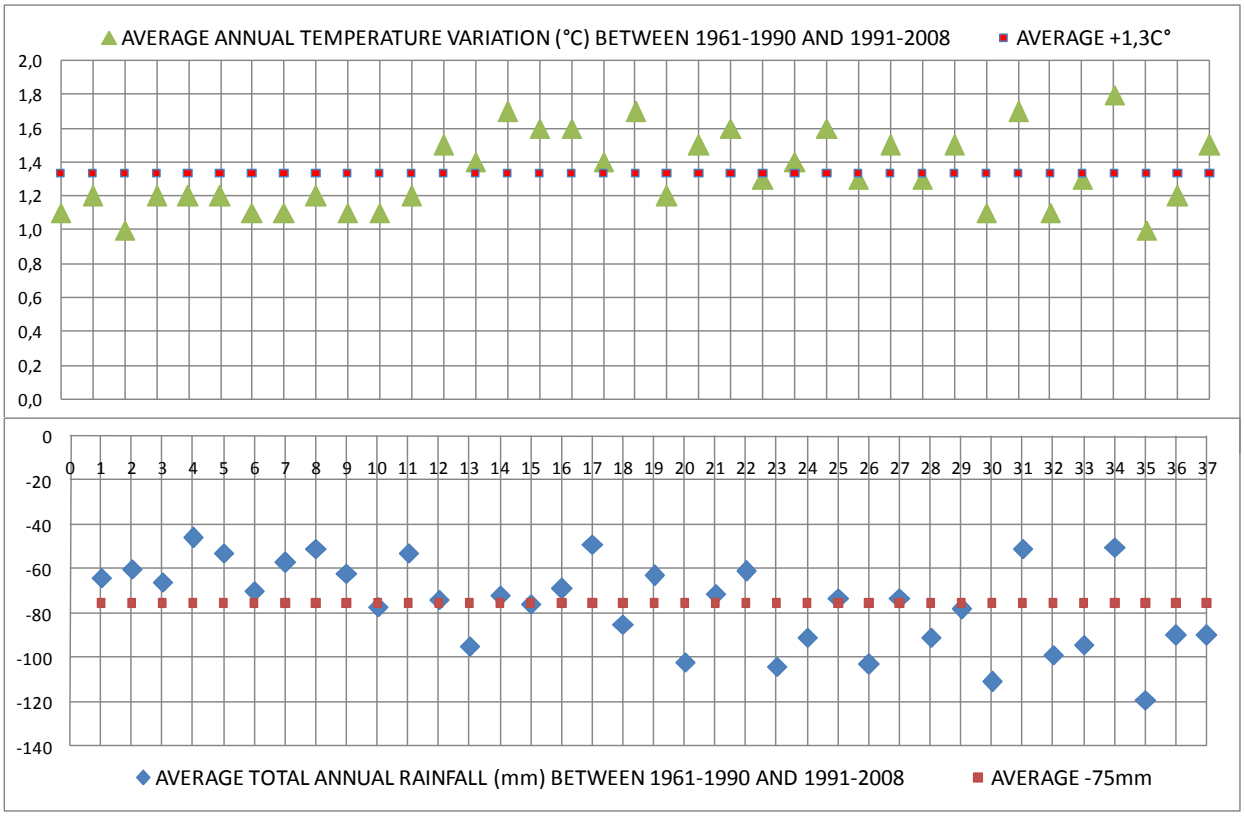

Figure 12: Temperature and rainfalls variation between 1961-1990 and 1991-2008 in the 37 municipalities of the study area (C°, mm)

Municipalities: 1-12 belong to Parma; 13-37 belong to Piacenza.

Source: our elaborations on data from Arpa-Simc (2010)

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Table 21: Daily water supply admitted for processing tomato (mm/day)

		1. Semina/Trapianto	2. Primi frutti	3. 2° Palco con frutti	4. 10% Bacche rosse	5. 25% Bacche rosse	6. Raccolta
a. Semina 15/3	Data rest.	15/3 - 14/5 1.1	15/5 - 29/5 2.4	30/5 - 9/7 4.2	10/7 - 24/7 3.8	25/7 - 5/8 2.3	6/6 --
Irrigazione		Non ammessa salvo indicazione del bollettino	Non ammessa salvo indicazione del bollettino	Ammessa	Ammessa	Ammessa	Non ammessa
b. Semina 30/4	Data rest.	30/4 - 29/5 1.8	30/5 - 14/6 3.3	15/6 - 19/7 4.4	20/7 - 4/8 3.7	5/8 - 15/8 2.1	16/8 --
Irrigazione		Non ammessa salvo indicazione del bollettino	Ammessa	Ammessa	Ammessa	Ammessa	Non ammessa
c. Trapianto 20/4	Data rest.	20/4 - 9/5 1.5	10/5 - 24/5 2.4	25/5 - 4/7 4.3	5/7 - 19/7 3.8	20/7 - 1/8 2.3	2/8 --
Irrigazione		Non ammessa salvo indicazione del bollettino	Ammessa	Ammessa	Ammessa	Ammessa	Non ammessa
d. Trapianto 10/5	Data rest.	10/5 - 29/5 1.8	30/5 - 9/6 3.3	10/6 - 14/7 4.4	15/7 - 30/7 3.8	1/8 - 10/8 2.1	11/8 --
Irrigazione		Non ammessa salvo indicazione del bollettino	Ammessa	Ammessa	Ammessa	Ammessa	Non ammessa
e. Trapianto 30/5	Data rest.	30/5 - 9/6 2.5	10/6 - 19/6 3.3	20/6 - 24/7 4.5	25/7 - 9/8 3.8	10/8 - 20/8 2.1	21/8 --
Irrigazione		Ammessa	Ammessa	Ammessa	Ammessa	Ammessa	Non ammessa

Source: Emilia Romagna Integrated production scheme 2016 – Cultivation technical standards

Table 22: Maximum irrigation volumes admitted according to soil structure (mm)

		ARGILLA %												
		10	15	20	25	35	40	40	45	50	55	60	65	70
	0	57	57	58	58	59	59	60	60	61	61	62	62	63
	5	55	56	56	57	58	59	60	61	61	62	63	64	65
	10	52	53	54	55	56	56	57	58	59	60	61	61	62
	15	50	51	51	52	53	54	55	56	56	57	58	59	60
S	20	47	48	49	50	51	52	52	53	54	55	56	57	57
A	25	45	46	47	47	48	49	50	51	52	52	53	54	55
B	30	42	43	44	43	46	47	47	48	49	50	51	52	52
B	35	40	41	42	41	43	44	45	46	47	48	48	49	-
I	40	38	38	39	39	41	42	43	43	44	45	47	-	-
A	45	35	36	37	36	38	39	40	41	42	43	-	-	-
	50	33	33	34	34	36	37	38	39	39	-	-	-	-
%	55	30	31	32	31	34	34	35	36	-	-	-	-	-
	60	28	29	29	29	31	32	33	-	-	-	-	-	-
	65	25	26	27	27	29	29	-	-	-	-	-	-	-
	70	23	24	25	24	26	-	-	-		-	-	-	-

Source: Emilia Romagna Integrated production scheme 2016 – Cultivation technical standards

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Table 23: Quality of surface water and groundwater in the study area

	Prov	Municipality	Catchment area	Water body	LC* 2006	LC* 2009-10	LC* 2011-12	LC* 2013-14	LC-EQS* 2009-10
SURFACE WATER	PC	Castel S. Giovanni	Asta Po	F. Po					
	PC	Piacenza	Asta Po	F. Po					
	PC	Castel S. Giovanni	Bardonezza	R. Bardonezza					
	PC	Castel S. Giovanni	Lora - Carogna	R. Lora - Carogna					
	PC	Castel S. Giovanni	Carona - Boriacco	R. Carona - Boriacco					
	PC	Piacenza	Nure	T. Nure					
	PC	Rottofreno	Tidone	T. Tidone					
	PC	Rivergaro	Trebbia	F. Trebbia					
	PC	Piacenza	Trebbia	F. Trebbia					
	PC	S. Giorgio Piacentino	Nure	T. Nure					
	PC	Cadeo	Chiavenna	T. Chero					
	PC	Cortemaggiore	Chiavenna	T. Chiavenna					
	PC	Villanova Sull'arda	Arda	T. Arda					
	PC	Villanova Sull'arda	Arda	T. Ongina					
	PR	Parma	Parma	Cavo Naviglio Nav. - Mandracchio T.					
	PR	Parma	Parma	T. Parma					
	PR	Parma	Parma	T. Baganza					
	PR	Parma	Parma	T. Cinghio					
	PR	Parma	Enza	T. Enza					
	PR	Collecchio	Taro	R.Manubiola					
	PR	Soragna	Taro	T. Stirone					
	PR	Parma	Taro	F. Taro					
GROUNDWATER	PC	Sarmato	Staffora - Luria - Versa - Coppa	Freatico di pianura fluviale					
	PC	Calendasco	Asta Po	Freatico di pianura fluviale					
	PC	Piacenza	Asta Po	Freatico di pianura fluviale					
	PC	Castelvetro Piacentino	Asta Po	Freatico di pianura fluviale					
	PC	Castelvetro Piacentino	Asta Po	Freatico di pianura fluviale					
	PC	Rottofreno							
	PC	Gragnano Trebbiense		Conoide Luretta - libero					
	PC	Gragnano Trebbiense		Conoide Trebbia - libero					
	PC	Caorso	Chiavenna	Pianura Alluvionale Padana - confinato superiore					
	PC	S. Giorgio Piacentino	Nure	Conoide Nure - libero					
	PC	Besenzone	Arda - Ongina	Pianura Alluvionale Padana - confinato superiore					
	PC	Pontenure	Chiavenna	Conoide Nure - libero					
	PC	Pontenure	Chiavenna	Conoide Nure - libero					

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	Prov	Municipality	Catchment area	Water body	LC* 2006	LC* 2009-10	LC* 2011-12	LC* 2013-14	LC-EQS* 2009-10
	PC	S. Giorgio Piacentino	Chiavenna	Conoidi montane e Sabbie gialle occidentali					
	PC	Castel S. Giovanni							
	PC	Castel S. Giovanni	Bardonezza	Freatico di pianura fluviale					
	PC	S. Pietro in Cerro	Arda - Ongina	Pianura Alluvionale Padana - confinato superiore					
	PC	S. Pietro in Cerro	Asta Po	Freatico di pianura fluviale					
	PC	Piacenza	Asta Po	Conoide Nure - libero					
	PC	Piacenza	Nure	Pianura Alluvionale Padana - confinato superiore					
	PC	Piacenza	Nure	Conoide Nure - libero					
	PC	Piacenza	Trebbia	Conoide Trebbia - libero					
	PC	Borgonovo Val Tidone	Staffora - Luria - Versa - Coppa	Conoide Tidone - libero					
	PC	Borgonovo Val Tidone	Staffora - Luria - Versa - Coppa	Conoide Tidone-Luretta - confinato superiore					
	PC	Agazzano							
	PC	Gazzola	Trebbia	Conoide Trebbia - libero					
	PC	Sarmato							
	PC	Vigolzone	Trebbia	Conoidi montane e Sabbie gialle occidentali					
	PC	Rivergaro	Trebbia	Conoide Trebbia - libero					
	PC	Podenzano	Trebbia	Conoide Trebbia - libero					
	PC	Podenzano	Nure	Conoide Nure - libero					
	PC	Gossolengo							
	PC	Cadeo		Pianura Alluvionale - confinato inferiore					
	PC	Parma	Parma	Conoide Parma-Baganza - libero					
	PC	Parma	Parma	Conoide Parma-Baganza - confinato superiore					
	PC	Noceto	Taro	Conoide Taro - libero					
	PR	Parma	Parma	Freatico di pianura fluviale					
	PR	Parma	Parma	Freatico di pianura fluviale					
	PR	Noceto	Taro	Conoide Stirone-Parola - libero					
	PR	Parma	Parma	Conoide Parma-Baganza - libero					
	PR	Parma	Parma	Conoide Parma-Baganza - libero					
	PR	Parma	Parma	Conoide Parma-Baganza - libero					
	PR	Parma	Enza	Conoide Parma-Baganza - libero					
	PR	Montechiarugolo	Enza	Conoide Parma-Baganza - confinato inferiore					

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	Prov	Municipality	Catchment area	Water body	LC* 2006	LC* 2009-10	LC* 2011-12	LC* 2013-14	LC-EQS* 2009-10
	PR	Montechiaru-golo	Enza	Conoide Parma-Baganza - libero					
	PR	Collecchio	Parma	Conoide Parma-Baganza - libero					
	PR	Montechiaru-golo	Enza	Conoide Enza - libero					
	PR	Fontanellato	Taro	Conoide Taro - libero					
	PR	Noceto	Taro	Conoidi montane e Sabbie gialle occiden-tali					
	PR	Parma	Parma	Conoide Parma-Baganza - libero					
	PR	Collecchio	Taro	Conoide Taro - libero					
	PR	Collecchio	Taro	Conoide Taro - libero					
	PR	Parma	Parma	Conoide Parma-Baganza - libero					
	PR	Polesine Parmense	Arda - Ongina	Pianura Alluvionale Pa-dana - confinato supe-riore					
	PR	Sorbolo	Enza	Pianura Alluvionale Pa-dana - confinato supe-riore					
	PR	Parma	Enza	Pianura Alluvionale Pa-dana - confinato supe-riore					

PC-Piacenza; PR-Parma *LC: Level of Confidence; **EQS: Environmental Quality Standard.
Source: our elaborations on data from regional environmental agency ARPAE

NON QUANTIFIABLE
WITHIN LIMIT
ABOVE LIMIT
NO DATA

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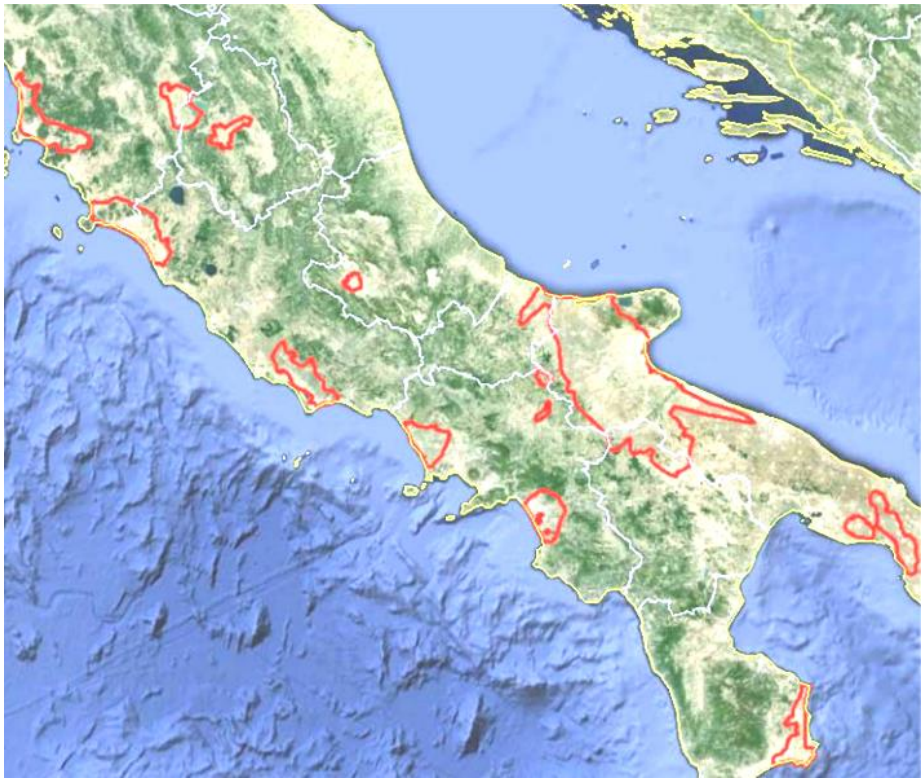

Figure 13: Areas growing tomatoes for processing in Centre and South Italy (in red)
Source: ANICAV, Mappatura delle superfici coltivate a pomodoro da industria nel Centro Sud Italia nel 2013 - Presentazione Belli.pdf, http://www.anicav.it/eventi

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