



Report on assessment of the social, environmental and economic sustainability of food quality schemes

Valentin Bellassen, Filippo Arfini, Virginie Amilien, Federico Antonioli, Antonio Bodini, Michael Böhm, Ruzica Brečić, Sara Chiussi, Peter Csillag, Abdoul Diallo, et al.

► To cite this version:

Valentin Bellassen, Filippo Arfini, Virginie Amilien, Federico Antonioli, Antonio Bodini, et al.. Report on assessment of the social, environmental and economic sustainability of food quality schemes. [Research Report] INRA (Institut National de la Recherche Agronomique), domaine de la Motte au Vicomte B.P. 35327, 35653 Le Rheu Cedex; Università degli Studi di Parma. 2019. hal-02790404

HAL Id: hal-02790404

<https://hal.inrae.fr/hal-02790404v1>

Submitted on 2 Jul 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Strengthening European Food Chain Sustainability by Quality and Procurement Policy

Deliverable 5.1:

REPORT ON ASSESSMENT OF THE SOCIAL, ENVIRONMENTAL AND ECONOMIC SUSTAINABILITY OF FQS

February 2019

Contract number	678024
Project acronym	Strength2Food
Dissemination level	Public
Nature	R (Report)
Responsible Partner(s)	INRA, UniPr
Author(s)	V. Bellassen, F. Arfini, V. Amilien, F. Antonioli, A. Bodini, M. Boehm, S. Chiussi, P. Csillag, A. Diallo, M. Donati, L. Dries, M. Drut, M. Dubois de Labarre, H. Ferrer, J. Filipović, L. Gauthier, C. Gil, M. Gorton, V. Hoàng, M. Hilal, K. Knutsen Steinnes, A. Lilavanichakul, A. Malak-Rawlikowska, E. Majewski, S. Monier-Dilhan, P. Muller, O. Napasintuwong, K. Nikolaou, A. Nguyễn Quỳnh, I. Papadopoulos, S. Pascucci, J. Peerlings, Á. Török, T. Poméon, B. Ristic, Z. Stojanovic, M. Tomic Maksan, M. Veneziani, G. Vitterso, A. Wilkinson.
Keywords	Indicators, food quality schemes, organic, geographical indications, impact assessment, sustainability, agri-food supply chains, performance, multi-criteria assessment

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 678024.



Academic Partners

1. **UNEW**, Newcastle University (United Kingdom)
2. **UNIPR**, University of Parma (Italy)
3. **UNED**, University of Edinburgh (United Kingdom)
4. **WU**, Wageningen University (Netherlands)
5. **AUTH**, Aristotle University of Thessaloniki (Greece)
6. **INRA**, National Institute for Agricultural Research (France)
7. **BEL**, University of Belgrade (Serbia)
8. **UBO**, University of Bonn (Germany)
9. **HiOA**, National Institute for Consumer Research (Oslo and Akershus University College) (Norway)
10. **ZAG**, University of Zagreb (Croatia)
11. **CREDA**, Centre for Agro-Food Economy & Development (Catalonia Polytechnic University) (Spain)
12. **UMIL**, University of Milan (Italy)
13. **SGGW**, Warsaw University of Life Sciences (Poland)
14. **KU**, Kasetsart University (Thailand)
15. **UEH**, University of Economics Ho Chi Minh City (Vietnam)

Dedicated Communication and Training Partners

16. **EUFIC**, European Food Information Council AISBL (Belgium)
17. **BSN**, Balkan Security Network (Serbia)
18. **TOPCL**, Top Class Centre for Foreign Languages (Serbia)

Stakeholder Partners

19. **Coldiretti**, Coldiretti (Italy)
20. **ECO-SEN**, ECO-SENSUS Research and Communication Non-profit Ltd (Hungary)
21. **GIJHARS**, Quality Inspection of Agriculture and Food (Poland)
22. **FOODNAT**, Food Nation CIC (United Kingdom)
23. **CREA**, Council for Agricultural Research and Economics (Italy)
24. **Barilla**, Barilla Group (Italy)
25. **MPNTR**, Ministry of Education, Science and Technological Development (Serbia)
26. **Konzum**, Konzum (Croatia)
27. **Arilje**, Municipality of Arilje (Serbia)
28. **CPR**, Consortium of Parmigiano-Reggiano (Italy)
29. **ECOZEPT**, ECOZEPT (Germany)
30. **IMPMENT**, Impact Measurement Ltd (United Kingdom)

TABLE OF CONTENTS

EXECUTIVE SUMMARY	5
LIST OF TABLES	6
LIST OF FIGURES.....	7
LIST OF ABBREVIATIONS AND ACRONYMS	8
1. INTRODUCTION.....	9
2. PROTECTED DESIGNATION OF ORIGIN	9
2.1. Meat and dairy sectors.....	9
2.1.1. PDO Comté cheese (France)	9
2.1.2. PDO Parmigiano Reggiano cheese (Italy).....	17
2.1.3. PDO Cornish clotted cream (UK)	21
2.2. Vegetal products	21
2.2.1. PDO olive oil (Croatia)	21
2.2.2. PDO Zagora apple (Greece).....	23
2.2.3. PDO Kalocsai paprika powder (Hungary)	29
2.2.4. PDO Opperdoezer Ronde potatoes (The Netherlands)	31
2.3. Unfed seafood and fish	35
2.3.1. PDO Saint-Michel bay bouchot mussels (France)	35
2.3.2. PDO Phu Quoc Fish Sauce (Vietnam)	38
2.3.3. PDO Fal oysters (UK)	41
3. PROTECTED GEOGRAPHICAL INDICATIONS.....	42
3.1. Meat and dairy sectors.....	42
3.1.1. PGI Dalmatian ham (Croatia)	42
3.1.2. PGI Gyulai sausage (Hungary)	45
3.1.3. PGI Sobrasada Porc Negre (Spain)	51
3.1.4. PGI Ternasco de Aragon (Spain)	55
3.1.5. PGI-applicant Sjenica cheese (Serbia)	58
3.2. Vegetal products	62
3.2.1. PGI Kastoria apple (Greece)	62
3.2.2. PGI Kaszubska strawberries (Poland).....	67
3.2.3. PGI Thung Kula Rong-Hai Hom Mali rice (Thailand)	71
3.2.4. PGI Doi Chaang coffee (Thailand)	76
3.2.5. PGI Buon Ma Thuot coffee (Vietnam)	79

3.3. Unfed seafood and fish	83
3.3.1. PGI Lofoten stockfish (Norway)	83
4. ORGANIC PRODUCTS	86
4.1. Animal products	86
4.1.1. Organic fresh pork meat (Germany)	86
4.1.2. Organic yoghurt (Germany)	90
4.1.3. Organic farmed salmon (Norway).....	94
4.2. Vegetal products	97
4.2.1. Organic flour and bread (France)	97
4.2.2. Organic processed tomatoes (Italy)	104
4.2.3. Organic pasta (Poland)	108
4.2.4. Organic raspberries (Serbia).....	114
4.2.5. Organic rice (France)	116
REFERENCES	122

EXECUTIVE SUMMARY

This report provides an assessment of the social, environmental and economic performance of 29 Food Quality Schemes including organic, Protected Designation of Origin and Protected Geographical Indication products. Each FQS is compared to a reference product in the same country which is not certified or to the national average for the relevant value chain. The same method and the same 20 indicators are applied to all products and their reference at farm, processing and – where possible and relevant – retail levels. The economic indicators cover prices, gross operating margins, exports and local spill-overs. The environmental indicators include carbon footprint, food miles, water use and water pollution. The social indicators cover employment, social capital, bargaining power distribution, generational balance and gender equity. The results for each case are summarized in a *sustainability diagram* displaying the value chain average differences for the key indicators. The diagrams are followed by an interpretation of the results and more details on each indicator on a case-by-case basis. Wherever an indicator could not be estimated, the reason for this is discussed, providing a basis for improving either the indicator or the data collection system.

LIST OF TABLES

Table 1. Economic performance of PDO Comté cheese along the supply chain.....	11
Table 2. Carbon footprint for PDO Comté cheese and its reference.....	12
Table 3. Extended food miles for PDO Comté cheese and its reference	13
Table 4. Employment for PDO Comté cheese and its reference.....	14
Table 5. Bargaining power for PDO Comté cheese and its reference.....	15
Table 6. Educational attainment for PDO Comté cheese and its reference	16
Table 7. Generational change and gender equality for PDO Comté cheese and its reference .	16
Table 8. Generational balance and gender equity for PDO Zagora apple and its reference	28
Table 9. SWOT analysis of the Sjenica sheep cheese.....	62
Table 10. Generational change and gender equity for PGI Kastoria apple.....	66
Table 11. Economic sustainability indicators	67
Table 12. Carbon Footprint indicators	68
Table 13. Food miles indicators	68
Table 14. Green, grey and blye water footprint indicators.....	69
Table 15. Labour productivity and educational attainment indicators.....	70
Table 16. Generational Change and Gender Inequality indicators	71
Table 17. Economic results for organic and conventional flour and bread production	99
Table 18. Food miles for organic and conventional flour production.....	100
Table 19. Water footprint for organic and conventional flour production.....	101
Table 20. Employment for organic and conventional flour production.....	102
Table 21. Bargaining power for organic and conventional flour	102
Table 22. Educational attainment for organic and conventional flour	103
Table 23. Generational change and gender equality for organic flour and its reference	104
Table 24. Economic indicators for Polish organic pasta.....	110
Table 25. Carbon Footprint of Polish organic pasta.....	110
Table 26. Green, grey and blue water footprint of Polish organic pasta.....	111
Table 27. Labour productivity and educational attainment of Polish organic pasta	112

LIST OF FIGURES

Figure 1. Sustainability performance of PDO Comté cheese (supply chain averages).....	10
Figure 2. Sustainability performance of PDO Parmigiano Reggiano cheese (supply chain averages).....	17
Figure 3. Sustainability diagram of Croatian PDO olive oil	21
Figure 4. Sustainability diagram of PDO Zagora apple	24
Figure 5. Economic indicator results of PDO Zagora apple and its reference conventional apple	25
Figure 6. Water footprint of PDO Zagora and its reference.....	27
Figure 7. Sustainability diagram of PDO Kalocsai paprika powder	29
Figure 8. Sustainability diagram for the Opperdoezer Ronde potatoes	32
Figure 9. Water footprint of the Opperdoezer Ronde and its reference	34
Figure 10. Sustainability performance of PDO Saint-Michel bouchot mussels (supply chain averages).....	36
Figure 11. Sustainability diagram of PDO Phu Quoc fish sauce	38
Figure 12. Sustainability diagram for PDO Fal oysters	42
Figure 13. Sustainability diagram for PGI Dalmatian prosciutto.....	43
Figure 14. Sustainability diagram of PGI Gyulai sausage	46
Figure 15. Sustainability performance of PGI Sobrasada Porc Negre (supply chain averages)	52
Figure 16. Indicators diagram for PGI Ternasco de Aragón.....	56
Figure 17. Sustainability performance of PGI Sjenica cheese (supply chain averages)	59
Figure 18. Sustainability diagram of PGI Kastoria apple	63
Figure 19. Economic indicators for PGI Kastoria apple and its reference.....	64
Figure 20. Water footprint of PGI Kastoria apple.....	65
Figure 21. Sustainability diagram of certified GI Khao Hom Mali Thung Kula Rong-hai	72
Figure 22. Sustainability diagram of PGI Doi Chaang coffee	76
Figure 23. Sustainability performance of PGI Buon Ma Thuot coffee (supply chain averages)	79
Figure 24. Sustainability diagram for the PGI stockfish from Lofoten	83
Figure 25. Sustainability performance of German organic pork (supply chain averages).....	87
Figure 26. Water footprint of organic pork per ton of product	89
Figure 27. Waterfootprint of organic pork per hectare	90
Figure 28. Sustainability performance of German organic yoghurt (supply chain averages)..	91
Figure 29. Sustainability performance of German organic pork (supply chain averages).....	95
Figure 30. Sustainability performance of French organic bread (supply chain averages)	98
Figure 31. Sustainability performance of Italian organic processed tomatoes (supply chain averages).....	105
Figure 32. Sustainability performance of Polish organic pasta (supply chain averages).....	109
Figure 33. Sustainability performance of Serbian organic raspberries	116
Figure 34. Sustainability performance of organic rice (supply chain averages).....	117
Figure 35. Water footprint of organic rice	118

LIST OF ABBREVIATIONS AND ACRONYMS

FQS	Food Quality Scheme
LCA	Life Cycle Assessment
GOM	Gross operating margin
GVA	Gross value added
PDO	Protected Designation of Origin
PGI	Protected Geographical Indication
REF	Reference product
WF	Water Footprint

REPORT ON ASSESSMENT OF THE SOCIAL, ENVIRONMENTAL AND ECONOMIC SUSTAINABILITY OF FQS

V. Bellassen, F. Arfini, V. Amilien, F. Antonioli, A. Bodini, M. Boehm, S. Chiussi, P. Csillag, M. Donati, L. Dries, M. Drut, M. Dubois de Labarre, H. Ferrer, J. Filipović, L. Gauvrit, C. Gil, M. Gorton, V. Hoàng, M. Hilal, K. Knutsen Steinnes, A. Lilavanichakul, A. Malak-Rawlikowska, E. Majewski, S. Monier-Dilhan, P. Muller, O. Napasintuwong, K. Nikolaou, A. Nguyễn Quỳnh, I. Papadopoulos, S. Pascucci, J. Peerlings, Á. Török, T. Poméon, B. Ristic, Z. Stojanovic, M. Tomic Maksan, M. Veneziani, G. Vitterso, A. Wilkinson.

1. INTRODUCTION

Only the results of the multi-criteria assessments are provided in this deliverable. [Deliverable 3.2](#) describes the method and the products are described briefly in [Deliverable 3.3](#). For each FQS, a longer 10-20 pages description of the product, its value chain and its governance is available upon request.

2. PROTECTED DESIGNATION OF ORIGIN

2.1. Meat and dairy sectors

2.1.1. PDO Comté cheese (France)

The sustainability performance of Comté cheese has been assessed, using the Strength2Food method (Bellassen et al., 2016). For economic indicators, the reference to which Comté is compared is PGI Emmental cheese, also produced in Central eastern France. For other indicators, the reference is the French national average for milk or cheese production.

Comté cheese performs almost unequivocally better than its counterpart (Figure 1). Its average 62% price premium is particularly impressive. This price premium renders the strict technical specifications acceptable to farmers and processors, which in turns generates other sustainability benefits. The only notable exceptions to this picture are the share of output exported, which is 40% lower than Emmental, and the CO₂ emissions related to milk transportation.

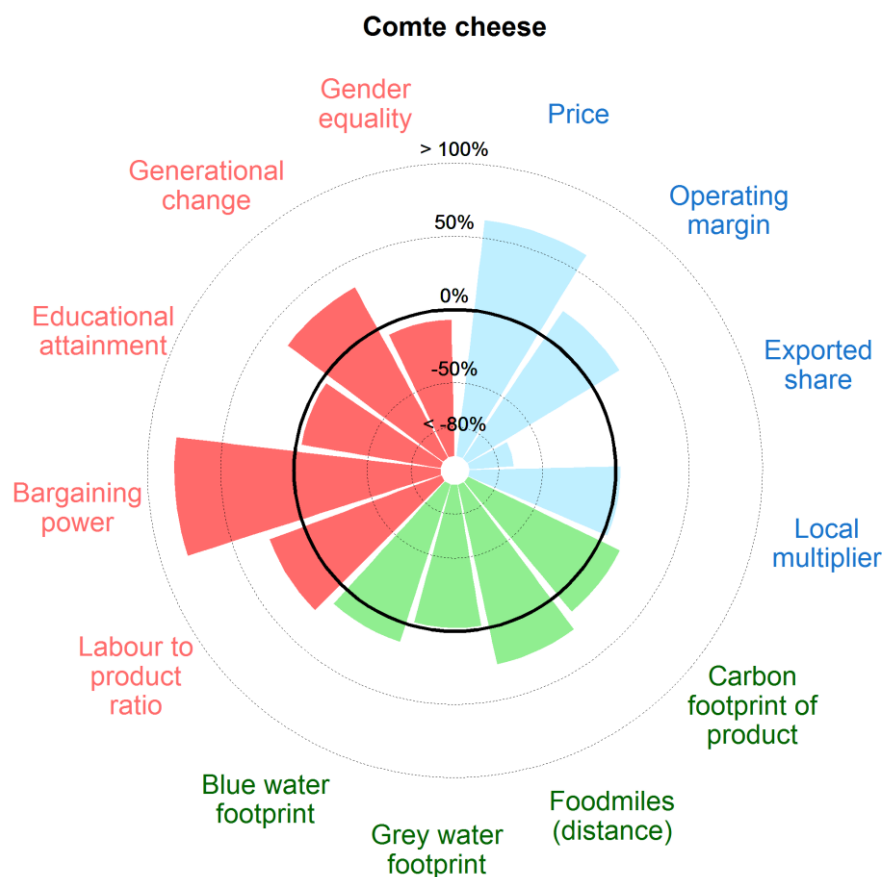


Figure 1. Sustainability performance¹ of PDO Comté cheese (supply chain averages)

2.1.1.1. Economic indicators

The **price premium**, i.e. the difference in prices, increases along the supply chain, with a sizable gap at processing level. **Profitability** is also higher for Comté cheese than for the reference cheese both at the upstream and processing levels. At the upstream level, we observe an increase of the Gross Operating Margin (GOM) with respect to the Gross Value Added (GVA) due to the presence of subsidies in the calculation of GOM. The **international market** for Comté and the reference cheese is European in nature, with a higher share of the output of the reference cheese exported.

¹ Each indicator is expressed as the difference between the FQS and its reference product. For environmental indicators for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower).

Table 1. Economic performance of PDO Comté cheese along the supply chain

	FQS	Reference	Difference
Price (€ kg⁻¹)			
Farm level	0.47	0.36	+29%
Processing level	7.87	4.54	+73%
Retail level	13.53	7.32	+84%
gross value-added (% of turnover)			
Farm level	35	27	+27%
Processing level	13.0	12.9	+1%
gross operating margin (% of turnover)			
Farm level	55	47	+16%
Processing level	5.6	4.4	+27%
Net result (% of turnover)			
Farm level	33	25	+32%
Processing level	3	1	+141%
Share of volume exported within Europe (%)			
Processing level	6.8	11.8	-42%
Share of volume exported outside Europe (%)			
Processing level	1.6	2.2	-27%

The local multiplier effect of Comté is 3% higher than for its reference product: each euro of turnover for Comté triggers 1.70 euros of re-expenditure in the same region versus 1.62 euros for the reference. Several elements drive of this difference:

- the assumption, derived from the technical specifications, that in the case of Comté 80% of the animal feed is local procured versus only 50 % for the reference;
- most Comté processors are locally based, so the margin is therefore mostly re-spent locally;
- the higher – locally spent – margin of Comté businesses.

The location of workers, and therefore their local spending, is however very similar between Comté and its reference.

2.1.1.2. Environmental indicators

Carbon footprint

Table 2. Carbon footprint for PDO Comté cheese and its reference

	FQS	Reference	Difference
Carbon footprint of product (t CO₂e t⁻¹)			
Farm level	1.13	1.13	+0%
Farm & processing levels	10.6	12.5	-15%
Carbon footprint of area (t CO₂e ha⁻¹)			
Farm level	4.2	6	-29%
Farm & processing level²	3.9	5.3	-28%

The carbon footprint of Comté (excluding transport) is 15% lower than for its reference, comparator product (Table 2), mostly due to a higher level of processing efficiency (10 litres per kg of Comté instead of 12 per kg of Emmental). Indeed, at farm level, the carbon footprint of milk is almost the same (1.131 and 1.126 tCO₂e t of milk⁻¹ respectively): while the higher share of pasture saves some emissions from fertilizer and machinery, these savings are offset by a 4% lower milk productivity of cows and by a higher share of rapeseed in feed. The carbon footprints at farm level are within the 0.52-2 tCO₂e per t of milk⁻¹ reported in the literature (Meier et al., 2015).

Extended food miles

Concerning food-miles, the PDO supply chain was compared to the conventional cheese chain in France, from farm to retail levels (Table 3). Over the entire supply chain, PDO Comte cheese travels 25% shorter distances (1,000 t.km t⁻¹ vs 1,300 t.km t⁻¹) and releases 15% less emissions (150 vs 175 kg CO₂e t⁻¹) than the average cooked and pressed cheese in France. This difference is mainly driven by the difference in the technical specification of the products, and more precisely by the product concentration (0.1 vs 0.08). Less milk is needed to produce 1 kg of the FQS cheese, and this reduces distances and emissions. The difference is to a lesser extent driven by the smaller share of exports in the case of the FQS (8% against 14% for the reference) that implies shorter distances and less emissions than for the reference product. Regarding food-miles indicators, we can conclude that PDO Comte cheese is more sustainable than its reference in terms of distance travelled (-25%) and emissions released at the transportation stage (-15%).

² Emissions per hectare are lower when the processing level is added because part of the emissions are then allocated to whey and therefore subtracted from the carbon footprint of cheese.

Table 3. Extended food miles for PDO Comté cheese and its reference

	FQS	Reference	Difference
Distance travelled (ton.km ton⁻¹)			
Processing level	745	915	-19%
Retail level	243	413	-41%
Value chain	988	1329	-26%
Carbon emissions related to the transportation stage (kg CO₂e ton⁻¹)			
Processing level	133	146	-9%
Retail level	16	30	-47%
Value chain	149	176	-15%

Water footprint

The grey water footprint of Comté, an indicator of water nitrate pollution, is 2% higher than for its comparator reference product. More organic nitrogen on barley (68 vs 58 kgN/ha) and on grass (36 vs 31 kgN/ha) implies a higher grey water footprint per tonne of fodder (105 vs 90 m³/tDM) despite a higher share of grass in the diet. This higher grey water footprint of fodder is reinforced slightly by the modestly lower productivity of Comté cows – 6.52 vs 6.76 tonne of milk per year – for approximately the same dry matter intake. This difference at farm level is almost offset by the higher level of processing efficiency (10 L per kg of cheese for Comté vs 12 for the reference). Note that on a per hectare basis, the grey water footprint of Comté is 27% lower than its reference due to the lower yield of Comté fodder.

The blue water footprint of Comté, an indicator of water withdrawal from ground and streams, is 2% lower for Comté than for its comparator reference product. It is, however, very small for both cheeses. Finally, the green water footprint, which measures total consumption of water, is also slightly lower for Comté. Barley and grass contribute more to the green water footprint of the FQS than that of the reference product. However, in the case of the latter, there is a greater overall impact on the indicator because of the high contribution of soy, which is not used in FQS production. While this is not currently a concern given the sufficient level of rainfall in the Comté area, it may become one if droughts were to become more frequent.

2.1.1.3. Social indicators

Employment

Employment is investigated using two indicators: the labour intensity of production, expressed in working units per tonne of product, and labour productivity expressed in euros turnover per working unit. The labour use ratio indicator, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope, 2001). Results for the employment indicators are presented in Table 4.

Table 4. Employment for PDO Comté cheese and its reference

	FQS	Reference	Difference
Labour-to-production ratio (AWU.t⁻¹)			
Farm level	0.007	0.005	+34%
Processing level	0.016	0.014	+16%
Turnover-to-labour ratio (€.AWU⁻¹)			
Farm level	66,968	67,823	-1%
Processing level	500,190	333,916	+50%

The allocation of labour to production is higher for Comté cheese than for its non-PDO reference (French Emmental). At the farm level, it takes 13 hours of work to produce a tonne of milk while the reference product requires only 10 hours. The difference (13%) indicates that the PDO product generates more labour activity than the reference system. The relative difference is slightly less important at the processing level since it takes 28 hours of work to prepare a tonne of PDO-Comté cheese against 24 hours for the non-PDO Emmental cheese. This is consistent with the technical specifications. At the farm level, the limitation on the use of concentrates and the emphasis placed on pasture may lead to the system of production being more time intensive. Similarly, the absence of vertical integration, the minimum ripening time and the constraints on milk collection likely require more labour at processing level. It seems however to be worth it financially. Indeed, the turnover-to-labour ratio indicator, which provides an insight into labour productivity, is similar at farm level but 50 % higher for Comté at processing level. Note that to avoid an artificial turnover inflation for Comté due to the absence of vertical integration, only the turnover of ripeners was used as the numerator for this indicator.

Bargaining power

The bargaining power indicator reflects the balance of bargaining power between the different levels of the value chain. It combines a simplified Herfindhal index with other more qualitative elements. It varies between 0 – perfect equality – and 1 where one level of the value chain dictates its will to the other levels. Results for the bargaining power indicator are presented in Table 5.

Table 5. Bargaining power for PDO Comté cheese and its reference

	FQS	Reference	Difference
Bargaining power			
Farm level	ie	0.33	-
P1	0.58	0.67	-13%
P2	0.78	-	-
Bargaining power distribution			
Value chain	0.02	0.11	-82%

n/a: not applicable

Bargaining power is very evenly distributed between independent levels of the supply chain, even though the second level of processing (ripening) has a slight advantage over the first level of processing (cheese manufacturing cooperative, integrating breeders), mainly due to the fact that ripeners are fewer in number than cheese manufacturers. Bargaining power is less evenly distributed between levels in the case of the reference product, to the benefit of the first processing level and at the expense of the milk production level. The reason for this mainly lies in the much greater concentration in processing compared to milk producers at both levels.

When inspecting the bargaining power for each level of the Comté supply chain, one can notice that bargaining power scores are high (>0.5) at all levels, which indicates that the bargaining power position can be labelled as strong at all levels of the supply chain. This indicates that levels of the supply chain can be considered as robust enough to cope with a significant modification in the structure of the Comté supply chain. In contrast, bargaining power values for the reference product are quite low (the "weakest" level reaches a score below 0.5), thus indicating that bargaining power positions are quite weak, especially at the production level: any significant change in the competitive environment of the supply chain would have significant consequences on all of its levels.

Educational attainment

Both Putnam (2000) and Halpern (1999) identified education as key to the creation of social capital and greater educational achievement as an important outcome. The education attainment indicator, which refers to the highest level of education that an individual has completed, allows us to indirectly measure certain components of social capital. Results for the educational attainment indicator are presented in Table 6.

This indicator is close to 0 if the majority of workers have a primary education level and approaches 1 as the level of education increases. There is no difference in the profile of education levels between producers of Comté cheese, at farm level, and those in the French conventional dairy sector. The level of education is dominated by graduates of secondary or middle schools (74-78%).

Table 6. Educational attainment for PDO Comté cheese and its reference

	FQS	Reference	Difference
Educational attainment			
Farm level	0.51	0.53	-4%
Processing level	0.46	-	-
Wage level (€/AWU⁻¹)			
Farm level	23,104	17,566	+32%
Processing level	54,838	47,524	+15%

Generational change and gender equality

Regarding generational change and gender equality, the PDO supply chain was compared to the national cheese supply chain at farm and processing stages (dairy manufacturing and to a lesser extent ripening). Table 7 presents results for the generational change and gender equality indicators.

Table 7. Generational change and gender equality for PDO Comté cheese and its reference

	FQS	Reference	Difference
Generational change (%)			
Farm level	52	34	+53%
Processing level	73	65	+12%
Retail level	73	-	-
Value chain	66	49	+35%
Gender inequality (%)			
Farm level	0.16	0.20	-20%
Processing level	0.29	0.04	+625%
Value chain	0.28	0.12	+133%

At farm level, Comté Cheese appears to be more sustainable than its counterpart, both in terms of Generational Change (52% vs 34%) and Gender Inequality (0.16 vs 0.20). However, because the Generational Change indicator is smaller than 100%, the farm stages of both supply chains appear somewhat endangered in their sustainability prospects due to the rather limited employment of 15-35 year-olds, compared to 45-65 year-olds. Moreover, what drives the difference regarding gender inequality is the fact that women are markedly under-represented in the workforce and that a larger share of male employees obtain a secondary qualification in the counterpart supply chain.

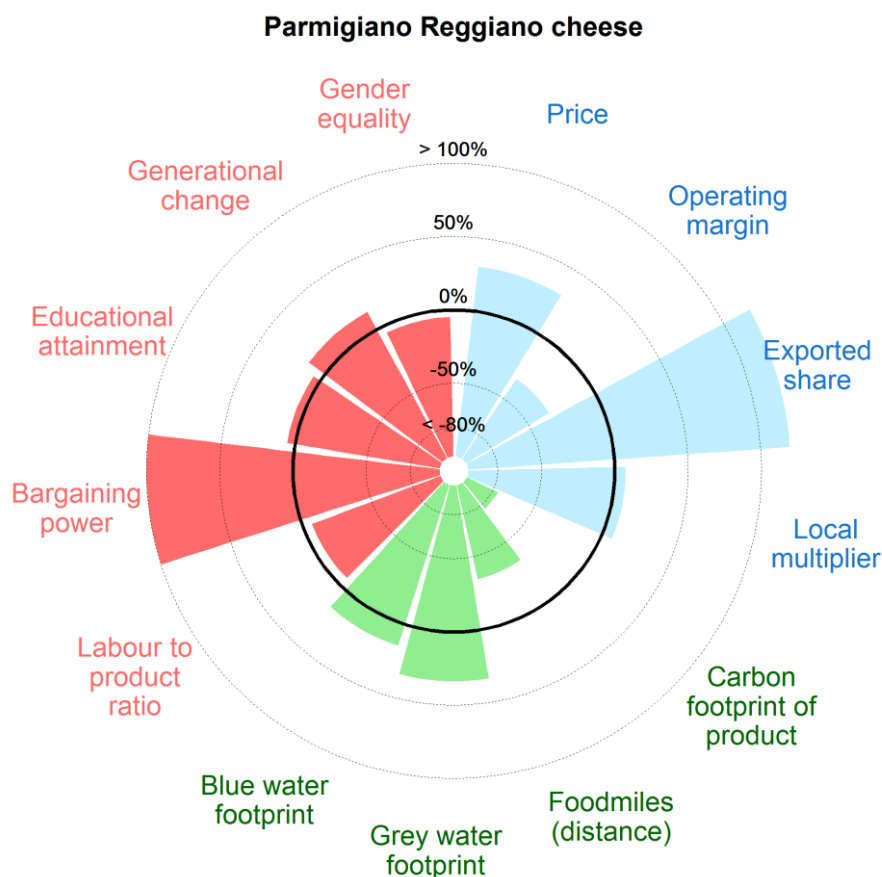
At the processing level, Comté Cheese appears much more sustainable than its counterpart in terms of Generational Change (73% vs 65%), auguring well for the preservation of crucial cheese-making know-how. However, there is a higher level of inequality in female opportunities, compared with the national average (0.29 vs 0.04). This result is driven by the very limited female ownership of dairies in Comté, contrary to more than a third of Conventional Cheese dairies being run by females.

Over the entire supply chain, we conclude that on average Comté cheese is more sustainable than its reference in terms of generational change (66% vs 49%) but less sustainable in terms of gender inequalities (0.28 vs 0.12).

2.1.2. PDO Parmigiano Reggiano cheese (Italy)

The sustainability performance of Parmigiano-Reggiano cheese has been assessed using the Strength2Food method (Bellassen et al., 2016). For economic indicators, the reference to which Parmigiano-Reggiano is compared is a generic hard cheese produced in Northern Italy. All the index calculations are based on primary data, collected from supply chain members (Consortium of Parmigiano-Reggiano, dairies, dairy farms) and secondary data extrapolated from scientific and technical literature, agricultural handbooks and agricultural databases (e.g. Italian FADN).

Figure 2. Sustainability performance³ of PDO Parmigiano Reggiano cheese (supply chain averages)



³ Each indicator is expressed as the difference between the FQS and its reference product. For environmental indicators for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower).

2.1.2.1. Economic indicators

Price premium, profitability and value distribution

The milk price for Parmigiano-Reggiano is 6.5% higher than its reference, while at processing level the price is 61% higher than the reference. This reflects the longer period of ripening and the higher cost of processing. At distribution level, Parmigiano-Reggiano reduces the differences with the reference (+24%). Indeed, Parmigiano-Reggiano is frequently sold in retail shops with a promotional price to attract consumers. Furthermore, within Parmigiano-Reggiano supply chain just one cheese producer can play a role in defining prices with the large retailers, whereas all the other producers sell the product to wholesalers which manage Parmigiano-Reggiano cheese together with other cheeses in their portfolio.

The gross value added is higher at the farm level, while at the processing level it is lower (-47%). The latter result incorporates the processing value that in the cooperatives is transferred to farmers. The objective of cooperatives, which for Parmigiano-Reggiano represent more than 60% of the entire production, is to maximize the benefits for their members, the dairy farms. Because of this objective, the cost of the milk provided by dairy farms is defined after the payment of the other costs leaving the cooperative net result equal to zero. This means that all the economic margins realized by the dairies are transferred to their members. The gross operating margin is lower both at farm level (-5%) and at the processing stage (-62%).

Local multiplier

The local multiplier for Parmigiano-Reggiano is 7.3% higher than for its reference. For both cases, the indicator exceeds the level of 2, i.e. one euro spent at processing phase generated more than one euro of extra financial flows within local area. For Parmigiano-Reggiano the local multiplier is equal to 2.64, whereas for the reference 2.46. Therefore, also the reference cheese contributes positively to the local economic dynamism, even though lower than Parmigiano-Reggiano. The main determinant of this result is the geographical origin of raw milk. The location of dairy farms is therefore a key variable that contribute to the high local multipliers for both the products. If we assume that raw milk originates outside the local area, the local multiplier would halve for Parmigiano-Reggiano, while for the reference the reduction would be 37%. In this respect, the higher value for Parmigiano-Reggiano is explained by the higher share of raw milk provided by local milk producers.

2.1.2.2. Environmental indicators

Carbon footprint

The carbon footprint of Parmigiano is 79% higher than its reference, mostly due to its higher density (16.7 litres of milk per kg of Parmigiano instead of 7.7 litres per kg of the generic hard cheese). To the contrary, at farm level, the carbon footprint of milk is 18% lower for Parmigiano (1.6 and 1.95 tCO₂e t of milk⁻¹ respectively). The two main drivers of this difference are the longer lifetime of Parmigiano cows, which lessens the “carbon deadweight” of unproductive heifers and cull cows, and the diet composition. Parmigiano cows eat substantially more alfalfa and mowed grass, which are less fertilized and require less fuel for field operations than silage maize. Parmigiano breeders also obtain slightly higher yields for some crops such as alfalfa. The difference in diet composition is largely due to the technical specifications, which limit many components (e.g. maize, soy, cereals) but not alfalfa and grass. The carbon footprints at farm level are within the 0.52-2 tCO₂e t of milk⁻¹ literature range (Meier et al., 2015).

Extended food miles

Over the entire supply chain, from farms to retails, PDO Parmigiano Reggiano cheese travels distances 35% longer (2,500 vs 1,900 t.km t⁻¹) and releases almost twice as much emissions (430 vs 225 kg CO₂e t⁻¹) as the reference cheese. The longer distance embedded in the PDO

cheese can be explained by the longer distance travelled by exported PDO cheese, which is sold to a larger extent outside Europe (34% vs 13% of the exports are sold outside Europe), and by the larger share of exports for PDO (38.2% vs 11.4%). However, the larger emissions generated by the PDO are entirely driven by the more carbon intensive mode used at processing level, light goods vehicles, compared to heavy goods vehicles. Indeed, although distances of exported PDO cheese are longer, the larger share of exports relying on sea transport contributes to lower the carbon bill. The distribution level (from processors to retailers) concentrates most of the kilometres embedded in the product (i.e. more than 60%), whereas the processing level (from farms to processors) concentrates most of the emissions generated along the value chain (i.e. 25 to 50%). Regarding food-miles indicators, we can conclude that PDO Parmigiano Reggiano is less sustainable than its reference both in terms of distance travelled (+35%) and in terms of emissions released at the transport stage (+91%).

Water footprint

Overall Parmigiano-Reggiano shows a lower water footprint than the reference. More specifically, Parmigiano-Reggiano consumes 9.5% less water than its reference. This is mainly due to the different agricultural practice characterising the Parmigiano-Reggiano with respect to the reference and the fodder crop yield. The Parmigiano-Reggiano code of practice forbids the use of silage in animal feeding, while in reference silages are allowed. Silages, in particular maize silage, requires more water than the other fodder crops. However, the yield milk-to-cheese affects greatly the results achieved for different water footprints.

The Parmigiano Reggiano consumes some 45% more green (4.33 m³/kg vs. 2.98 m³/kg) and some 26% more blue water (7.33 m³/kg vs. 5.84 m³/kg) at the farm stage, than its counterpart product. It consumes less grey water by some 34% (0.51 m³/kg vs. 0.77 m³/kg). At the processing stage, the Parmigiano Reggiano consumes less blue water by 15% compared to the counterpart (51.46 m³/kg vs 60.75 m³/kg).

2.1.2.3. Social indicators

Employment

The labour use ratio indicator, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope, 2001). The allocation of labour to production is lower for Parmigiano-Reggiano cheese than for its non-PDO reference (Italian milk specialised farms). At the farm level, it takes 6 hours of work to produce a ton of milk when the reference product requires 9 hours. The difference (-37%) indicates that the PDO product generates less jobs than the reference system. This result can be explained by the fact that in Parmigiano-Reggiano dairy farms family workers prevails over the hiring workers.

At the processing level, the relative difference is slightly less important and favourable to PDO cheese since it takes 46 hours of work to prepare one tonne of cheese compared to 37 hours for the reference product. This relies on the milk-to-cheese ratio and the artisanal nature of the processing “technology” of Parmigiano-Reggiano cheese.

The turnover-to-labour ratio indicator provides an insight into labour productivity. The average turnover per employee is higher for the PDO farm compared to the reference (+69%). The productivity levels are much higher at the processing level, with a bit less relative difference (+38%) in favour of the PDO Parmigiano-Reggiano. These differences can be due to the combination of the price premium and the lower AWU at farm level, while at processing stage this result should be attributed to the price premium of Parmigiano-Reggiano compared to the counterpart.

Bargaining power

Bargaining power is quite evenly distributed among producers and processors for the FQS, even though processors enjoy an advantage over farmers, thanks to their collective organization in a professional union. By way of contrast, bargaining power is very unevenly distributed for the reference, because of the fact that processors are much fewer than farmers.

Educational attainment

At farm level, the level of educational attainment is higher for Parmigiano-Reggiano than in its reference (+8%), while at processing level the indicator for Parmigiano-Reggiano is lower than 5%. At processing level this result could be driven by the rise of immigrant labour employed at this stage of the production process. It could also be due to the more industrialised production process for the counterpart requiring improved knowledge to operate the processing equipment.

Generational change and gender equality

At the farm stage, the supply chain of Parmigiano-Reggiano PDO is barely more sustainable than the one for the counterpart hard cheese, according to the value of the Generational Change indicator. In absolute terms, the dairy farming stage of the supply chains of both products appears largely endangered in its sustainability prospects because the value of the indicator is smaller than 100%. This stems from a limited participation of 15 to 35 years old workers at the farming stage, compared to 45 to 65 years of age workers. The Gender Inequality index calculated at the farming stage suggests that this stage of the Parmigiano-Reggiano PDO supply chain is more unsustainable than the same one for the reference product, because the value of the indicator for the former product is much larger than the value of the indicator for the latter product. This is largely due to the very low percentage of females with at least a secondary education in the workforce. The lower rate of female farm ownership in the supply chain of the Parmigiano-Reggiano PDO, compared to the supply chain of the reference product, is an additional source of gender inequality. While the difference in the Gender Inequality Index are very significant if the gender-based educational achievement of the workforce, the gender-based farm/firm ownership and the gender composition of the workforce are considered, it declines markedly if calculations are restricted to the latter two domains of inequality. Focusing on the simplified version of the Gender Inequality Index, any difference in Gender Inequality levels vanishes almost completely, with reference product remaining marginally more sustainable than the Parmigiano-Reggiano PDO. This highlights the impact that the very large share of female farm employees with a higher than secondary education in the supply chain of the reference product has on the results. This could be deemed an “outlier-like” behaviour, compared to the same value for the farm level value for the supply chain of the Parmigiano-Reggiano PDO, which could depend upon the data sources employed. In turn, all the data on the three domains on which inequality is evaluated are drawn from the Italian Farm Accountancy Data Network.

At the dairy processing stage, the Parmigiano-Reggiano PDO appears more sustainable than the reference product, with respect to the Generational Change indicator. However, because the values of the indicator for both supply chains are smaller than 100%, both products appear somewhat endangered in their social sustainability prospects as suggested by the moderate employment of young people, compared to older ones.

Overall, and on average across all the stages of the supply chains for which indicators were calculated, the supply chain of the Parmigiano-Reggiano PDO is slightly more sustainable than the one for the reference product according to the Generational Change indicator. On the contrary, the reference product is more sustainable than the Parmigiano-Reggiano PDO according to the Gender Inequality indicator. In absolute terms, the supply chains of both products seem characterised by limited social sustainability.

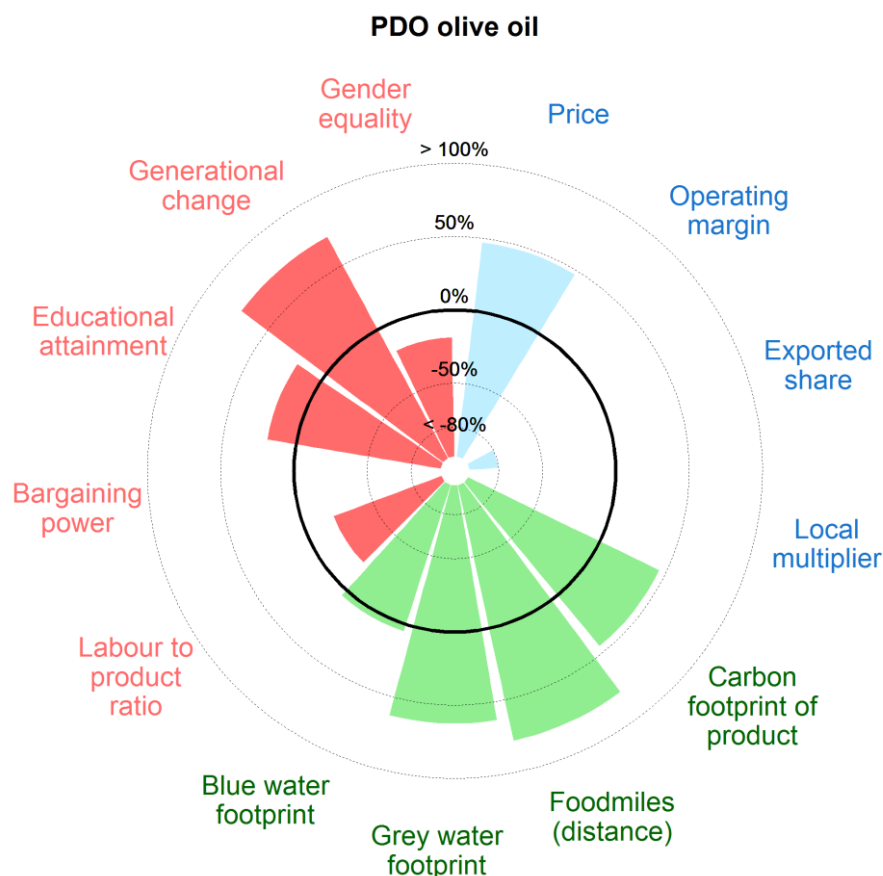
2.1.3. PDO Cornish clotted cream (UK)

For operational reasons, data collection on Cornish clotted cream underwent significant delays. While preliminary data is now available, the quality and completeness checks, as well as the processing of the data, have not been undertaken at the time of the submission of this deliverable.

2.2. Vegetal products

2.2.1. PDO olive oil (Croatia)

Figure 3. Sustainability diagram of Croatian PDO olive oil



Regarding **economic indicators** (price premium) PDO Olive oil has the same price as conventional olive oil at processing level. At downstream level, the product under PDO has a high price premium (of the order of 90%). This high price premium is explained by the way of selling the product: it is intended for tourists in direct sales. Moreover, the product under PDO represents only 0.3% of the total production of olive oil. Other common economic indicators such as value-added, gross operating margin or net result could not be estimated due to the lack of accountancy in PDO “farms”. Indeed, for PDO producers, olive and olive oil is a very marginal activity, almost a hobby, and therefore they do not record the specific intermediary consumption and labour allocated to it.

If we look at exported share indicator, there is no export of PDO olive oil, whereas export share of conventional olive oil is 3.9% of total turnover (5% of total production), mainly exported to Europe. Price of conventional olive oil on Europe market is close to that of inside price, whereas

price on extra-Europe market is smaller than that of domestic market. It is more profitable to sell on the domestic market.

The **carbon footprint** ($\text{kg CO}_2\text{e t}^{-1}$) of PDO olive oil is 45% lower than its reference. The PDO has a much lower carbon footprint than the reference, mostly thanks to the higher olive yield and lesser use of energy for soil and plant preparation for production. The order of magnitude is comparable to the $3.52 \text{ kg CO}_2\text{e t}^{-1}$ reported by Rinaldi et al. (2014) for the cultivation stage in Italy. The overall footprint Croatian olive oil is much lower though, due to the absence of freezing in the Croatian process.

Concerning **food-miles**, the PDO supply chain was compared to the conventional olive chain from farms to processors, and to the conventional Croatian olive oil sector from processors to retailers. Over the entire supply chain, from olive farms to distribution, there is a significant difference between the FQS and its reference. The former travels on average much shorter distances ($80 \text{ vs } 350 \text{ t.km t}^{-1}$) and releases lower emissions ($45 \text{ vs } 70 \text{ kg CO}_2\text{e t}^{-1}$) than the latter. The shorter distance embedded in the PDO olive oil, as well as the lower emissions generated, can be explained by the fact that this product is not exported, contrary to its reference. Most of the kilometres travelled and emissions generated along the value chain are concentrated at the processing level (from farms to processors) for the FQS (i.e. around 90%). An interesting point is that though the distribution level (from processors to retailers) concentrates most of the kilometres embedded in the reference product (i.e. 75%), most of the emissions released (i.e. 75%) are concentrated in the processing level. This is due to the fact that although exported conventional olive oil travels long distance (43% of exports are outside Europe), part of it uses carbon-extensive modes (sea transport) while olives rely on carbon-intensive modes (road transport) and imply a low product ratio from olives to olive oil. We can conclude from the sustainability diagram (Figure 10) that the PDO olive oil is more sustainable than its reference in terms of distance travelled (-80%) and carbon emissions related to the transport stage (-40%).

Water footprint at farm level (m^3/t olives) for the conventional olive oil is 54% higher than for FQS (PDO olive oil). At processing level (refineries) water footprint is just 4% higher for conventional olive oil in comparison to PDO olive oil. Water footprint at final, downstream level is even 56 % higher for conventional olive oil than for PDO. What causes such difference?

For both products computation of the water footprint concerned the agricultural phase and the refinery process. The small difference in the water footprint is mainly due to the different input of water that used in the refinery phase. All the other issues (i.e. electricity consumption) that characterize the refinery process are the same and thus do not contribute any difference to the indicator values.

Most of the difference between FQS and the REF lies in the agricultural phase. In particular, the highest difference concerns the **green water footprint**, which is 8,92 (m^3/kg of oil produced) for FQS and 19,63 for the REF product. This difference is due entirely to the different yield in terms of olives produced per ha of surface, which is higher for FQS (3,22) than REF (1,55).

Next there is a different water requirement as **grey water footprint** in favour of the FQS because the use of fertilizers and pesticides is higher in the REF product. In particular, the production process for the latter employs more nitrogen than FQS, both in the form of mineral (78 vs. 75 kg/ha) and organic nitrogen (27 kg/ha vs. 12 Kg/ha). In both cultivars, copper is used as pest control but in REF's production also "dimethoate" is used, which contributes to increase the grey water footprint of the REF product.

The **blue water footprint** further contributes to the difference between FQS and REF. The blue water footprint due to the overhead is higher for the REF product in particular because it

requires a higher quantity of fertilizers and pesticides; on the other hand diesel consumption is higher for the FQS but not enough to compensate for the difference due to the other issues.

The relationship between olives and olive oil (ton oil/ ton olives) is similar for PDO and conventional olive oil (0.1 ton of oil from 1 ton of olives).

If we look at **Educational attainment** results in Figure 4, we can see that PDO olive oil producers at farm level have 31% and at processing level 9% higher education compared to conventional olive oil producers.

Bargaining power was not possible to calculate for PDO olive oil supply chain in Croatia because it was fully integrated; olive producers are also in charge of its distribution.

Regarding **Generational change and gender equality indicator**, there is no difference in the Generational Change Indicator between PDO olives and conventional olives at the farming stage. Moreover, the olive growing stage of the supply chains of both types of oils produced in Croatia are somewhat endangered in their sustainability prospects due to a rather limited employment level of 15-35-year-old, compared to 45-65-year-old. Conventional olive farming in Croatia appears to be more socially sustainable than the PDO Olive Oil due to a lower level of gender inequality (half the value). This result derives from a very low level of female entrepreneurship (farm ownership) and low educational attainment at the farm stage in the PDO production, compared to the one for the conventional olive oil. However, this result could also be since it was not possible to collect separate data for olive growers and processors in the Conventional Olive Oil Supply Chain because of the lack of suitable sources. In turn, the values of the indicators for the Conventional Olive Oil supply chain are the same at different stage of the Supply Chain and could be deemed to represent an “average” for the whole Supply Chain.

The stage for processing olives into oil of both the PDO and Conventional supply chains is characterised by the most peculiar results, due to the specificity of the data sources. In particular, for PDO Olive Oil, we survey four processors producing PDO Olive Oil (this is total number of processors included in production of PDO olive oil in Croatia, because it is an industry in its infancy in Croatia). All of processors were the managers of very small operations with a very limited workforce. In turn, managers reported a perfect age balance in their workforce. In turn, the Generational Change Indicator is then calculated at 100%, which is encouraging, especially if future recruits will be young rather than old, hence enhancing the probability of this production being maintained/increased in the future. However, this value is rather uninformative of the current state of sustainability of the PDO Olive Oil Processing stage of the supply chain. Because of the limited number of informants and the small-scale operation they run, the data provided for the PDO Olive Oil Processing stage of the supply chain are unsuitable to properly calculate the Gender Inequality Indicator. In fact, the data provided suggest that there are neither female plant managers nor female employees at this stage of the supply chain. In turn, Gender Inequality at the Processing stage of the PDO Olive Oil supply chain could be deemed at the “Maximum” level, mainly because women not being represented in the workforce/ownership of this stage of this supply chain implies the maximum level of inequality and social/human penalty and loss. The Gender Inequality indicator can be calculated at a value close to its “Maximum” (0.99) replacing the relevant zeros with very small numbers (0.001).

2.2.2. *PDO Zagora apple (Greece)*

The findings of the PDO Zagora apple and the reference conventional apple of the Kissavos cooperative in Agia are summarized in Figure 4. Specifically, the economic results, as they are demonstrated at the blue tertile, reveal the superiority of the PDO Zagora apple on the selling price and the operating margin results. However, the PDO apples of Zagora are mainly

distributed in the domestic market in addition to the reference case which demonstrates more exports but in a lower selling price.

The environmental results of the PDO Zagora apple show that the carbon footprint is higher than the reference case. This is explained by the lower yields of the PDO Zagora apple and the lack of advance mechanization in comparison with the reference case. On the other hand, the food-miles (distance) results of the PDO Zagora apple are lower than the reference case. FQS shows a higher footprint than the REF product for green and blue water footprint, whereas the grey fraction is higher for the REF product mainly because of the difference on the yields (1.35t/ha for the PDO Zagora apple and 3.5t/ha for the conventional reference apple).

The social indicators results, shows that the PDO Zagora apple is more sustainable than the reference conventional apple. In particular, the *generational change* indicator is in favour of the PDO Zagora apple due to the fact that the workforce in the PDO case is younger than the reference. The *turnover to labour ratio* is higher at the PDO case since it requires more working hours for the production of one tonne of apples and thus creates more jobs than the reference case. Furthermore, the educational attainment results indicate that the employees of the PDO case have more advanced education than the reference case. Lastly, the PDO case provide more equal opportunities between the male and female workers than the reference case.

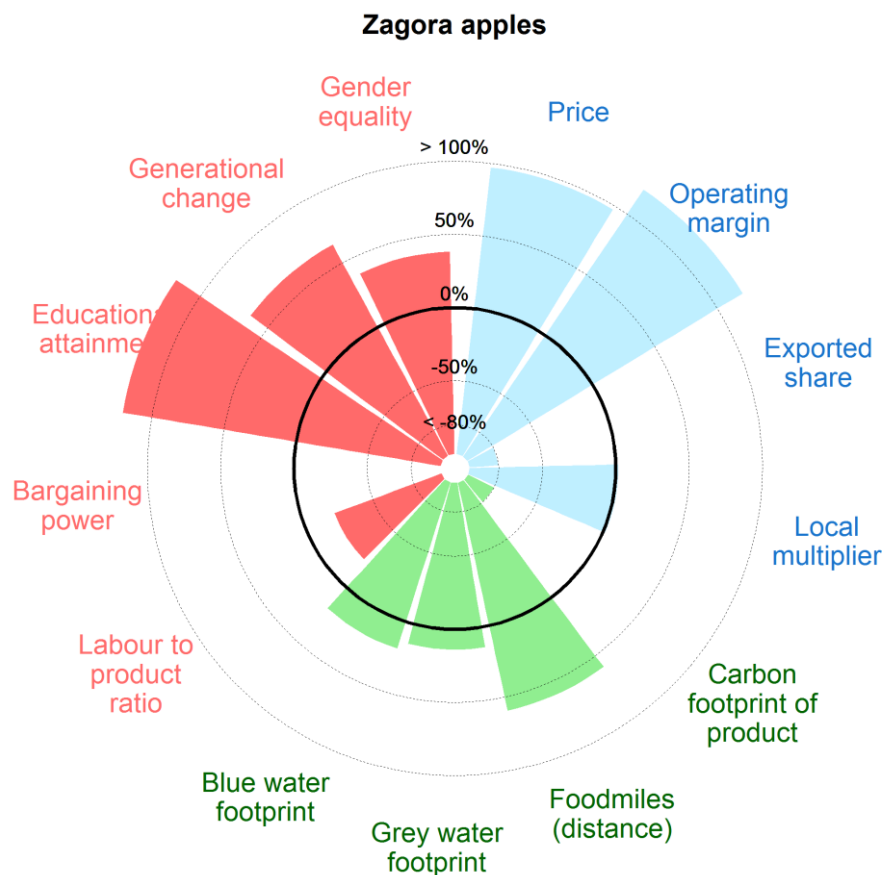


Figure 4. Sustainability diagram of PDO Zagora apple

Hence, the results of the Sustainability diagram suggest that the PDO Zagora case is more sustainable than the reference conventional apple. The following subchapters, 7.1 to 7.3, present the detailed indicator results in terms of sustainability between the two cases.

2.2.2.1. Economic indicators results

The economic indicators analyses applied between the collected data of the PDO Zagora apple and the conventional apple of Agia. The subchapter 7.1 demonstrates the Ec1 indicator results between the PDO Zagora case compare to the conventional apple of Agia (subchapter 7.1.1) and the local multiplier results of the Ec2 indicator analysis at the subchapter 7.1.2.

Price, margin and exports

The economic indicator analysis revealed that the price premium (74%) is higher at the processing level than the upstream level (23%) of the PDO Zagora apple and the reference case. Profitability, in terms of GVA and GMO, is similar in the FQS case than the reference product at upstream level and higher at the processing level. The profitability of the FQS product is higher than that of the reference product, because of the significant weight of intermediate consumption for the production of the reference product. The FQS apple is mainly distributed in the domestic market and a small share is being exported in lower prices than that in the domestic market. Figure 5 details the results of the economic indicator variables between the PDO Zagora apple and the reference conventional apple.

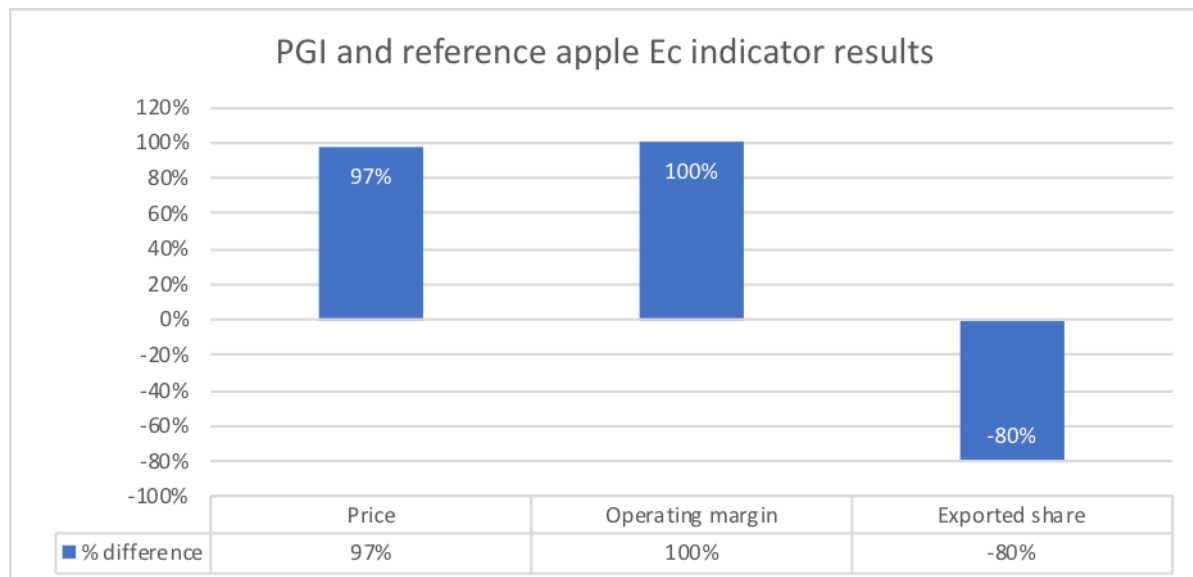


Figure 5. Economic indicator results of PDO Zagora apple and its reference conventional apple

According to the economic indicator results, the economic performance of the FQS apple is better than the reference case although the export share of the reference case is higher than the PDO Zagora apple. However, the selling price is higher in the FQS case than for the reference product both at the farm and the processing levels.

Local multiplier of Zagora

The total turnover of the Zagora apples cooperatives corresponds to about 10 million € and it is used mostly to buy apples (59%) and the other inputs necessary for the selection and packaging processes (25%); 1% of the total turnover is spent on other direct costs (e.g. margin and taxes); and, more than 15% on personnel.

The local multiplier indicator for Zagora apples is 2.53, therefore 1€ received by the cooperative contributes to activate a global expenditure within the identified local area of 2.53€. We can also state that for every € spent by the cooperative, the local economy benefits from 1.53€. Assuming all the suppliers are located in the local area, the local multiplier would correspond to 2.89, with the same meaning of the global one; while assuming all the suppliers are located

outside the local area the local multiplier would reduce to 1.01. This would mean also that the share of local expenditure of non-local suppliers is very limited and it does not affect significantly the global local multiplier result.

In the case of non-PDO apples, and similarly to the PDO product, most part of the cooperative budget is distributed to apple producers (53%), with 100% of the farms placed within the local area. The wage bill corresponds to 15% of the initial budget with all the personnel living in the local area. The other inputs account for 27% of the initial budget, 25% of which addressed to local suppliers. Farms spend 99% of their budget associated with the apple production to purchase inputs from local suppliers. In particular, 100% of the wage bill is spent for workers living in the local area, and almost 99% of the other input costs for local suppliers.

The global local multiplier for the non-PDO apples is 2.49, about 1.6% lower than the result obtained for the PDO product. This is due in particular to the payroll and core inputs shares on total budget, both higher for the FQS

In conclusion, the local multiplier effect of Zagora apples is slightly higher than its reference product: each euro of turnover for Zagora apples generates 1.53€ of re-spending in the same region versus 1.49€ for the reference. The main drivers of these outcomes is the share of cooperative payroll and the share of core inputs on the total budget: for the PDO product the higher shares means more local expenditure due to percentage retained at local level (100%). Without local apple farms, the local multiplier would reduce of -46% for both the cases. Therefore, the location of apple farms is a key driver of local economy impact.

2.2.2.2. Environmental indicators

Carbon footprint

The carbon footprints of the Zagora apple and its reference, 326 and 177 kgCO₂e ton⁻¹ respectively, are within the literature range of 70-890 kgCO₂e ton⁻¹ (ADEME, 2017; Clune et al., 2017). The key driver of the 84% higher footprint of the PDO is its 61% lower yield. The lower yield is mainly attributable to less intensive practices imposed by the technical specifications: absence of mechanization for harvest, use of a refined fertilization strategy based on measured leaf nitrogen content, etc. In terms of fuel use, the absence of mechanization for harvest is offset by the higher fuel requirements of long range hoses used instead of tractors for fertilizer and pesticide spraying.

Food-miles

Concerning food-miles, PDO Zagora apple supply chain was compared to the conventional apples produced by the Kissavos cooperative in the Agia region. Over the entire supply chain, from crates (before the farm gate) to distribution units, there is a 50 to 60% difference in favour of the FQS. The latter travels 60% shorter distances (960 vs 2,400 t.km t⁻¹) and releases half the emissions (85 vs 170 kg CO₂e t⁻¹) of the reference product. The shorter distance embedded in the PDO Zagora apples, as well as the lower emissions, can be explained by the smaller share of exports (24% for FQS vs 75% for its reference), and thus by shorter distances and lower emissions at the distribution level. The distribution level (from processors to retailers) concentrates most of the kilometres embedded in the product and most of the emissions generated for transport along the value chain (i.e. more than 95%). Regarding food-miles indicators, we can conclude that the PDO Zagora apples are more sustainable than its reference in terms of distance travelled, as well as in terms of emissions released at the transport stage.

Water footprint

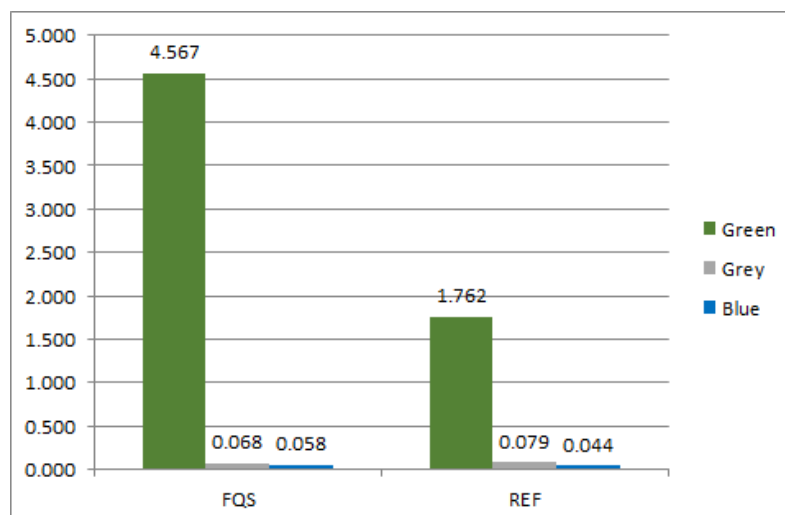


Figure 6. Water footprint of PDO Zagora and its reference

FQS shows a higher footprint than the REF product for green and blue water footprint, whereas the grey fraction is higher for the REF product. For both products green fraction has the greatest share of the overall water footprint. In this case the difference is exclusively due to the different yield that characterizes the two productions. Yield in fact is 1.35 tonne/ha for FQS and 3.5 for REF. If we multiply the ratio $3.5/1.35$ by the value of the green water footprint for REF we obtain exactly the amount of green evapotranspiration shown by the FQS product. This is due to the fact that areas of productions are the same so meteorological values (Zagora station, Climwat database) are the same and this holds for crop parameters and soil features as there are no differences in these values for the two productions. The difference in the amount of water used for irrigation (50 m³/ha for FQS and 60 m³/ha for REF) does not affect much the difference caused by the difference in yield between the two production. This is why, still, FQS shows a worse performance than REF in terms of blue water footprint. In absolute terms, however, the amount of blue water footprint contributes little to the overall value of the water footprint. Grey water footprint is higher for REF production. What makes its demand of water for dilute pollutants higher is associated to the higher amount of mineral nitrogen based fertilizers that are employed in that production.

2.2.2.3. Social indicators

Employment and social capital

The labour use ratio indicator, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope, 2001). At the farm level, it takes 333 hours to product one tonne of Zagora apples when the reference product requires 184 hours. The difference (55%) indicates that the PDO product generates more jobs than the reference system. The turnover-to-labour ratio indicator provides an insight into labour productivity. The average turnover per employee is more important in PDO farm than in non-PDO ones. The productivity levels are much higher at the processing level, with a relative difference of 203% in favour of the PDO-Zagora apples. These results are mostly due to the farms/firms structure, the technical specification of the product and for a part to the geographical conditions since the PDO Zagora apples are mainly cultivated in terraces in the mountainous landscape of Zagora in addition to the more advanced cropping system of the conventional apple.

The education attainment indicator is higher for the PDO sector both at farm and processing level. The difference is 284% at the farm level and is attributable to the fact that 80% of producers have gone beyond elementary school compared to 20% for the reference.

Table 8. Generational balance and gender equity for PDO Zagora apple and its reference

Index	PDO Zagora apple	Counterpart apple
<i>U3 Stage – Farm Stage</i>		
Generational Change	100%	200%
Gender Inequality	0.38	0.62 ^a
<i>P1 Stage –Processing</i>		
Generational Change	39%	14%
Gender Inequality	0.92	0.83 ^a
Supply Chain Average		
Generational Change	70%	107%
Gender Inequality	0.65	0.73

Note to Table: ^a indicator value calculated replacing 0 with 0.001.

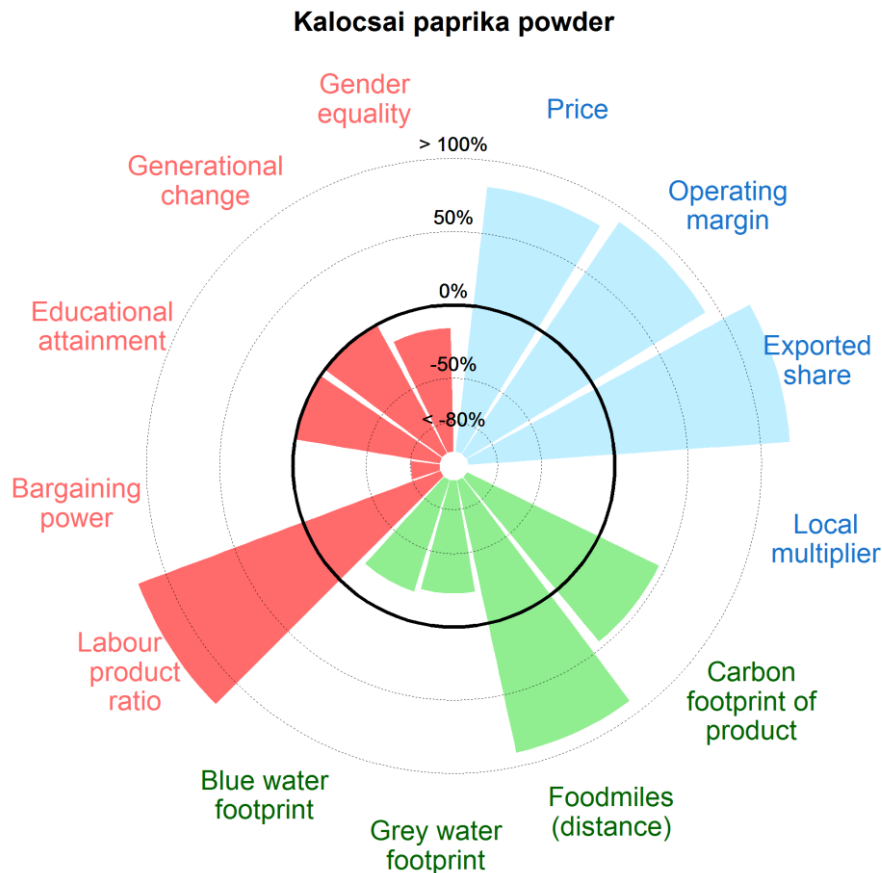
This evidence suggests that:

- At the farm stage, both the Zagora and the Counterpart Apple are socially sustainable, according to the Generational Change indicator, because the calculated values are greater or equal to 100% for both products. Moreover, the Counterpart Apple is more sustainable than the Zagora one, because the value of the former indicator is actually double the value of the latter one. However, these fairly large values of the indicators are calculated on the basis of very few observations, such that the “representativeness” of this evidence may be called into question
- On the contrary, at the farm stage, the Zagora apple is more sustainable than the Counterpart Apple, because the value of the Gender Inequality indicator calculated for the former is smaller than the value of the latter. Even in “absolute” terms, the Zagora Apple appears socially sustainable, because of a moderate value of the calculated Gender Inequality indicator. This result arises because of the extremely low level of female farm ownership, the very limited educational achievement of male workers and small female participation of females in the agricultural workforce
- The apple processing stage of both supply chains is characterised by rather low levels of social sustainability, as assessed by both the Generational Change and the Gender Inequality indicators. In fact, the Generational Change indicator, for both the Zagora and the Counterpart Apples, are much smaller than 100%, suggesting that the social sustainability of this stage of the supply chains is not granted. However, the Zagora Apple is much more sustainable than the Counterpart one, because the value of the Generational Change indicator for the former is almost three times the one for the latter product

Likewise, the value of the Gender Inequality indicator is calculated at very high values both for the Zagora and the Counterpart Apple, suggesting that very high penalties in opportunities exist across genders at this stage of the supply chains. However, in comparative terms, the Counterpart Apple is slightly more sustainable than the Zagora one. This additional sustainability penalty characterising the Zagora Apple can be ascribed to the marked difference in educational attainment across the workforce of the processing stage, by gender.

2.2.3. PDO Kalocsai paprika powder (Hungary)

Figure 7. Sustainability diagram of PDO Kalocsai paprika powder



In order to estimate the sustainability of the Hungarian PDO paprika powder, the specific methodology of the Strength2Food project was applied. For the benchmarking purposes, as reference or counterpart product, the special characteristics of the product was considered. First, the significant paprika producing areas are almost all covered by the two PDO territories (Kalocsai and Szegedi paprika powder), therefore we can say that the only paprika production in Hungary that is not allowed to be used in the PDO value chains are the modernist varieties that are not mentioned in the code of practice. These varieties are mainly used for paprika paste production. Therefore in this monography we consider the paprika powder produced from imported (mainly Chinese) raw materials (and therefore not allowed for the Hungarian PDO name) as a reference product.

Due to the very limited amount of official data of the paprika value chain, the majority of the inputs for computing the indicators are collected via personal interviews (producers, processors and industry experts). On the other hand, all the available data are included, mainly gained from the databases of the Hungarian Central Statistical Office and the Hungarian FADN. The sustainability diagram is presented in Figure 7.

Concerning the economic indicators of the paprika, the PDO paprika value chain gains significant price premium, on all levels. However, the price premium decreases with the process: on farm level the price premium is +130%, while at processing level it is 69%, and on the market it is sold on with only 47% of price premium. At processing level – the only level where we have comparable results – the profitability is quite moderate, but for the FQS it is higher: 9% and 4%, respectively. It should be noted that profitability at upstream level is

difficult to compare, as reference is based on directly imported dried paprika from different countries, for which no data was available. The gross value added for PDO production is higher than the gross operating margin, as the processing is more labour intensive here in order to fulfil the PDO requirements. Regarding the external markets we can say that mainly PDO paprika powder (though in many cases without PDO label but suitable for the certification) is exported and the paprika export focuses on European destination. The exported products are above the average price, as the share of export in value is (much) higher, than the share in volume.

The carbon footprint of the raw PDO pepper and its reference – 94 and 223 kgCO₂e ton⁻¹ respectively – are comparable, although somewhat lower than the only literature reference of 368 kgCO₂e ton⁻¹ (Wang et al., 2018). The 43% difference – 1 and 1.7 tCO₂e ton⁻¹ respectively – found for the paprika itself (excluding transport) is explained by two main drivers: a twice larger use of mineral fertilizers in China – where the reference pepper is assumed to be produced – than in Hungary, and a twice higher yield in Hungary. Fuel use for cropping, one hundred times more important in Hungary, does not offset the first two drivers of carbon footprint.

Concerning food-miles, PDO supply chain was compared to the conventional paprika powder chain in Hungary. Over the entire supply chain, from raw paprika to paprika powder (from farms to retailers), there is a significant difference between the FQS and its reference. PDO paprika powder travels much shorter distances (1,200 vs 80,000 t.km t⁻¹) and releases much less emissions (160 vs 3,000 kg CO₂e t⁻¹) than the reference. The ratio is respectively 1 to 60 and 1 to 20 in support of the FQS. The shorter distance embedded in the PDO paprika powder can be explained by the shorter distance travelled by raw paprika from farms to processing units, as PDO specifications impose on farmers and processors to be located in a geographically restricted area, the Kalocsa region. Similarly, the higher emissions embedded in the reference can be explained by the emissions resulting from the imports of raw products. The distribution level (from processors to retailers) concentrates most of the kilometres embedded in the product and most of the emissions generated along the value chain (i.e. almost two third) for the FQS. While the production and processing levels (from farms to processors) concentrate most of the kilometres and most of the emissions (i.e. more than 80%) for the reference product. We can conclude from the sustainability indicators that the PDO Kalocsai paprika powder is more sustainable than its reference in terms of distance travelled (-98%) and carbon emissions related to the transport stage (-95%).

Considering the water footprint of the paprika production, in the agricultural phase, which yields raw paprika, the fractions of the water footprint (green, grey, blue) are the same for the PDO (FQS) and for the counterpart (REF). The water footprints depend on meteorological conditions that are the same for the two productions, and so were data about crop parameters (see Agricultural phase spreadsheet). Nonetheless, water footprint fractions per kg of final product are different between FQS and REF. In particular, FQS paprika has higher value for green, grey and blue water footprint for the agricultural phase due to the different ratio “ton raw paprika/ton paprika powder” which defines how much paprika powder is obtained from row paprika. Such ratios are 0.1167 for FQS and 0.1429, that is the process through which paprika powder is obtained from raw paprika seems to be more efficient for REF. FQS show a higher fraction of blue water footprint also in the processing phase in comparison with the REF product (0.18 m³/kg for FQS and 0.15 for REF). Overall FQS paprika requires 2.05 m³ of water per kg of final product whereas the REF product requires 1.67 m³ of water.

We also compared the values of the fraction of the water footprint with the values of water footprint for an average Hungarian production of paprika and that we obtained from literature (water footprint network, <http://waterfootprint.org/en/>). Results show that FQS and REF requires less water than the average Hungarian production in terms of green and blue

agricultural water footprint. Data about the grey water footprint were not available for the average Hungarian paprika production so that the comparison about this fraction could be done.

The labour use ratio indicator, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope, 2001). At the farm level, it takes 688 hours to product one ton of Kalocsai paprika powder. There is no information on conventional production at farm level because the raw material is mostly imported. At the process level, the allocation of labour to production is higher for Kalocsai paprika powder than for its non-PDO reference. It takes 1152 hours of work to produce a ton of PDO paprika when the reference product requires only 279 hours. The difference (313%) indicates that the PDO product generates more jobs than the reference system. The turnover-to-labour ratio indicator provides an insight into labour productivity. The average turnover per employee is of the same order in PDO firm than in non-PDO ones. These results are mostly due to the farms/firms structure, as the FQS requires more labour as this processing method (e.g.: hand drying and small-scale milling) is quite labour intensive, while the conventional production is more mechanized.

The education attainment indicator for PDO-paprika powder is very low at the farm level: most workers have a primary (75%) or secondary (20%) educational attainment. At the processing level, the educational attainment level indicator is much higher and identical for PDO and non-PDO product: 25% employees have at least a licence (bachelor).

Bargaining power is quite evenly distributed among producers and processors for the FQS, even though processors take advantage over producers, as evidenced by the higher by their higher bargaining power score (0,71 vs. 0,31). This can be explained by a lower number of processors than of producers. Besides, contrary to producers, processors are organized in professional unions, whether pertaining to the FQS or not. Finally, they enjoy small advantage in terms of resource specificity (drying and milling equipment). Bargaining power seems to be even more evenly distributed for the reference.

At the farming stage, Kalocsai paprika growing could be somewhat endangered in its sustainability prospects due to a rather limited employment of 15-35-year-old, compared to 45-65-year-old. It should be noted that because the counterpart product is imported dried paprika which is turned into powder, no data are available for the paprika growing stage of the supply chain to calculate the Generational Change indicator. Hence, no comparison on the levels of social sustainability can be drawn at the farming stage across the two products

An even lower level of social sustainability, in terms of the value of the Generational Change Indicator, characterises the stage of the paprika driers and mills. Furthermore, it appears that the GI and the counterpart product register the same value of the indicator

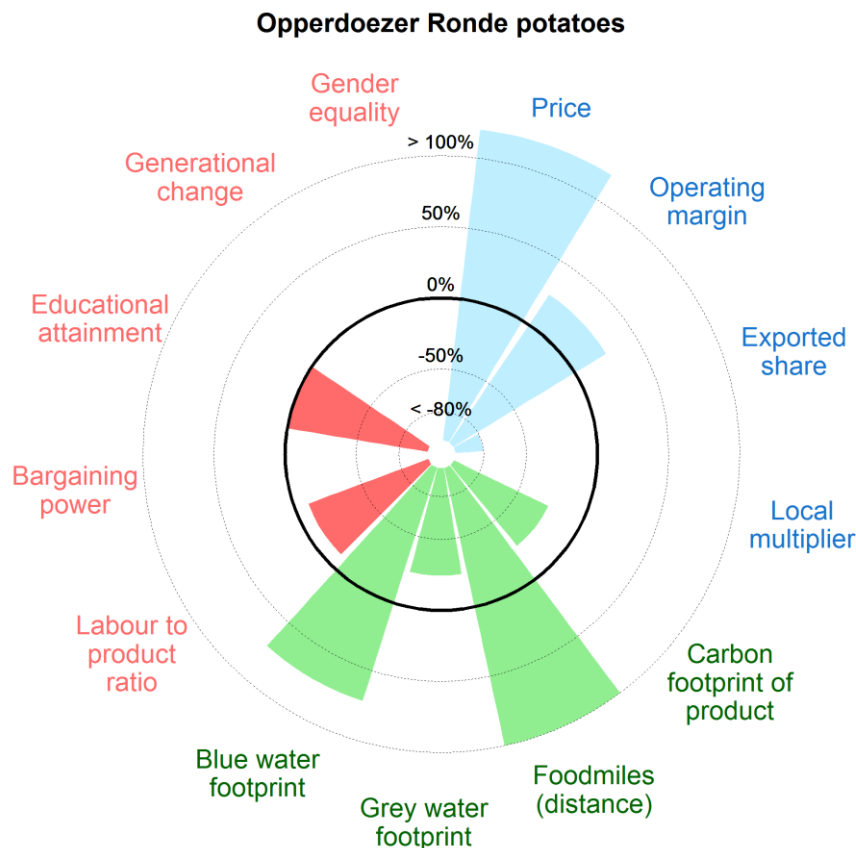
Regarding the Gender Inequality Indicator, the supply chain of the Kalocsai Paprika Powder features high values of the indicator, suggesting that the GI product is less sustainable than the counterpart, at least at the paprika driers and mills stage, which is the only one for which a direct comparison can be made. This result is brought about by the very small share of female employment in the Kalocsai Paprika Powder supply chain. Everything else being equal across the two supply chains, the higher level of female employment in the processing stage of the counterpart (imported) dry paprika contributes to a higher level of sustainability of the latter, compared to the GI product

2.2.4. PDO Opperdoezer Ronde potatoes (*The Netherlands*)

To assess the sustainability aspect of the Opperdoezer Ronde we compared the Opperdoezer Ronde with consumption potatoes grown in the so-called IJsselmeerpolders (an adjacent region). Information on output and input use of consumption potatoes in the IJsselmeerpolders has been published in the so-called KWIN (KWIN, 2015). Consumption potatoes are used for

direct consumption or the production of potato products such as fries and potato chips. Besides consumption potatoes there are seedlings and starch potatoes (both are important in the Netherlands). Figure 8 presents the score of the Opperdoezer Ronde on different economic, environmental and social indicators. We will discuss the different indicators clockwise starting with the price and operating margin.

Figure 8. Sustainability diagram for the Opperdoezer Ronde potatoes



Price and operating margin

The price of the Opperdoezer Ronde is 4.6 times the price of regular consumption potatoes (0.74 €/kg versus 0.16 €/kg). However, combined with the lower yield (25 tonne/ha versus 54 tonne/ha) this results in a smaller difference in revenue per hectare (18,475 €/ha versus 8,332 €/ha). Slightly higher operating costs for the Opperdoezer Ronde make the difference in operating margins smaller than the difference in revenues (15,708 €/ha versus 5,888 €/ha). However, the difference is still substantial.

Exported share and local multiplier

The Opperdoezer Ronde is a very small product with an annual production of only 3,000-4,000 tonnes while total potato production in the Netherlands is more than 3 million tonnes. The production is sold only domestically, so there are no exports. Given that production, and therefore, employment and income generated are small, the local multiplier effects of production are also small. The reference product is much bigger and a large share of it is exported (24% of its value), and therefore, has a larger local multiplier. The people interviewed indicate that because of the Opperdoezer Ronde, the village of Opperdooes has become more known and that this might have a positive effect on the number of tourists visiting the village but the effect is probably small. However, given the fact that the Opperdoezer Ronde is already grown since 1860 makes that it has become part of Dutch heritage.

Carbon footprint

Without transport, the carbon footprint of the PDO is 30% higher than the reference – 84 and 65 kgCO₂e per tonne respectively. Indeed, the higher yield of the reference product more than compensates for its higher use of mineral fertilizers. The lower yield of the PDO largely stems from the technical specifications: as an “early potato”, the Opperdoezer has a shorter growing period than regular consumption potatoes. The lower fertilizer use is an indirect consequence of this shorter growing period: the Opperdoezer would not have time to profit from higher amounts of fertilizers. However, both footprints are on the lower end of the levels found in the literature, which range from 80-360 kgCO₂e per tonne (Clune et al., 2017; Meier et al., 2015). Indeed, potato cooling which usually weights around 50% of the energy demand is 100 times less carbon intensive in the Netherlands than in the UK (Hillier et al., 2011).

Food miles

Concerning food-miles, PDO Opperdoezer potato supply chain was compared to the conventional fresh consumption potato chain in The Netherlands. The Opperdoezer Ronde is not exported so transport is limited to transport from the farms to the distributing company J.H. Wagenaar, transport from J.H. Wagenaar to retailers’ distribution centres and from the centres to local retail shops. We were not able to estimate these distances. We only have available data regarding exports. There is a substantial difference between the FQS and its reference. Indeed, exports of Opperdoezer potatoes is considered as negligible, while 30% of the Dutch conventional fresh consumption potato production is exported. On average, the FQS travels 0 km while its reference travels 2,000 t.km t⁻¹ for exports, and 570 t.km t⁻¹ at the distribution level (from processors to retailers), assuming 0 km distance for products distributed on the domestic market. The FQS releases much less emissions (0 vs 30 kg CO₂e t⁻¹) than the reference. The higher emissions embedded in the reference can be explained by the emissions resulting from exports.

Grey and blue water footprint

Figure 9 summarizes the results of the water footprint calculation for the Opperdoezer Ronde and its reference, the regular consumption potatoes from the IJsselmeerpolders. Overall, the Opperdoezer Ronde shows a higher water footprint value than its conventional counterpart. For single fractions of the indicator the reference product consumes more blue water as shown in the blue water footprint. The Opperdoezer Ronde shows a higher impact in terms of both green and grey water footprint. What determines the difference in the blue water footprint is the amount of water required in the processing phase, which coincides with the storage phase before selling, because the Opperdoezer Ronde is not processed. If only the blue water footprint in the cultivation phase is considered, then the Opperdoezer Ronde shows a higher water requirement than the reference product (11.9 versus 9.37 m³/tonne). However, this discrepancy is not due to the water required by the potato plants but it refers to the overhead, the water used for operations connected with potato production (e.g. fertilizer and phytosanitary production, energy production, diesel production, and so forth).

By looking at the different values of fertilizers and phytosanitary products applied, the reference product makes use of more of these substances than the Opperdoezer Ronde (e.g. for nitrogen fertilizers the amount used for the reference product is one and a half times the amount applied to the Opperdoezer Ronde). Hence, one would expect that blue water (overheads) and grey water footprint will be higher for the reference product than for the Opperdoezer Ronde. However, in reality this is not the case because of the higher yield of the reference product compared to the Opperdoezer Ronde. The yield of the reference product per hectare is more than twice the yield of the Opperdoezer Ronde. Since the water footprint is calculated per unit

of production (kg), the overall water requirement must be divided by the yield. The higher the yield, the lower the water footprint becomes. Hence, the Opperdoezer Ronde is more demanding in terms of water requirement because of its lower yield. In fact, yield is the only discriminating factor between the two productions and all the other parameters used to compute this fraction (soil and crop parameters) as well as meteorological data were the same.

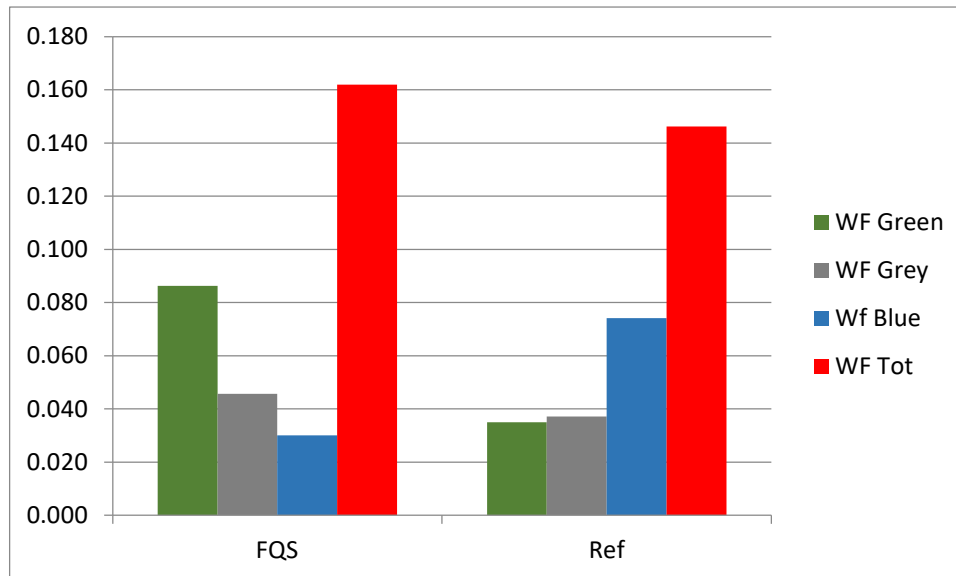


Figure 9. Water footprint of the Opperdoezer Ronde and its reference

Water is not scarce in Opperdoeze nor in the IJsselmeerpolders, so there is no irrigation. However, it is standard to have a drainage system for the fields. The use of fertilizers and plant protection products is especially relevant in the Netherlands given the concerns for water quality. The application of fertilizers and plant protection products is highly restricted by application norms. Most fertilizer comes from artificial fertilizer. Given the shorter growing season, the use of fertilizers is lower than for the reference crop (145 versus 252 kg N, 65 versus 105 kg P₂O₅ and 23 versus 180 kg K₂O) but per kg of potatoes this is different because of the lower yields. The same goes for most plant protection products. One should also note that the land used to grow Opperdoezer Ronde is mostly used for a second crop later in the season.

Labour

The labour use ratio indicator, calculated on the basis of output, reflects labour requirements per unit of physical output (Just and Pope, 2001). The allocation of labour to production is lower for Opperdoezer Ronde potatoes than for its non-PDO reference. At the “farm” level, it takes 27 hours of work to produce a tonne of Opperdoezer Ronde potatoes while the reference product requires 30 hours. The difference (-10%) indicates that the PDO product generates fewer jobs than the reference system. The main reason for the difference is the shorter growing season of the Opperdoezer Ronde leading to a lower requirement. The turnover-to-labour ratio indicator provides an insight into labour productivity. The average turnover per employee is 147% higher in PDO farms than in non-PDO ones. This difference is mostly due to the higher price of the Opperdoezer Ronde. However, a small part of the crop is harvested by hand which requires more work (up to 340 hours per ha). The work is largely done by high school children who can also find seasonal employment in the flower bulb industry.

Education

The interviews give no indication that there is a difference in the profile of education levels between producers of Opperdoezer Ronde potatoes and those in the reference sector. As

indicated in the agricultural census, the level of education of farmers is dominated by secondary (29%) and tertiary (54%) school degrees.

Bargaining power

There are 20-25 farmers that work together in the co-operative 'Coöperatieve Pootaardappelteeltvereniging "De Opperdoezer Ronde" WA.' The co-operative determines the level of production. In this respect, they have market power. The co-operative deals with one wholesaler J.H. Wagenaar. Given the one to one relation with the wholesaler, it is difficult to determine the bargaining power of the co-operative towards the wholesaler. For the wholesaler the Opperdoezer Ronde potato is only a small product. Given that the Opperdoezer Ronde is only a minor product for J.H. Wagenaar it is likely that the trading conditions are largely determined by the wholesaler. However, compared to the large number of producers of the reference product it can be expected that the producers of Opperdoezer Ronde have greater bargaining power than the producers of the reference product.

Generational change

The co-operative and the experts interviewed did not possess data regarding the age of farmers, nor did they feel confident enough to provide an expert judgement on this aspect. However, from the interviews it appears that the number of producers of the Opperdoezer Ronde is rather constant over time indicating that there might be less generational change than for the reference product.

Gender equality

Unfortunately the cooperative and the experts interviewed did not possess data on gender equality, nor did they feel confident enough to provide an expert judgement on this aspect.

2.3. Unfed seafood and fish

2.3.1. PDO Saint-Michel bay bouchot mussels (France)

Sustainability assessment of PDO mussels from the bay of Mont Saint Michel was implemented through the specific methodology of Strength2Food (Bellassen et al., 2016).

The indicators were elaborated by using the whole French bouchot mussels production as a reference for economic indicators. Social and environmental indicators were compared with the whole French shellfish sector as reference.

Saint-Michel bay bouchot mussels

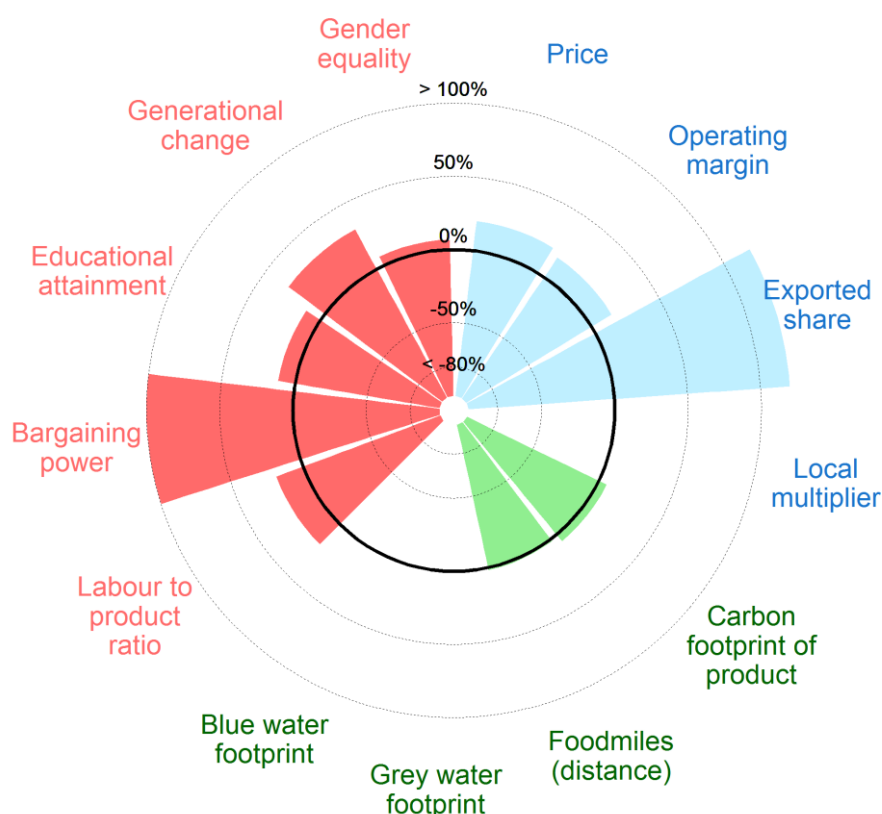


Figure 10. Sustainability performance⁴ of PDO Saint-Michel bouchot mussels (supply chain averages)

2.3.1.1. Economic indicators

Performance on economic indicators reflects the price premium of PDO mussels, which is kept to around 20% all along the supply chain from producers to consumers. Calculation on the net result indicator was not possible but comparison on the Gross operating margin at producer level shows a difference of approximately 15% in favour of the PDO mussels compared to reference supply chain. Price difference (20%) is not totally transferred into margin difference as intermediate costs per unit of product are a bit higher for the PDO producers.

There is an increase in production about 17% between 2013 and 2016 and at the same time a stagnation of the production of non PDO mussels. Volume exports are not high for both kind of mussels: 3% for the FQS product and 5.3% for the standard product. The latter is exported to Europe almost exclusively, whereas the FQS product targets the external market.

2.3.1.2. Environmental indicators

Environmental assessment was also completed for two indicators: carbon footprint and food-miles. The carbon footprint indicator calculated takes into account the production stage and is basically based on the energy consumption at farm level in the FQS and the reference. There is practically no difference between the PDO and the reference (184 and 195 kgCO₂e ton⁻¹ of fresh mussel respectively), which is not surprising as the energy inputs are similar and because

⁴ Each indicator is expressed as the difference between the FQS and its reference product. For environmental indicators for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower).

nothing in the technical specifications seems likely to have an impact on the carbon footprint. One could have expected higher fuel use in the PDO due to the higher use of amphibious boats in the Mont Saint Michel bay (large foreshore, long distances to the bouchots), but it does not materializes in the accounts of mussels farms. The results are towards the lower end of the literature: SARF (2012) reports 252 kgCO₂e/ton of fresh suspended mussels and Winther et al (2009) reports 165 kgCO₂e/ton of fresh mussels (shell included). This makes sense as we do not account for the CFP of materials (ropes, etc.) and because the French electricity mix is much less carbon intensive than average. Aubin (2018) reports 9.5 kgCO₂e/ton of fresh mussels when including C sequestration not only in shell but also in wooden bouchots. The high values from Irribaren (2010) were disregarded because the extremely high energy consumption involved is deemed unrealistic.

Concerning food-miles, PDO supply chain was compared to conventional bouchots mussels chain from baby mussels farms to processors, and to the national mussel sector from conditioners to retailers. Over the entire supply chain, from baby mussels to distribution units, there is not much difference between the PDO and its reference. PDO mussels travel slightly shorter distances (1,230 vs 1,250 t.km t⁻¹) but releases slightly more emissions (155 vs 150 kg CO₂e t⁻¹) than the reference. The shorter distance embedded in the PDO bouchot mussels can be explained by the shorter distance travelled by mussels from farms to conditioning units, as PDO specifications require conditioners to be located in the bay of Mont St Michel. Similarly, the higher emissions embedded in the FQS can be explained by the higher emissions released per ton of product exported, due to a higher share of long distance air transport for FQS than for its reference (export to non-EU countries). The distribution level (from conditioners to retailers) concentrates most of the kilometres embedded in the product and most of the emissions generated along the value chain (i.e. more than 95%).

2.3.1.1. Social indicators

The **labour use ratio indicator**, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope, 2001). The allocation of labour to production is a bit higher for Saint-Michel bay bouchot mussels than for its non-PDO reference (bouchot mussels sector in France). At the farm level, it takes 38 hours of work to produce a tonne of mussels when the reference product requires 32 hours. The difference (19%) indicates that the PDO product generates more jobs than the reference system. The **turnover-to-labour ratio indicator** provides an insight into labour productivity. The average turnover per employee is 11% lower in PDO sector than in non-PDO ones, which means that labour force is better remunerated in average at national scale. This result must be nuanced by the fact that part of the PDO farms are also producing oysters, which intensively employs low qualified seasonal labour. For the reference, the sample is composed of specialized mussel farms only.

The level of education is slightly higher for the PDO mussels producers (in fact chiefs of farms) compared to French bouchot mussels producers. Qualitative interviews among processors and farmers in the bay also highlighted the high rate of young low educated employees, at both production and processing level.

Based on the Generational Change indicator, there is a weak evidence that the PDO Bouchot Mussels are slightly more sustainable at the mussels breeding stage than their non-PDO counterpart. However, both supply chains are somewhat endangered in their sustainability prospects due to a rather limited representation of the younger generation of farmers (15-35-year-old).

The Gender Equality indicator also performs better for the PDO than the reference at breeding stage. Data collected showed a very low representation of women in farm leaders in both PDO

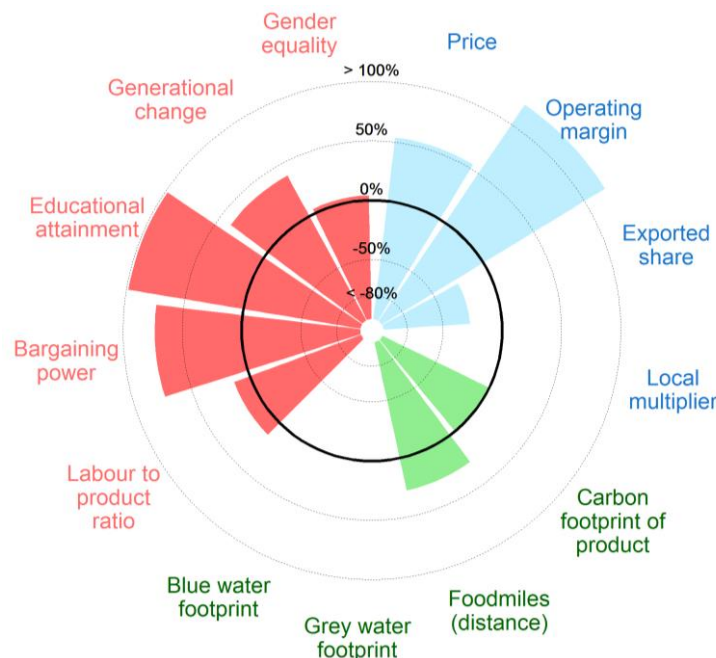
and French shellfish national sector (around 10%). Regarding female employees, their part is twice higher in the PDO sector.

Bargaining power (BP) analysis shows that BP is evenly distributed between levels U3 and P1 of the PDO supply chain, as both levels reach identical scores for all variables. Farmers are still very present at the processing (purification, cleaning) and packaging level, even though the tendency to pack mussels for the conventional retail market is increasing. At retail level, the mussel market is nevertheless much more concentrate, unfortunately data collected in this research were not sufficient to calculate bargaining power distribution at this level.

2.3.2. PDO Phu Quoc Fish Sauce (Vietnam)

The sustainability analysis of Phu Quoc PDO fish sauce generally shows that the PDO result in relatively better economic, environmental, and social indicators for the actors in the value chain. The reference product is Phu Quoc Non-PDO fish sauce, which is a traditional fish sauce and also produced in Phu Quoc island without PDO certificate.

Figure 11. Sustainability diagram of PDO Phu Quoc fish sauce



2.3.2.1. Economic issues

Price Premium at fishing, processing, and distributing levels

In average, the sale prices of the PDO products (fish material and fish sauce) are 54% higher than those of the Non-PDO products. The lowest price premium is at upstream level with only 6% due to the small difference between the PDO and Non-PDO materials. The highest price premium is at processing stage with 131% since the PDO fish sauce is packaged in bottles and sold to the end-user markets with high sale price while the Non-PDO product is mainly sold to the re-processing companies or/and sold to the end-user markets with lower sale price. This is partly driven by the technical specification of GI which requires that the packaging process of PDO fish sauce must be done in Phu Quoc island with the generally regulated labels, information, and designs. However, this is a two-way interaction. The PDO enhances the brand name, production process, price, and prestige of processors and, in turn, mainly the big processors with better processing system and higher market shares are able to apply for the PDO.

Profitability and Value Distribution

The general difference in operating margin between PDO and Non-PDO value chains is about 100%. The most difference of operating margin is at downstream level with the lower costs of two main items: intermediate consumption and wages. Firstly, the fish sauce cost is the main part in the intermediate consumption of retailer and the cost of PDO retailer is lower than that of Non-PDO retailer. The main reason is the higher trade discount given by the PDO processors for PDO retailers, some retailers are even relatives of the processors' owners. Secondly, the lower wage rate of PDO retailers indicates the fact that PDO retailers utilize their resources more effectively than Non-PDO retailers who are usually the old people and spend their spare time on selling fish sauce as a part-time job for extra earning, or/and fun. The driver of the difference is partly the technical specification, standard, prestige and of PDO. In particular, PDO promotes the psychology, brand name, and trust of strong and effective retailers. In turn, the retailers with larger scope and stronger resources are more interested in PDO products.

International trade

In general, the exported share of Non-PDO fish sauce is higher than PDO product in both EU and outside EU markets with the difference of 8%. The exported share of Non-PDO fish sauce is much higher than PDO product in EU market while the exported share of Non-PDO fish sauce is lower than PDO product in outside EU market. The higher rate of Non-PDO fish sauce export to EU is due to the taste habit and export code. Firstly, the technical specification of GI make the PDO fish sauce have stronger taste and smell (more fish and salty) and they are more appropriate for the Asians than the Europeans. Secondly, most fish sauce is entrusted export and the big processors do not expect that. In addition, the traditional fish sauce exporters in Phu Quoc mainly export the Non-PDO fish sauce with their the traditional partners and markets. This can be explained by the specific value chain organisation itself rather than by the PDO.

2.3.2.2. Environmental issues

Carbon footprint

For carbon footprint, there is no clear and significant difference between the PDO and Non-PDO (462 kgCO₂e/tonne vs 459 kgCO₂e/tonne for the reference). The diesel consumption by boats remains the main contributor of the overall footprint and it is lower in PDO chain than Non-PDO chain. The main explanation is that: the Non-PDO fishing boat uses more fuel than PDO fishing boat for the longer distances to harvest more quantity of anchovy. That diesel consumption in Vietnam is 2-4 times lower than Norwegian captured fish (Winther et al., 2009), but Norwegian fishermen may go further away to catch their fish. The carbon footprint difference at fishing level is compensated by the opposite difference at processing level. The diesel consumption of PDO processor is lower than Non-PDO processor due to the lower processing ratio or less quantity of the final fish sauce product of the PDO fish sauce.

Food miles

Concerning food-miles, the PDO Phu Quoc supply chain was compared to the conventional fish sauce produced on Phu Quoc island as well, from fish ports to distribution units. Over the entire supply chain, the FQS performs better than its reference as regards distances travelled, but performs worse as regards the emissions released at the transportation stage. PDO fish sauce travels 30% shorter distances (4,000 vs 5,500 t.km t⁻¹) but releases 15% more emissions (115 vs 100 kg CO₂e t⁻¹) than the latter. First, the difference is driven by exports, since FQS fish sauce is mostly exported in Asia, implying shorter distances, while conventional fish sauce is mostly exported outside Asia. Second, the domestic export distribution implies shorter distances for the conventional product, as 91% of conventional fish sauce is sold locally to industrial fish sauce processors, against 1.3% of the FQS production. However, it is not able to compensate for the shorter export distances travelled by the FQS. Another major difference

relates to the share of coproducts that is relatively high (82%) for the FQS, against less than 1% for the reference product. However, coproducts impact only the processing level, which accounts for few kilometres and emissions along the value chain, and does not make much a difference in the end. The distribution level (from processors to retailers) concentrates most of the kilometres embedded in the product and most of the emissions generated for transportation along the value chain. Regarding food-miles indicators, we can conclude that PDO Phu Quoc fish sauce is more sustainable than its reference in terms of distance travelled, but less sustainable in terms of emissions released.

2.3.2.3. Social issues

Employment

Concerning labour requirements, the labour to product ratio of PDO is 14% higher than Non-PDO. This most difference is at processing level (0.0239 awu/ton for PDO processors 0.0176 awu/ton for non-PDO processors). The PDO firms usually employ more labour than non-PDO firms as all of the PDO fish sauce products are packaged in bottles and sold to the end-user markets. Moreover, the PDO packaging process must be done in Phu Quoc Island with the generally regulated labels, information, and designs strictly according to the GI technical specification. On the other hand, the Non-PDO fish sauce may be sold to the re-processing companies and it does not need to be packaged, labelled and stamps. For labour productivity, the 43% higher turnover to labour ratio is mostly driven by the higher price of PDO fish sauce than non-PDO fish sauce. Thus, the technical specification of GI significantly contributes to the difference in both labour requirement and labour productivity by generating more professional in the packaging process.

Educational Attainment

The 98% higher level of education is mostly driven by the differences at processing and upstream stages. At upstream level, there is a 1.1 percent of the workforce on PDO fishing boats that have highest educational attainment is associates while no one attain the associate's degree or higher degree on Non-PDO fishing boats. This is due to the fact that the crew on PDO fishing boats seem to have official licenses of fishing vessels than the Non-PDO. In addition, the PDO processors usually have their own fishing boats, so that the owners may employ relatively higher level of crew members and other staffs than the Non-PDO. Similarly, the workforces of the PDO processors and retailers obtain the higher educational attainment in comparison with the Non-PDO processors and retailers since these PDO actors have more effective and modern management structures and distribution systems.

Bargaining power distribution

Bargaining power distribution shows a strong balance for both the FQS supply chain and the reference, even though a slight advantage benefits to processors. The advantage of processing levels for the PDO can be explained by the higher scores reached for "transactional" variables: they enjoy higher levels of contractual flexibility (i.e. Lower value for the "prop_contract" variable). On the other hand, the advantage of processing level for the Non-PDO is explained by the advantage obtained for the "competitive context variables": actors at this level are slightly fewer and the market is more concentrated than at the U3 level. This seem to be driven by the specific value chain organisation itself. However, bargaining power positions for both the PDO and the Non-PDO supply chains can be considered as relatively weak, as levels in both supply chains barely manage to reach a bargaining power score of 0.50. This implies that any significant event affecting the supply chain is likely to translate into a significant change in the bargaining power distribution. Finally, the bargaining power is significantly better distributed for the PDO than for the Non-PDO, thus indicating that the PDO possesses a significant sustainability advantage (73%) over the Non-PDO.

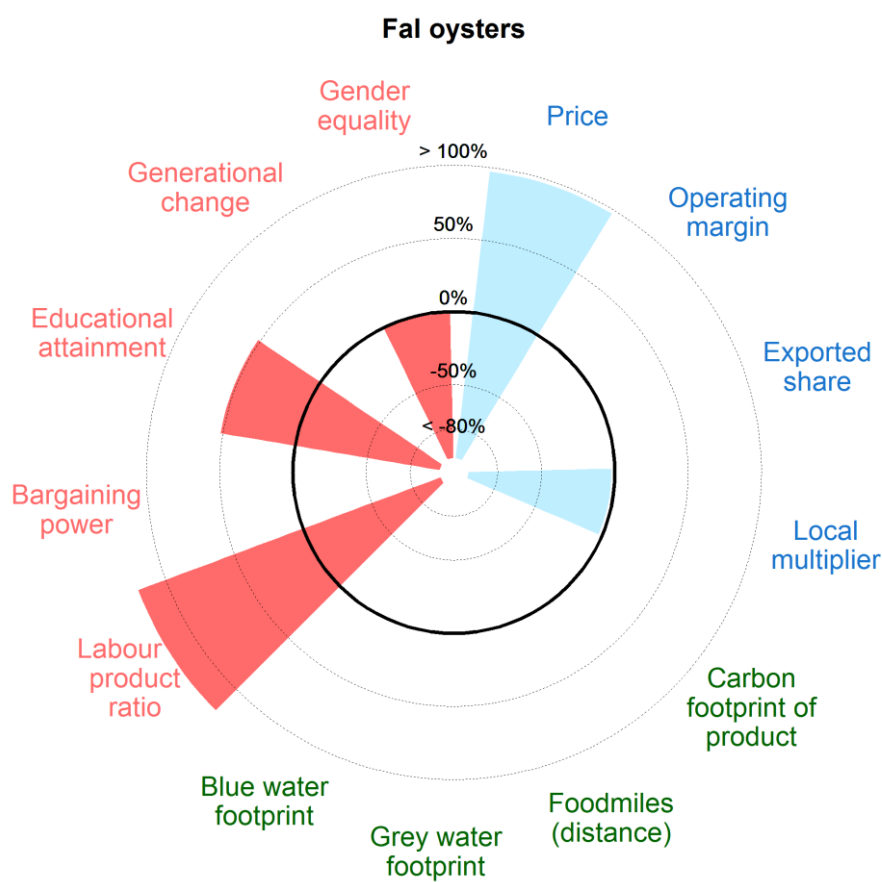
Generational Change and Gender Equality

For age balance, PDO products is 39% more sustainable than Non-PDO products. The high value of the generational change indicator for both the supply chains of the PDO and Non-PDO are due to the physically demanding nature of the work (ex. at upstream level, physically demanding labour requires the strength and the stamina of a young person) and the young workers' willingness to get engaged in these supply chains because of the high margin the products can secure. The higher generational change indicator is mostly driven by the difference at downstream level. Mainly Non-PDO retailers are the older and they spend their free time (or family people's) to do the fish sauce business. They buy Phu Quoc Non-PDO fish sauce from the processors to sell to their relatives, friends, and around people as a part time job for extra earning. On the other hand, PDO retailers are usually younger people and this work is a profitable work for their main incomes. This may also explain the higher net margin of the PDO retailers. Moreover, the PDO significantly affect on the psychology, pride, and prestige of the effective retailers and, in turn, the retailers with stronger and effective resources are more interested in PDO products.

For gender equality, there is no clear difference between PDO and Non-PDO. At the fishing stage, both PDO and Non-PDO actors mostly employ the male staffs since the physically demanding nature of the work to be carried out on fishing boats is deemed more suitable for male crews. The processing stages of both the PDO and the Non-PDO are characterised by very low levels of Gender Inequality. The important role of females in the supply chains of both the PDO and Non-PDO is due to family ownership of even large businesses by women and is also reflected in the Chair of the Association of Phu Quoc fish sauce being a female. The highest difference is revealed at the retailing stage. Only the Non-PDO retailer is characterised by moderate Gender Inequality due to the low level of male employment and entrepreneurship. What drives the difference at downstream level is that female is more appropriate in small retailers such as wet markets, online shops, or traditional markets which are the main retail channels for Non-PDO fish sauce.

2.3.3. PDO Fal oysters (UK)

The Fal Oyster PDO, approved in 2015, is not working in the way intended and an alternative governance mechanism is under consideration. Currently only 4% of oyster production from the Fal estuary is being processed following the PDO Code of Practice and the future of the PDO is uncertain. It proved difficult to estimate the full range of economic, social and environmental indicators. Given the uncertainty surrounding the PDO and likely restructuring, those indicators that have been estimated should be treated with caution.

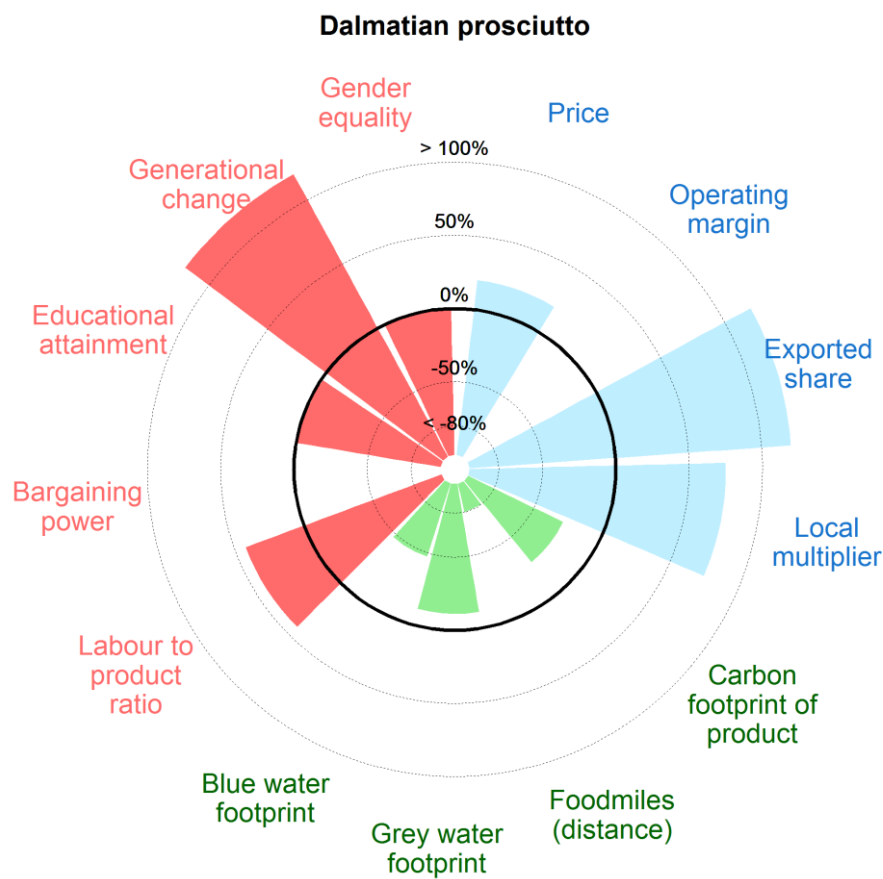
Figure 12. Sustainability diagram for PDO Fal oysters

3. PROTECTED GEOGRAPHICAL INDICATIONS

3.1. Meat and dairy sectors

3.1.1. PGI Dalmatian ham (Croatia)

The sustainability diagram (Figure 13) is based on comparison of economic, environment and social indicators for PGI product, which is Dalmatian prosciutto and reference product, which is conventional prosciutto produced by one company, the biggest producer in non-PGI or PDO prosciutto production in Croatia.

Figure 13. Sustainability diagram for PGI Dalmatian prosciutto

Regarding **economic indicators** (price premium) there is no price premium for FQS prosciutto at upstream level, whereas FQS benefits from a price premium about 45% at processing level. This high price premium is explained by the technical specifications; FQS require a more intense drying compared to reference product. Moreover, FQS producers used traditional production process. Only FQS product is exported. Exports (mostly in Europe) represent 5% of the volume and 18.7% of the value. This gap in percentages reflects a high valuation of exported FQS products (within or outside Europe). Price of Dalmatian prosciutto on Europe market is similar to that of inside price.

The local area assumed for the **local multiplier calculation** is the area of origin for the product, i.e. Dalmatia region; the same will apply for the reference. The total turnover of the ham processor corresponds to about 4.2 million € and it is used mostly to buy fresh meat (41%) and to pay investments (e.g. margins) and taxes (42%); 9% of the total turnover is spent on personnel; and, 8% on other intermediate inputs, like energy. Just 7% of the amount of money spent for fresh meat (slaughterhouses) remain within the local area. This is a consequence of the rules imposed by the code of practice that allows the slaughtering activity also outside the origin area of Dalmatian Prosciutto (e.g. in Hungary and Austria). The presence in the area of few number of actors might imply a moderate level of coordination within the supply chain. For personnel involved in meat processing, 100% of the wages are paid to workers living in the local area. Furthermore, 36% of the firms providing other inputs belongs to the local area. The small number of first tier suppliers located in the region seems to identify an industrial organisation (large firms) rather than a network of small firms. The third level relates to the amount re-spent in the territory by the suppliers of the ham processor (first tier suppliers). In this respect, the local slaughterhouses expenditure for inputs (e.g. labour, energy, etc.) from

suppliers (second tiers suppliers) with headquarter within local area corresponds to 100%. All the inputs for local slaughtering activity originates from the local area. The same for the local second tier suppliers of the category “other inputs and services”: 100% is purchased within the local area. The local re-spend by ham processor personnel is estimated by using the following proxies: a) local staff spends 66% of their total income locally, and b) non-local staff spends 33% of their income locally; these percentages are defined according to the evidence provided by local multiplier results time series. The local multiplier indicator for the Dalmatian Prosciutto is 1.75, therefore 1 € received by the ham processor concurs to activate a global expenditure within the identified local area of 0.75 €. We can also state that for every € spent by the processor, the local economy benefits from 0.75 €. Assuming all the suppliers are located in the local area, the local multiplier would correspond to 2.72, with the same meaning of the global indicator; while assuming all the suppliers are located outside the local area the local multiplier would reduce to 1.09. Therefore, 1 € spent by non local suppliers contributes to generate a financial flow in the local area of 0.09 € (9%). The main determinant of the local multiplier of Dalmatian Prosciutto is the share of turnover devoted to other direct costs, of which 62% remains within the local area. Without this local economic component, local multiplier would reduce of -33%.

The **carbon footprint** (excluding transport) of PGI prosciutto is 23% higher than its reference, although the footprint of the fresh meat used for PGI prosciutto is only 5% higher. This is largely due to the technical specifications which require a more intense drying for the PGI. Therefore, an accounting unit like $\text{tCO}_2\text{e kcal}^{-1}$ may yield results similar to those of fresh meat. The lower footprint of fresh meat is mostly due to manure management: Hungarian pig farms – from which most of the PGI fresh meat come from – use more solid manure systems than their Croatian counterparts. These small differences are to be taken cautiously due to a larger use of default values in PGI estimates than in the reference. Our estimates for fresh meat – 2.04 and 2.24 $\text{tCO}_2\text{e t of liveweight}^{-1}$ for PGI and reference respectively – are at the lower end of the literature which ranges from 2.1 to 11.9 $\text{tCO}_2\text{e ton}^{-1}$ pork meat (Clune et al., 2017; Meier et al., 2015).

Concerning **food-miles**, PGI supply chain was compared to the conventional prosciutto chain in Croatia. Over the entire supply chain, from fresh ham to prosciutto, there is a significant difference between the FQS and its reference. PGI Dalmatian prosciutto travels much longer distances (4,000 vs 1,000 t.km t^{-1}) and releases much more emissions (400 vs 100 $\text{kg CO}_2\text{e t}^{-1}$) than the reference. The ratio is 1 to 4 in support of the conventional product. The longer distance embedded in the PGI Dalmatian prosciutto can be explained by the longer distance travelled by fresh ham from slaughterhouses located abroad (Hungary and Austria) to processing units in Croatia. Similarly, the higher emissions embedded in the FQS can be explained by the emissions resulting from the imports of raw products. Indeed, conventional prosciutto is produced and processed locally, while fresh ham for PGI prosciutto is imported. Nonetheless, the level of per kilometre emissions is relatively high for the FQS. This may be explained by the fact that imports rely on road transport. The processing level (from farms to prosciutto producers) concentrates most of the kilometres embedded in the product and most of the emissions generated along the value chain (i.e. around 80%) for the conventional product, while the distances and emissions are more equally distributed among the processing level (from farms to producers) and the distribution level (from producers to retailers) (35% and 65% respectively) for the FQS. Regarding food-miles indicators, we can conclude that the PGI Dalmatian prosciutto is less sustainable than its reference both in terms of distance travelled (+270%) and in terms of emissions released (+270%).

The **employment indicator (labour use ratio indicator)**, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope, 2001). The allocation of labour to production is higher for Dalmatian prosciutto than for its non-PGI reference. It takes 25.6 hours of work to produce a tonne of ham when the reference product requires 18 hours. The difference (42%) indicates that the PGI product generates more jobs than the reference system. The turnover-to-labour ratio indicator provides an insight into labour productivity. The average turnover per employee is 7% higher in PGI sector than in non-PGI ones. These differences are mostly due to the very different production technologies. FQS producers use a traditional production procedure based on long smoking and drying (up to 45 days) as requested in the technical specifications of the PGI product. The production of the reference product is more automated.

The **bargaining power** values for both the FQS and the reference are high (>0.5). This indicates that their position can be therefore qualified as strong. This means that they are likely to be less impacted by significant changes operated at the supply-chain level. This strong position can be explained by the low number of actors for both supply-chains, thus rendering coordination among them easier and by the fact they use highly specific resources for operating their activity (high spec_res). This is all the more true for the FQS because of its high concentration level (marketshare1 = 35% & marketshare2 = 25%).

The level of education is approximately the same in both sectors (PGI versus non-PGI), with approximately 80% of staff having a secondary school degree.

Regarding **Generational change and gender equality indicator**, the meat processing stage of the supply chain of the Dalmatian Prosciutto PGI is more sustainable than the same stage of the supply chain of the counterpart prosciutto, according to the Generational Change indicator. The meat processing stage of the PGI product employs way more young people than older ones. Looking at the Gender Inequality index, Prosciutto production – both PGI and counterpart – appears largely unsustainable due to high levels of the indicator. However, the counterpart prosciutto appears slightly more sustainable in terms of gender equality than the PGI prosciutto. The zero level of female entrepreneurship in meat processing and the consistently different gender opportunities in secondary education and overall employment levels drive the actual value of the indicator, suggesting that gender inequality is higher for the PGI than the counterpart product.

3.1.2. PGI Gyulai sausage (Hungary)

In order to estimate the sustainability of this Hungarian PGI sausage, the specific methodology of the Strength2Food project was applied. For the benchmarking purposes, as reference or counterpart product, the special characteristics of the product was considered. In order to get reliable comparison, we used generic (not GI) sausage as reference product, except for local multiplier calculations where small sausage processors (within the GI territory but producing no GI sausage) were considered.

Due to the quite limited amount of official data of the sausage value chain, the majority of the inputs for computing the indicators are collected via personal interviews (butchers, sausage processors, representative of the Hungarian Meat Industry Federation, the management of the biggest GI processor company and other industry experts). On the other hand, all the available data are included, mainly gained from the databases of the Hungarian Central Statistical Office and the Hungarian FADN, while for trade flows we used the dataset of the World Bank.

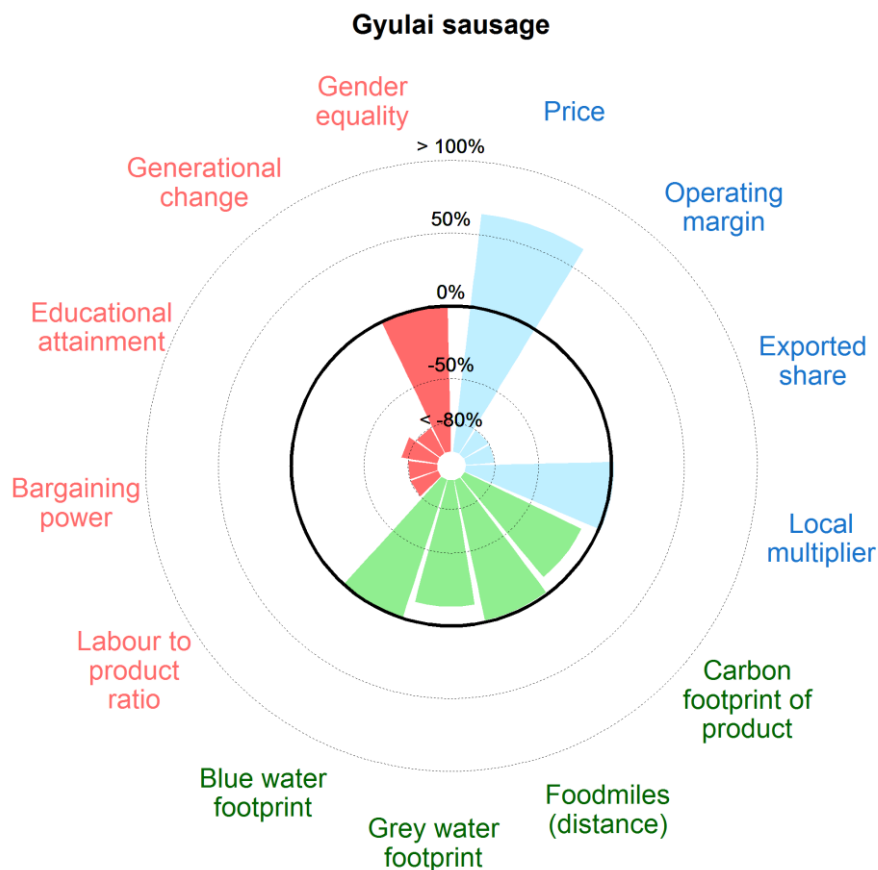


Figure 14. Sustainability diagram of PGI Gyulai sausage

This diagram features the relative difference between Gyulai sausage and its reference product along 13 performance indicators.

3.1.2.1. Price, profit and exports

At U3 level, there is no significant difference for pig production, and economic indicators are the same. At processing level, the price premium is high, but profitability of PGI is lower than its reference. Indeed both intermediate consumption and wages cost are higher for PGI (due to the traditional processing method, mainly the smoking and ripening process). At distribution level, price premium is stronger, and at this level PGI appears to be more profitable, considering costs are almost the same for distribution.

Concerning export, the majority of the conventional product is exported, while Gyulai sausages are destined largely for local and national markets. However, Gyulai sausage benefits from a higher price at export level, as the difference between share of volume and share of value is higher for PGI than for reference.

3.1.2.2. Local multiplier

The local area assumed for the local multiplier calculation is the Gyula and Békéscsaba region; the same applies for the reference.

The local multiplier effect of Gyulai sausage is 11.7% higher than its reference product: each euro of turnover for Gyulai sausage triggers 0.43 € of responding in the same region versus 0.28 € for the reference. The main driver of this difference is the processor's payroll: in the case of Gyulai sausage 12.6% of the processor's costs is devoted to local wages, while for the non PGI-product, just 8%. Indeed, without local spending of payroll, the local multiplier would reduce

of -12% for the PGI product and -9% for non-PGI sausage. In both cases, the supply chain seems to be relied on external resources (just 5% of the slaughterhouses is local). The result is then a limited contribution, or a limited flow of financial resources, along the local value chain both for FQS and REF. For the FQS, just 22.2% of the initial budget remains within the local area at round 2 (expenditure addressed to local first tier suppliers), and 20.3% of the initial budget is kept within the local area at round 3 (expenditure addressed to second tier suppliers). In the case of REF, 15.4% of the total budget remains at local level in the second round and 12.9% in third round.

3.1.2.3. Carbon footprint

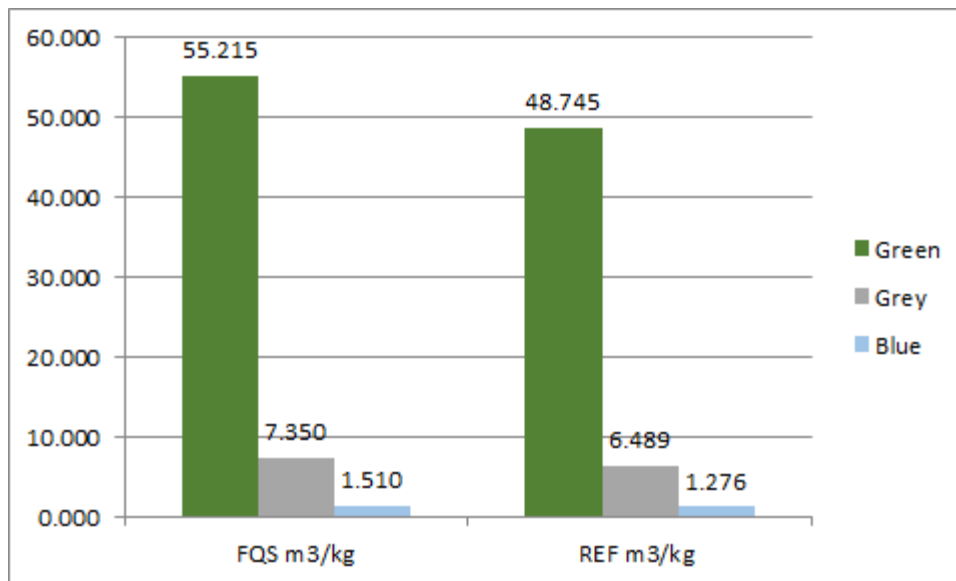
The carbon footprint ($\text{tCO}_2\text{e t}^{-1}$) of PGI sausage is 11% higher than its reference, despite a similar footprint of the fresh meat used for PGI ham. This is largely due to the technical specifications which require a more intense drying for the PGI. Therefore, an accounting unit like $\text{tCO}_2\text{e kcal}^{-1}$ may yield results similar to those of fresh meat. Our estimate for fresh meat – $2.7 \text{ tCO}_2\text{e t}$ of fresh meat $^{-1}$ for both PGI and reference – is at the lower end of the literature which ranges from 2 to $11.9 \text{ tCO}_2\text{e ton}^{-1}$ pork meat (Clune et al., 2017; Lesschen et al., 2011; Meier et al., 2015).

3.1.2.4. Food-miles

Over the entire supply chain, from farms to retailers, there is a slight difference between the FQS and its reference. The former travels slightly longer distances ($4,500$ vs $4,400 \text{ t.km t}^{-1}$) and releases slightly more emissions (445 vs $415 \text{ kg CO}_2\text{e t}^{-1}$) than the latter. The longer distance embedded in the PGI Gyulai sausage can be explained by the difference in product concentration (0.58 for FQS vs 0.66 for its reference) at the second level of the processing stage, from slaughterhouses to processors. Indeed, more meat parts are needed to produce PGI sausage, leading to longer embedded distances travelled by imported meat parts, which concerns most of the production (95%) and involves long distances. Shorter distances travelled at retail level due to a smaller share of exports for PGI (12% vs 35% for its reference) are totally offset by the longer distances travelled at processing level by imported meat parts. Similarly, the larger emissions embedded in the FQS can be explained by the larger emissions resulting from the imports of meat parts. Distances (and emissions) related to imports of meat parts outweigh distances (and emissions) related to exports due to the lower transformation ratio at processing level that leads to more embedded distances (and emissions).

The processing level, and especially the second level of processing, from slaughterhouses to processors, concentrates most of the kilometres embedded in the product and most of the emissions generated along the value chain (i.e. more than 70%). Regarding food-miles indicators, we can conclude that the PGI Gyulai sausage is less sustainable than its reference both in terms of distance travelled (+1.5%) and in terms of emissions released at the transport stage (+7%).

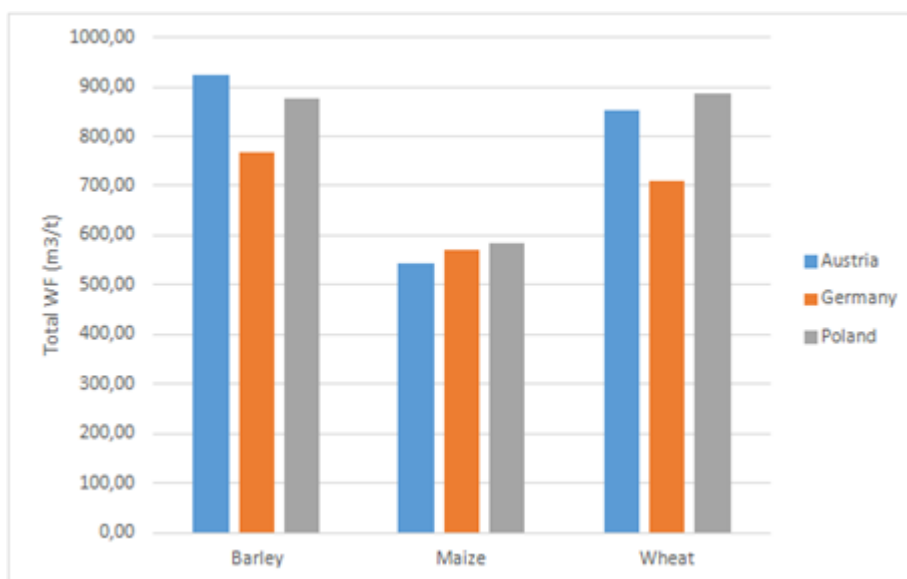
3.1.2.5. Water footprint



Since slaughtered meat has been declared to be imported, impacts of the agricultural phase are not located in Hungary. Data from the three main meat exporters to Hungary were used in the calculation: Germany, Austria and Poland. FQS and REF production systems have the same upstream level and, therefore, the same WFs related to agriculture, diet and breeding.

Most part of the water footprint is due to the agricultural phase which takes place in these countries. FQS production is more water demanding than the REF product. Using default values for agricultural productions (taking place in the three major meat exporting countries to Hungary) did not allow discriminating between the two schemes of production because yield, meteorological data and crop parameters could not be differentiated and was necessarily assumed to be the same for FQS and REF. What produces the observed differences in the fractions of the agricultural water footprint is simply the final product ratio which is 0.332 (t sausage/t live-weight) for FQS and 0.376 (t sausage/t live-weight) for REF.

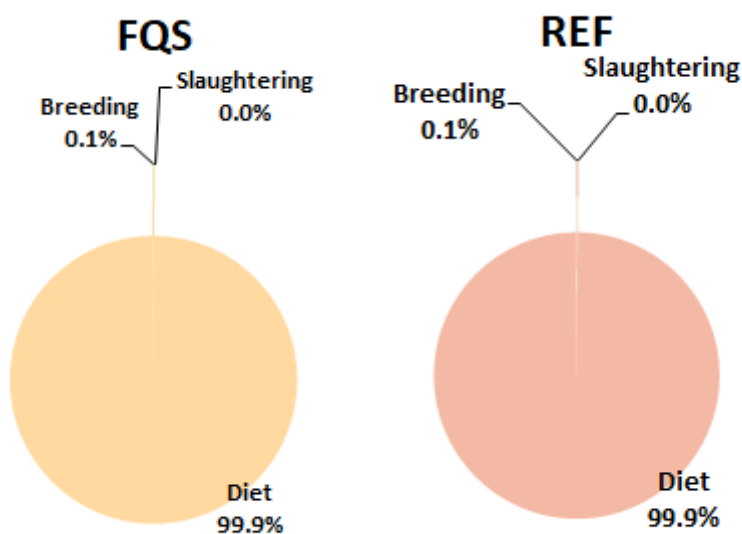
As for agricultural production it seems that barley and wheat have higher WFs of maize, and in general, products cultivated in Austria or in Poland have greater WF, as shown in the following diagram:



In this study, the WF related to the import of a commodity from abroad to Hungary has not been considered, and therefore the WFs reported in this study are underestimated.

The WF_{blu} of all the raw materials was considered to be zero. The LCA component, through which we determined a quota of the blue water footprint, that related to product used in and for the activities performed in the farm, produced similar outputs for the two products. Still it was not possible to differentiate between FQS and REF in terms of farm activities and related impacts. So that even for LCA blue water footprint the only difference concerns the final product ratio.

Data input for breeding phase include only electricity consumption. We used secondary as they were taken from S2F Organic Pork case study. Final WF of breeding depends on the final product ratio, that is the only primary data provided by partner. WF of breeding is higher for FQS (36.82 m³/t) than REF (32.51 m³/t). But breeding represents < 1% of the whole WF in both production systems, as shown in the following diagram



Slaughtering takes place in exporter countries, while sausage production takes place in Hungary. Because of the lack of specific data, a unique processing phase was considered, taking into account the final product ratios of both slaughtering and production. Data for processing include only energy consumption. Electricity consumption impact was estimated by using the Hungarian electric mix. Data are secondary and they are taken from S2F Organic Pork case study.

WF blue of processing is 0,028 m³/kg of sausage for both FQS and REF. This amount is negligible in comparison with the whole WF of Gyulai sausage.

3.1.2.6. Employment and educational attainment

The **labour use ratio indicator**, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope, 2001). The allocation of labour to production is lower for Gyulai sausage than for its non-PGI reference (meat processing industry). It takes 161 hours of work to produce a ton of sausage when the reference product requires 1.178 hours. The difference (-86%) indicates that the PGI product generates less jobs than the reference system. The turnover-to-labour ratio indicator provides an insight into labour productivity. The average turnover per employee is 96% lower in PGI sector than in the meat processing sector. These differences are mostly due to the firms structure. The biggest PGI processor Gyulahús Ltd. has a well-established processing facility while the average and small scale other Hungarian sausage processors are not that efficient. The size of the other non GI sausage processors and their production portfolio explains the difference in the average turnover per employee: among the Gyulahús Ltd. core products the dried sausage plays a more important role than in the other big meat processors in Hungary, and in case of the latter the average firm size is significantly higher.

The level of education is very low compared to what is observed for the reference sectors. The large majority of employees in the sector (80%) have only a primary education level compared to a minority in the reference sector (20%). The low level of education (having only primary or secondary degree) is a general phenomena in the Hungarian meat industry as the core process allows to have less educated employees.

3.1.2.7. Bargaining power distribution

Bargaining power is rather unevenly vertically distributed along the FQS supply chain (BPD value 0,42). This is mainly due to the low bargaining power score obtained at the U3 level (0,14), which is due to the fact that processors mostly source raw materials at the international level (Germany, Poland, Austria, Spain), mainly meat and firm lard is needed for producing sausage through a market logic. By way of contrast, the dominant position held by processors P1 of the FQS is due to two factors. First, they are very few in number, with, in particular, a very strong market leader. Second, this level enjoys a strong advantage over the upstream level in terms of "transaction costs": they master the specific resources needed for producing sausage, the P1 level is key for the distinctiveness of the end

3.1.2.8. Generational change and gender equality

The Generational Change Index and the Gender Inequality Index in Employment were calculated only for the meat processing stages of both supply chains because the meat for both sausages may come mainly from abroad and the procurement of the national or local agricultural raw material may occur only whenever particular market conditions come about. Furthermore, the Generational Change indicators for both products could be calculated only

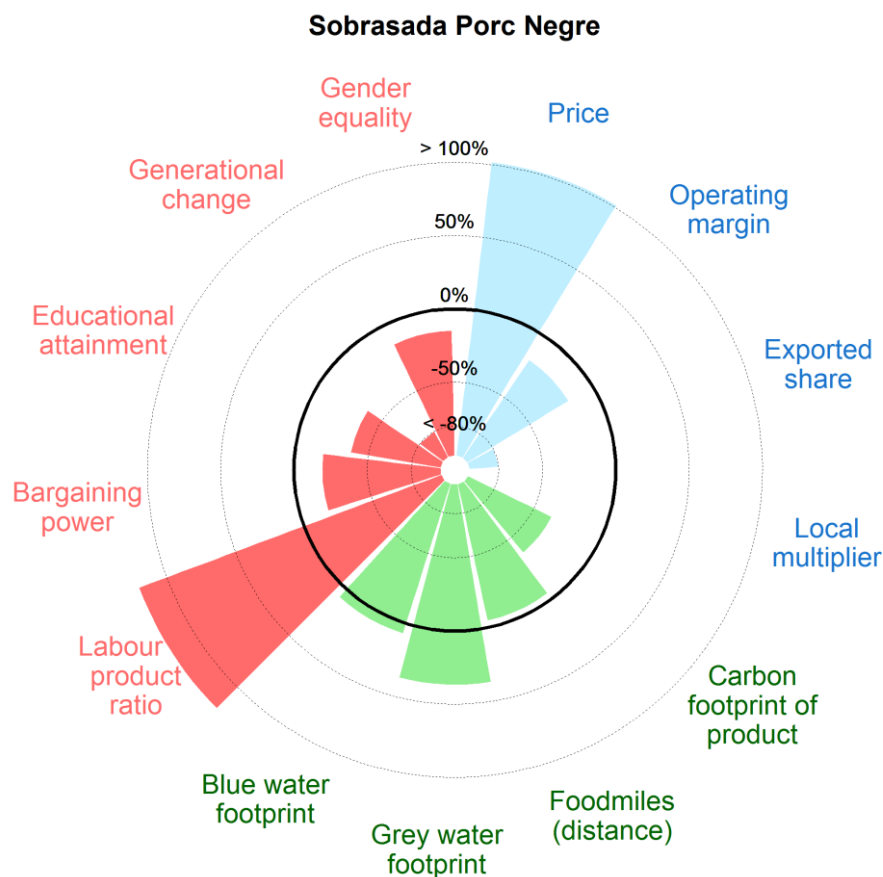
because the zero percent rate of female ownership of processing firms was replaced by a very small number (0.001).

In the case of the Gyulai sausage PGI, at the meat processing stage, the supply chain of the reference sausage is more sustainable than the one of the Gyulai Sausage PGI because the Generational Change Indicator is more than ten times the one for the latter. This may be because the Gyulai Sausage PGI is produced in a very small area (the small city of Gyula, and Békéscsaba in fact) and the firms producing the PGI product are only a handful. Nonetheless, the Generational Change indicator suggests that there may troubles ahead for continuing to produce the PGI Sausage, due to the very limited involvement of young workers in the processing stage, compared to older ones

Likewise, both the production of the Gyulai Sausage PGI and the reference product appear hampered by the high penalty brought about by the differences in opportunities between males and females at the processing stage of the supply chains. In fact, firm ownership accrues completely to males, determining the high values of the indicator (suggesting, in turn, that both supply chains are markedly unsustainable). The values of the Gender Inequality indicators for the two products suggest that the Counterpart Sausage is marginally more sustainable than the Gyulai Sausage PGI

3.1.3. PGI Sobrasada Porc Negre (Spain)

In this section, we present the results derived from the sustainability assessment of the PGI Sobrasada de Mallorca of Porc Negre (FQS product) compared to the PGI Sobrasada de Mallorca (REF product) using the methodology suggested by Bellassen et al. (2016) to develop economic, environmental and social indicators, which are reported in Figure 15 along with a summary of their main results.

Figure 15. Sustainability performance⁵ of PGI Sobrasada Porc Negre (supply chain averages)

As for the economic indicators, one may observe that the price premium is 78% at the upstream level and 125% at processing level for the FQS product. At the both levels, the cost of intermediate consumptions is very high compared with the turnover, leading to a weak profitability for both products. However, looking at the profitability (GVA and GOM) one may realize that the results are not so different for the two categories of product. In sum, the FQS product is less profitable than the reference one. The main reason of this low profitability of the Porc Negre is the daily reality of farmers, who tend to run Porc Negre farms as a complement of agriculture as explained before with the main objective of maintaining the Porc Negre breed instead of achieving higher profits.

The local multiplier effect of Sobrasada de Mallorca PGI is more than the double of its reference product: each euro of turnover for Sobrasada de Mallorca PGI triggers 1.81 € of re-spending in the same region versus 1.28 € for the reference. The main driver of this difference is the location of the first and second tier suppliers: for the reference case, if we assume the local supplier pattern, the local multiplier would increase to 2.25. Without farms located in the region, local multiplier for the PGI product would reduce of 28%. Furthermore, under the hypothesis that all the pig farm's inputs (excluding labour) are purchased outside the local area, the local multiplier reduction for the PGI product would be -31% and for the non-PGI one -4% with respect to the current situation.

⁵ Each indicator is expressed as the difference between the FQS and its reference product. For environmental indicators for which lower is better, the opposite of the difference is displayed (eg. +20% when the carbon footprint is 20% lower).

As for the environmental indicators, it can be seen that the carbon footprint (excluding transport) of PDO sausage is 44% higher than its reference. This is mostly due to the characteristics of the Porc negre breed whose sows lay less than half the number of piglets that reference sows do and whose fattening pigs live around three times longer than reference pigs before being slaughtered. Despite the lower carbon intensity of one ton of fodder in the PDO, PDO pigs end up needing around three times as much of it per ton of sausage. Similarly, as pigs spend most of their time outside, the manure management system emits less per ton of manure in the PDO, but longer lifetime and larger intake generate much more manure per ton of sausage in the PDO. Our estimate for fresh meat – 4.4 and 3.1 tCO₂e t of fresh meat⁻¹ for the PDO and the reference respectively – is within the literature range of 2 to 11.9 tCO₂e ton⁻¹ pork meat (Clune et al., 2017; Lesschen et al., 2011; Meier et al., 2015).

Concerning food-miles, the PGI Sobrasada de Mallorca de Porc Negre supply chain was compared to the PGI Sobrasada de Mallorca chain, from farms raising pigs to distribution units, although no data were available for the reference at the processing levels. Over the entire supply chain, FQS Sobrasada travels 5% longer distances (410 vs 400 t.km t⁻¹) and releases 1% more emissions (71 vs 70 kg CO₂e t⁻¹) than reference Sobrasada. This difference is mainly driven by exports, and also by the product concentration. Indeed, FQS Sobrasada is more exported than reference Sobrasada (6.5% vs 5.4%), driving distances and emissions up. On the contrary, less pigs are needed to produce a given unit of FQS final product, driving distances and emissions down. The exports effect is slightly stronger than the product concentration effect, leading to longer distances and more emissions for the FQS. Regarding food-miles indicators, we can conclude that PGI Sobrasada de Mallorca de Porc Negre is less sustainable than its reference in terms of distance travelled (+5%) and in terms of emissions released at the transportation stage (+1%).

In relation to the water footprint (WF), the two productions are based on different diets. Essentially FQS uses grass, pea and barley whereas REF utilizes maize and soybean. The differences in the green water footprint, which is higher for REF, depends on four different factors: type of crops, meteorological conditions, diet and transformation efficiency. All of these factors affect the green water footprint. If we consider only the fraction of the green water footprint due to crop production we have that REF shows a lower impact than FQS, although it makes use of soy to feed the animals. Soy has the highest green water footprint as a crop but it is given in the diet in a quite moderate amount so that it does not affect too much the result and the REF production requires less green water. However, the scenario changes when we include the transformation procedure (fattening pig → carcass weight; carcass weight → meat). The REF system is less efficient than FQS and this makes its green water footprint higher than FQS'. This is so because efficiency of transformation determines how much crop is transformed to obtain a unit final product and this reflects on the green water footprint as well as on the other fractions of the indicator.

The REF production shows higher grey water footprint than FQS. This indicator, computed considering the amount of nitrogen-based fertilizers used in crop production, reveals that REF production would impact water quality less than FQS, but still the scenario is reversed when one considers how the grey water footprint is modified by the efficiency of transformation as in the case of the green water footprint.

The blue water footprint as computed for crop needs (e.g. irrigation) is more or less the same for the two products. However, when efficiency of transformation is considered the REF system becomes more water demanding per unit product. LCA component of WF blue of beverage is higher for REF than FQS. The beverage represents only 0.3% of the whole WF both in REF and FQS. Diet is the most important contribution and represents about 99% of the whole WF

in both production systems. FQS breeding has a slightly higher WF than REF (67.54 m³/t for FQS vs 54.13 m³/t for REF). Breeding represents < 1% of the whole WF in both production systems.

Finally, as for the social indicators: the labour use ratio indicator, calculated based on output, reflects labour requirements for a unit of physical output (Just and Pope, 2001). The allocation of labour to production is higher for Sobrasada Porc Negro than for its non-PDO reference. At the farm level, it takes 212 hours of work to produce a tonne of pigs when the reference product requires 31 hours. The difference (577%) indicates that the PDO product generates much more jobs than the reference system. The relative difference is on advantage of Sobrasada Porc Negro at the process level (528 %) since it takes 714 hours of work to prepare a tonne of product against 113 hours for the reference product. The turnover-to-labour ratio indicator provides an insight into labour productivity. The average turnover per employee is 74% and 64% lower in PDO sector than in non-PDO ones, respectively at farm and process level. These differences are mostly due to the different production procedure employed with the Porc Negro breed as the production of the reference product is more automated.

The education attainment indicator for the PDO-product is very low at the farm level: most workers have a primary (75%) or secondary (21%) educational attainment. At the processing level, the educational attainment level indicator is much higher than on farm level and similar for FQS and REF product.

Furthermore, a comparison of the bargaining power indicator for the FQS and the reference does not allow to conclude about any significant sustainability advantage of the former over the latter, as both supply chains perform well concerning the distribution of their bargaining power. In the same time, our calculation show that neither supply chains would be highly resistant to major shocks, although our results show evidence of a small advantage of the FQS over the reference product.

It is noteworthy that the values of the generational change and gender equity indicators are the same for the two products, for every stage of the supply chains. This may be due to breeders and processors performing their activities for both the quality and counterpart products. This evidence may suggest also that:

- At the farm stage (pig breeding), the reference sausage appears to be more sustainable than the Sobrasada Porc Negro, because the Generational Change indicator is larger in the former than the latter. However, because the Generational Change indicator for the farm stage of both products is smaller than 100%, both products appear endangered in their sustainability prospects due to a high employment level of 45-65-year-old, compared to of 15-35-year-old individuals. In particular, the intergenerational transmission of the knowledge necessary to breed pork suitable for the production of Sobrasada Porc Negro appears particularly undermined by the very small value of the Generational Change indicator
- Similar results arise, at the farm stage of both supply chains, with respect to the calculation of the Gender Inequality indicator. Once again, the Counterpart Sobrasada appears more sustainable than the one of Porc Negro due to a lower value of the Gender Inequality indicator. This is due to the very limited female participation and achievement in every domain the Gender Inequality Indicator considers: secondary education of employees, female entrepreneurship and female employment. The significant difference existing with the same values for the Counterpart Sobrasada justify the values of the indicator being at the opposite end of the indicator range

- A somewhat different result is obtained for the meat processing stage where the Sobrasada Porc Negre could be deemed as sustainable as the Counterpart one, if not more, with respect to both indicators. On the one hand, there is only a 1% difference in favour of the Counterpart Sobrasada in the value of the Generational Change indicator. However, because both the indicator for both products is smaller than 100%, both products face significant challenges in their sustainability prospect. On the other hand, there is a very small difference in the value of the Generational Change indicator, in favour of the Sobrasada Porc Negre being slightly more sustainable than the Counterpart one. The processing stage of both products (the Sobrasada Porc Negre, in particular) appears to grant many more opportunities to women than the pig breeding one. However, the interpretation of these results has to be cautious due to the indicators for the processing stage being calculated with the same data of the pig breeding one for the Counterpart Sobrasada product. This is because the latter supply chain is highly integrated.
- Mainly because the supply chain of the Counterpart Sobrasada is characterised by values of the indicators which are the same across the two stages of the supply chain, the Counterpart Sobrasada appears – as a whole – more sustainable than the Sobrasada Porc Negre, according to both indicators. While both products appear somewhat endangered in their sustainability prospects according to the Generational Change indicator, the low level of Gender Inequality indicator for the Counterpart Sobrasada poses well for its sustainability prospects.

3.1.4. PGI Ternasco de Aragon (Spain)

In this section we present the results derived from the sustainability assessment of the PGI Ternasco de Aragón using the approach proposed by Bellassen et al. (2016) accounting for economic, environmental and social indicators, which are reported in Figure 16, and briefly discussed below.

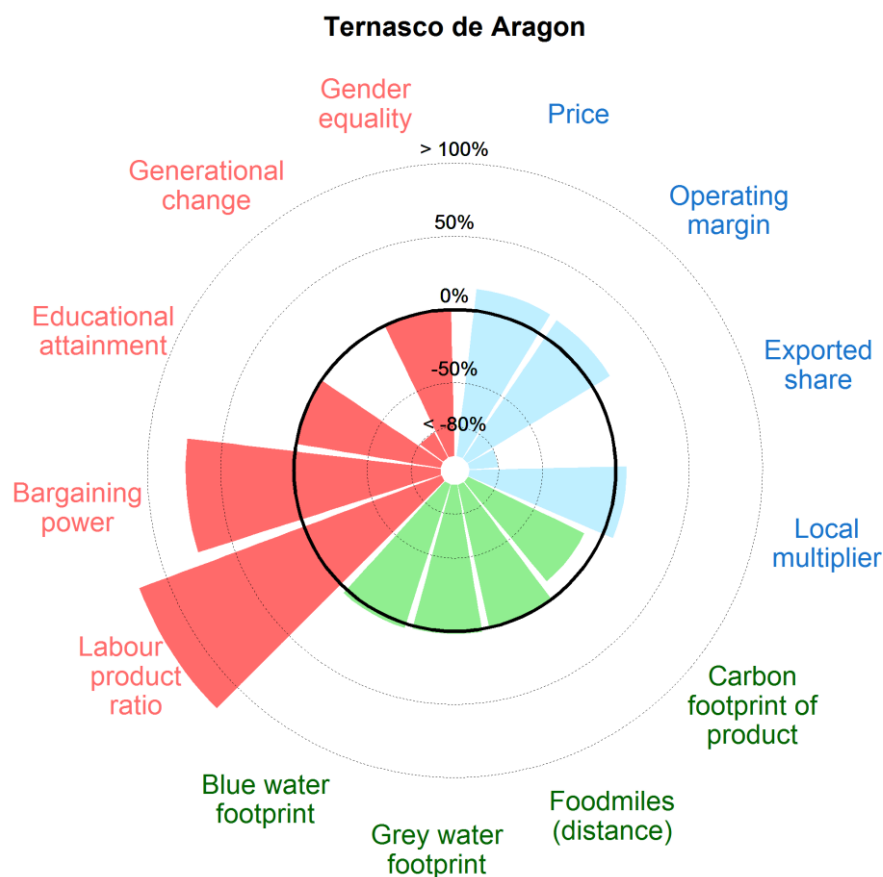


Figure 16. Indicators diagram for PGI Ternasco de Aragón

As for the economic indicators, one can observe that the price premium is almost constant along the supply chain, with a value around 15%. At upstream level and processing level, the cost structures are similar for FQS product and reference product. So the profitability (GVA and GOM) are not so different for the two categories of product. Data do not allow calculating the net result at these levels of the chain. Profitability at upstream level cannot be calculated. Only the reference product is exported, however its valuation is lower than those of other distribution channels. FQS product exports, inside Europe and outside Europe, are very low (0.2% respectively). The reference product is exported mainly to Europe (about 36% by volume), however its valuation (17% in value) is lower than those of other distribution channels.

Moreover, the local multiplier effect of Ternasco de Aragón PGI is 7% higher than its reference product: each euro of turnover for Ternasco de Aragón PGI triggers 1.97 € of responding in the same region versus 1.77 € for the reference. The main driver of this difference is the location of the second tier suppliers: in both cases, without farms located in the region, the local multiplier would reduce of 57%. Furthermore, under the hypothesis that all the sheep farm's inputs (excluding labour) are purchased outside the local area, the local multiplier reduction for the PGI product would be -13% and for the non-PGI one -11% with respect to the current situation.

As for the environmental indicators, it can be seen that the carbon footprint of Ternasco lamb is 59.3 tCO₂e ton⁻¹ of meat, that is 12% higher than its non-PGI reference from the same region. The difference in carbon footprint is mostly due to the lower weight at slaughter of reference lambs. Because lambs eat much less and live much shorter than ewes, the carbon footprint of system is dominated by the “deadweight” of juvenile and reproductive ewes. As a result, a

12.5% lower amount of meat produced per ewe FQS directly translates into a higher carbon footprint per ton of meat. Both values are within the 38.9-56.7 tCO₂e ton⁻¹ of meat range reported by Ripoll-Bosh et al. (2011) for Spanish lamb.

Concerning food-miles, PGI supply chain was compared to the conventional lamb chain in Aragon, Spain. Over the entire supply chain, from farms to distribution units, there is a significant difference between the FQS and its reference. The former travels half shorter distances (820 vs 1,900 t.km t⁻¹) and releases half less emissions (80 vs 180 kg CO₂e t⁻¹) than the latter. The shorter distance embedded in the PGI Aragon lamb can be explained by the much smaller share of PGI exports (0.3% vs 37% for conventional lamb), although export distances are longer for the FQS. Similarly, the lower emissions embedded in the FQS can be explained by the lower emissions resulting from the exports. The distribution level (from processors to retailers) concentrates most of the kilometres embedded in the product and most of the emissions generated along the value chain (i.e. around 75%) for the conventional product, while the burden is more equally distributed among processing (from farms to processors) (55%) and distribution levels (45%) for the FQS. Regarding food-miles indicators, we can conclude that the PGI Aragon lamb is more sustainable than its reference both in terms of distance travelled (-57%) and in terms of emissions released (-55%).

The PGI Ternasco de Aragón shows a higher water footprint for all the components of the indicator. However the differences are not particularly high. This is due to the fact that same data were used for FQS and REF in terms of crop used to feed the animals, crop yield, crop parameters, and amount of fertilizers. Even the same crop composition in the diet characterized the two production system. The only difference concerns the different efficiency in converting fattening lamb into carcass weight. These values are 0.011 for FQs and 0.012 for REF. The blue water footprint represents a conspicuous fraction of the water footprint. Moreover, it is noteworthy to mention that all the crops that enter in the diet of lambs are irrigated and that the contribution of the various phases to the indicator shows that phases other than agriculture (breeding and slaughtering) give a negligible contribution.

Finally, as for social indicators: the labour use ratio indicator, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope, 2001). The allocation of labour to production is higher for Ternasco lamb than for its non-PGI reference (lamb from the same region). At the farm level, it takes 409 hours of work to produce a ton of lamb meat when the reference product requires only 127 hours. The difference (223%) clearly indicates that the PGI product generates more jobs than the reference system. The relative difference is of the same order at the process level since it takes 11 hours of work to prepare a ton of PGI-lamb meat against 3 hours for the non-PGI lamb meat. The turnover-to-labour ratio indicator provides an insight into labour productivity. The average turnover per employee is 66% lower in PGI farm than in non-PGI ones. Productivity levels are much higher at the processing level but the relative difference between PGI-product and non-PGI one is of the same order as at the farm level. These differences are mostly due to the technical specification of the product (as specific rigid controls must hold).

According to Casa de Ganaderos, a cooperative of approximately 270 sheep farmers, there is no difference in the profile of education levels between producers of Ternasco lamb and those in the conventional sector, as most farmers raise lambs for the PGI and non-PGI designation. The level of education is dominated by initial primary (40%) and secondary (28%) education. At the process level, the educational attainment level indicator is higher: 47% employees have a secondary education or middle school degree and 38% have a license (bachelor) or equivalent level, which means three or four years after high school.

The supply chain is very concentrated at upstream (the leading coop's market share at U3 level is higher than 50%) and at downstream (the leading firm's market share at P1 level is higher than 50%) levels. This implies that the supply chain is dominated by two actors, one for each level, thus preventing any firm conclusion about the dominating level. One should however expect a fair distribution of bargaining power among those two levels. Furthermore, one should note that the bargaining power position of the upstream level, which is the weakest level, remains strong (value of 0.75). This implies that the bargaining power distribution would be likely to evolve significantly at the benefit of the U3 level in the case of an increased competition at the P1 level after, for instance, the entry of a competitor at that level.

It is noteworthy that the values of the indicators are the same for the two products, for every stage of the supply chains. This may be due to breeders and processors performing their activities for both the quality and counterpart products. This evidence may suggest also that:

- At the farm stage, both types of Ternasco appear to be largely unsustainable, according to the Generational Change indicator. This is due to the very limited employment level of young workers, compared to older ones
- Similar levels of social unsustainability seem to arise, at the farm stage of both supply chains, with respect to the calculation of the Gender Inequality indicator. The large value of the Gender Inequality indicator is due to the very limited female participation in farm entrepreneurship and employment, compared to male involvement.
- Even higher levels of social unsustainability characterise the processing stage of both supply chains, compared to the respective farm ones. This is due to a lower value of the Generational Change indicator and a higher one of the Gender Inequality. The further increase in the Gender Inequality indicator is due to entrepreneurship at the meat processing stage being completely dominated by the male gender while differences in gender-based employment levels are smaller than at the farm stage
- As a whole, the supply chains for the quality and counterpart Ternasco appear largely undermined in their social sustainability prospects, according to both indicators.

3.1.5. PGI-applicant Sjenica cheese (Serbia)

In order to estimate the sustainability of sheep cheese from Sjenica, the specific methodology of “Strength2Food” project (Bellassen et al. 2016) was applied. Sjenica cheese can be considered as a classic PGI product.⁶ The suitable reference appears to be the production of cow cheese in general in the whole territory of Serbia. Reference case shows some common characteristics of cheese production and can serve as a “default” anchor for a comparison between these two products. The key indicators of the performances are depicted in Figure 5. It should be noticed that necessary data for S2F methodology were collected both from the *primary sources* (conducted interviews with farmers and experts and calculations based upon available secondary sources) and from the *secondary sources* (above all SORS and FADN). As mentioned already, the comparison between the FQS product and its reference is made in few dimensions: economic, environmental and social. Some of the main results are illustrated in Figure 17. Each dimension deserves a short comment as follows.

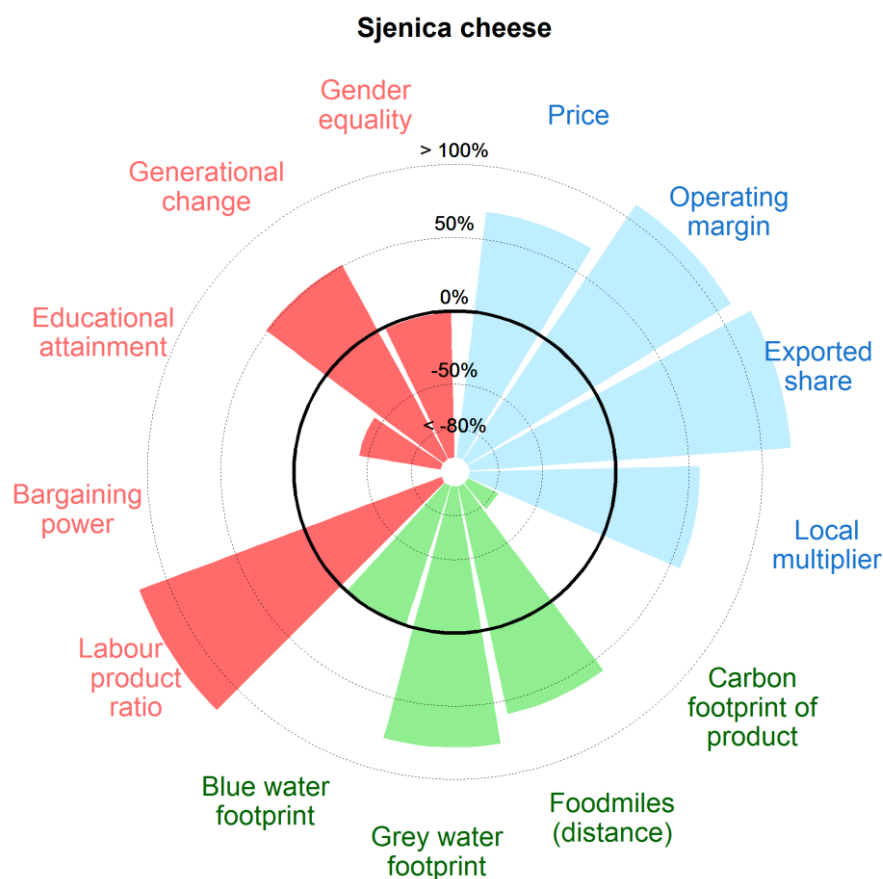
In the sphere of **economic indicators**, it seems that FQS product outperforms its reference both in the case of price and net results. Those results are strongly driven by the higher price premium related to sheep cheese, and lower production costs of sheep milk production (predominant part of grazing in animal diet, traditional labour-intensive milk processing, cheap labour, and above

⁶ Protected Geographical Indication (PGI).

all, enormous subsidies at farm level). At the upstream level, the FQS product benefits from very high subsidies. This results in a very high net (% of turnover) result and much higher than in the case of the reference product. Moreover, the price premium for the FQS product is very high.

Export is pretty the same when it comes to the percentages but it is quite the opposite when it comes to the total volumes of both products. Based on the cow milk production in the whole territory of Serbia, the reference case record much larger production volume at the farming stage than FQS product. For comparison, we should have in mind that in 2016, Serbia recorded nearly 17 million hectolitres of milk (predominantly cow milk). Around 60% of that volume was processed by 123 active (small, medium and large) dairy factories and 40% was processed at households. Therefore, the total export of cow cheese is significantly higher in volume than in the FQS case. So, percentages of export in total production cannot tell much about the relative performance of the focused FQS product.

Figure 17. Sustainability performance⁷ of PGI Sjenica cheese (supply chain averages)



The **local multiplier** effect of Sjenica cheese is 57% higher than its reference product: each euro of turnover for Sjenica cheese triggers 1.72 € of re-spending in the same region versus 0.73 € for the reference. The main driver of this difference is the location of the first tier suppliers: in the case of Sjenica cheese 100% of the farms and 90% of other intermediate inputs suppliers are within the same region, while in the case of the reference product the percentages decrease to 40% and 59% respectively. In particular, without local spending for core inputs, the

⁷ Each indicator is expressed as the difference between the FQS and its reference product. For environmental indicators for which lower is better, the opposite of the difference is displayed (eg. +20% when the carbon footprint is 20% lower).

local multiplier would reduce of -54% for the PGI cheese and -26% for non-PGI cheese; while, without local spending for non-core inputs, the local multiplier would reduce of 8% for the Sjenica cheese and -15% for the non-PGI cheese.

As for the **environmental indicators**, we will focus our attention on carbon footprint, food miles and water footprint issues. So, the carbon footprint of the sheep cheese FQS 85% higher than the reference cow cheese (21.7 vs 11.7 tCO₂e ton⁻¹ of cheese). The large difference comes from the higher efficiency of cow herds in transforming fodder into milk: while the carbon footprint of each ton of fodder is similar between FQS and reference, ewes need three times more fodder to produce the same amount of milk than cows. While the diet of FQS ewes contains a higher share of grass and a lower share of maize than the reference, the associated carbon benefits are offset by the yield of the dominant forage in both diets – grass – which is twice higher for the reference without much more fertilizer use. This is due to the plateau land of the Sjenica region which is much less productive than the national average reference, as well as the combination of alfalfa with grass in the reference.

Concerning food-miles, PGI Sjenica cheese supply chain was compared to the conventional cow cheese in Serbia. Over the entire supply chain, from milk to distribution units, there is a 40 to 55% difference in favour of the FQS. The latter travels less than half shorter distances (200 vs 450 t.km t⁻¹) and releases less than half fewer emissions (25 vs 55 kgCO₂e ton⁻¹) than the reference product. The shorter distance embedded in the Sjenica cheese is mainly explained by the shorter distance travelled by exported cheese – though a small share of the cheese production is exported. Furthermore, the lower product concentration implies less raw products to obtain a unit of Sjenica cheese, and therefore fewer kilometres and emissions embedded in the product at the processing level. Finally, the difference stems to a smaller extent from shorter distances travelled at the processing level since PGI cheese is processed locally in the Sjenica area, according to the product technical specification. The distribution level, from processors to retailers, concentrates most of the kilometres embedded in the product and most of the emissions generated for transport along the value chain (i.e. more than 75%). Regarding food miles indicators, we can conclude that PGI Sjenica cheese is more sustainable than its reference in terms of distance travelled, as well as in terms of emissions released at the transport stage.

Comparison of sheep cheese and its reference related to water footprint are made by all three components of water footprint – the blue, green and the grey water footprint.⁸ In all three cases, there is a significant difference between the two products at the farm level – which was taken as the suitable anchor for comparison. When it comes to the green water footprint FQS records about 52% lower net consumption of water than its reference (2.01 vs 4.25 m³ kg⁻¹), while in the case of the blue water footprint this percentage is even higher (around 73% in favour of the FQS, 0.055 vs 0.21 m³ kg⁻¹). Water pollution, measured by the grey water footprint is 72% lower in the case of FQS than in the reference case (0.12 vs 0.55 m³ kg⁻¹). All three components show that FQS product significantly outperforms its reference, calculated at the farm level.

According to the S2F methodology, the sphere of the **social indicators** consists of four complementary components as follows: (1) employment, (2) bargaining power distribution, (3) educational attainment and (4) generational change and gender equality.

⁸ The blue water footprint is the volume of freshwater that evaporated from the global blue water resources (surface water and ground water) to produce goods and services consumed by the individual or community. The green water footprint is the volume of water evaporated from the global green water resources (rainwater stored in the soil as soil moisture). The grey water footprint is the volume of polluted water that is associated with the production of all goods and services for the individual or community.

The labour use ratio indicator, calculated by output, reflects labour requirements for a unit of physical output. The allocation of labour to production is higher for Sjenica cheese than for its non-PGI reference. At the farm level, it takes 4.622 hours of work to produce a ton of sheep milk when the reference product requires only 279 hours. The difference (1.555%) indicates that the PGI product, as more labour intensive, generates more jobs than the reference system. This is in relation to the fact that sheep milk production is less efficient than cow milk production. The relative difference is of the same order as for the process level since it takes 18.993 hours of work to prepare a ton of Sjenica cheese against 1.174 hours for the non-PGI Serbian cheese. The turnover-to-labour ratio indicator provides insight into labour productivity. The average turnover per employee is 85% lower in PDO farm than in non-PGI ones. Productivity levels are much higher at the processing level, but the relative difference between PGI-product and non-PGI one is of the same order as at the farm level. As already mentioned these differences are mostly driven due to the farms/firms' structure, the technical specification of the product and for a part to the geographical conditions.

Low or negligible bargaining power of actors in the different parts of the value chain is characteristic of sheep cheese production in Sjenica. For example, there is just one association of Sjenica cheese producers – “Sjenica cheese”, which was founded in 2011. This association incorporates small dairy factories, while the majority of households are not the part of any association or union, which could fortify their bargaining power or advocate for their interests. Clusters of cheese producers exist, but they are informal and rare. It seems that U3 or P1 levels of CS could be just price takers and are integrated into the most of the cases, so there cannot be any bargain between those two levels. On the other side, downstream level, especially wholesale distribution and retail poses more significant bargaining power in relation to the U3-P1. The situation of milk producers in the rest of the country is quite similar to individual milk producers atomised the same way as in the sheep farming. However, at the P1 level, the situation is significantly different, as 60% of total raw milk production in Serbia is oriented toward 123 active dairy factories. Some of them are large enterprises. For example, the largest one is processing up to the 21% of total raw milk production in Serbia (Lončar and Ristić 2011). If we compare the U3 level of FQS and its reference, it seems that bargaining power is infinitely larger in the reference case, since in the FQS is non-existent. On the other side, it can be expected that the P1 level can follow almost the same storyline.

The education attainment indicator, which refers to the highest level of education that an individual has completed, allows us to measure certain components of social capital indirectly. This indicator is close to 0 if the majority of workers have a primary education level and approaches one as the level of education increases. The level of education is slightly lower for Sjenica cheese producers compared to Serbian cheese conventional sector producers. The former has a majority of primary school degree (58-59%) while the latter reach a majority of secondary school degree (55-56%).

Evidence from generational change and gender equality spectrum may suggest two things. First, the sheep farming stage for the Sjenica Cheese is more sustainable than the one for the Counterpart Cheese, concerning the Generational Change indicator. Being larger than 100% suggests that the sheep farming stage employs more young workers than older ones. This may be instrumental to the transmission of knowledge necessary to keep or increase the levels of production of the PGI product. The same holds for the cheese processing stage concerning the same indicator. Second, looking at the Gender Inequality index, sheep farming for the reference cheese appears slightly more sustainable than the one for the Sjenica Cheese, due to a lower level of the indicator and, in turn, inequality in opportunities across genders. This result is driven by more equal percentages of secondary (and higher) education individuals – across

genders – being employed in sheep farming for the reference Cheese, than the Sjenica Cheese. Third, the values of the indicators are very consistent across the stages of the two supply chains. However, differences remain across products. This implies that the supply chain for the Sjenica Cheese could be deemed – as a whole – more sustainable than the one for the reference Cheese, at least based on the Generational Change indicator (which is the only one calculated for all the stages of the supply chains of both products)

At the end of this discussion, there are several elements identified in the previous analysis which could affect the sustainability of the production and sales of Sjenica sheep cheese in the future. The most significant ones are summarized in the form of SWOT analysis in Table 9 – which tells enough for itself and should need no further comments.

Table 9. SWOT analysis of the Sjenica sheep cheese

Strengths	Weaknesses
product authenticity	lack of associations or cooperatives – small bargaining power
high quality	inflexible packaging
methods of animal feed – grazing	unstandardized production
ecologically clean area of production	inability to export to EU countries without changing the manner of production
artisan (traditional) product	lack of the promotion
low price	low availability in markets
Opportunities	Threats
PGI label popularisation	the low number of sheep
rising consumers' interest for traditional products	inconsistent national agricultural policy
regional branding	competition of the established brands of cheese
export to non-EU countries	low level of education of the producers
better organisation of the packaging and delivery activities	non-compliance with regulations on foreign markets

3.2. Vegetal products

3.2.1. PGI Kastoria apple (Greece)

The outcome of the applied research on PGI Kastoria apple in comparison with the reference conventional apple of Agia is summarized in Figure 18. In particular, the economic aspects of the research reveal that the selling price and the operating margin of the PGI Kastoria apple is better than in the reference case. However, the reference case exported more apple volumes than the GEOK cooperative. This is being explained by the fact that the PGI Kastoria apple selling price in the domestic market is higher than the selling price of the conventional apple and thus, the cooperative (GEOK) strategically slightly oriented the apple distribution towards the domestic market rather than abroad.

As regards to the environmental aspects, the PGI Kastoria apple carbon footprint is lower than that of the conventional apple mainly because of the higher yields and the lower use of agrochemical inputs. Similarly, the food-miles (distance) of the PGI Kastoria apple are lower than in the reference case. The PGI Kastoria apple demonstrates lower grey and blue water footprint but higher green water footprint than the reference case (less is better). The higher results of the green footprint is explained by the higher evapotranspiration of the PGI Kastoria apple that is attributed to the higher yields compared to the reference apple.

The red area of the Figure 18 tertile presents the social indicators results of the PGI Kastoria apple in comparison with the reference conventional apple. Referring to the *generational change* indicator, the PGI Kastoria apple is more sustainable than the reference case since the workforce of the FQS is younger than the reference. The *turnover to labour ratio* is higher at the PGI case since it requires more working hours for the production of one ton apples and thus creates more jobs than the reference case. Lastly, the educational attainment results indicate that the employees of the PGI case are more educated than the reference case while the gender equality results are similar between the two cases.

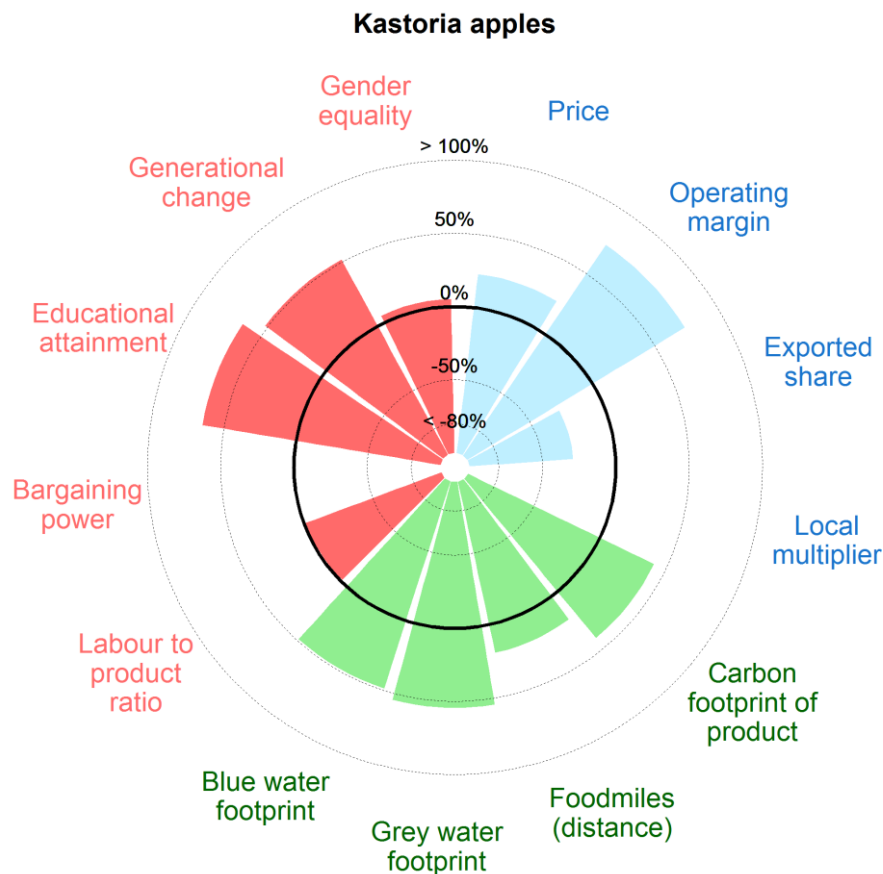


Figure 18. Sustainability diagram of PGI Kastoria apple

Overall, the PGI Kastoria apple results indicate that it is more sustainable than the reference case.

3.2.1.1. Price, margin and exports

The economic indicator analysis revealed that the price premium (100%) is identical at upstream level and processing level of the PGI Kastoria case. Profitability, in terms of GVA and GMO, is similar for PGI Kastoria apple and the reference product at upstream level. At the

processing level, the profitability of the FQS product is higher than that of the reference product, because of the significant weight of intermediate consumption for the production of the reference product. About a quarter of the production is exported, mainly outside Europe. Figure 19 demonstrates the results of the economic indicator variables between the PGI Kastoria apple and the reference conventional apple.

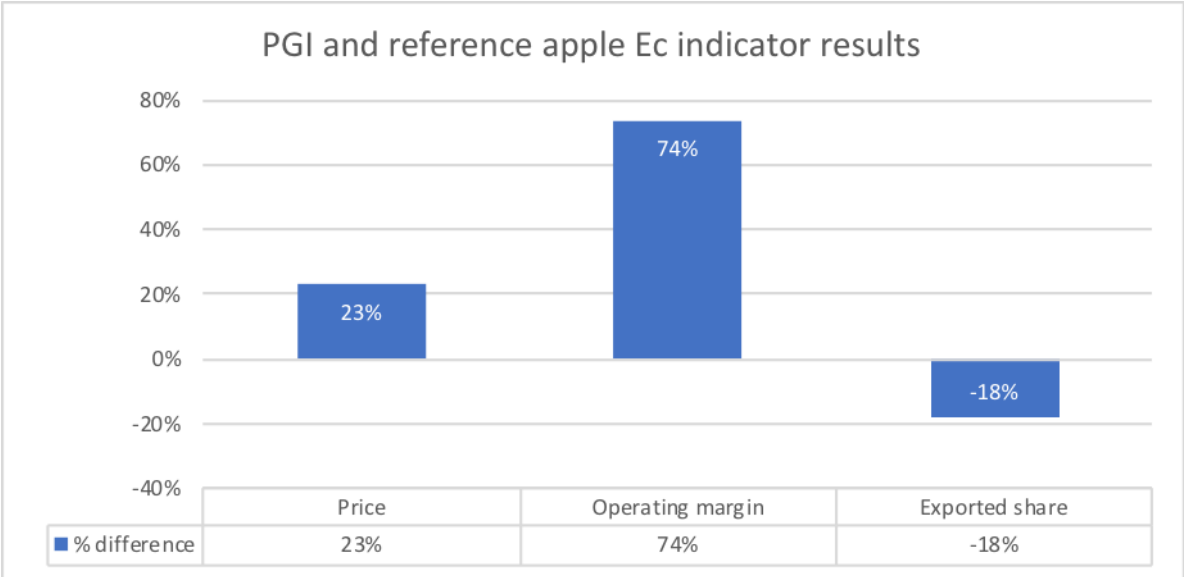


Figure 19. Economic indicators for PGI Kastoria apple and its reference

The results of the economic indicators indicates that the economic performance is in favour of the FQS apple compared to the reference case. However, the conventional apples are more exported mainly because of the lower selling apple price.

3.2.1.2. Environmental indicators results

Carbon footprint

The carbon footprints of the Kastoria apple and its reference, 100 and 177 kgCO₂e ton⁻¹ respectively, are within the literature range of 70-890 kgCO₂e ton⁻¹ (ADEME, 2017; Clune et al., 2017). Two main factors explain the 44% lower footprint of the PGI: lower use of fertilizers and higher yield. The higher yield is mainly attributable to better pedo-climatic conditions but the lower use of fertilizers is more related to the PGI, while the technical specifications do not mention fertilizers, FQS farmers all use a refined fertilization strategy based on measured leaf nitrogen content. This strategy has been so widely adopted because it is paid for by the local cooperative as part of the quality management of the PGI product.

Food-miles

Concerning food-miles, PGI Kastoria apple supply chain was compared to the conventional apples produced by the Kissavos cooperative in the Agia region. Over the entire supply chain, from crates (before the farm gate) to distribution units, there is a 20% difference in favour of the FQS. PGI Kastoria apples travel slightly shorter distances (1,900 vs 2,400 t.km t⁻¹) and releases slightly less emissions (130 vs 170 kg CO₂e t⁻¹) than the reference. Indeed, this difference can be explained by the shorter distance travelled by exported Kastoria apples, some of them – though a small share – being exported to neighbouring countries, while conventional apples are exported to more distant locations. Moreover, the FQS experiences lower emissions released per tonne of product exported due to a lower share of road transport. Exports affect the entire supply chain since they concern a large share (75%) of the total production. The distribution level, from conditioners to retailers, concentrates most of the kilometres embedded

in the product and most of the emissions generated for transport along the value chain (i.e. more than 98%). Regarding food-miles indicators, we can conclude that the PGI Kastoria apples are more sustainable than its reference in terms of distance travelled, as well as in terms of emissions released at the transport stage.

Water footprint

The green water footprint has the greatest share of the indicator. The highest value shown by the FQS cultivar in respect to REF depends on the different climatic conditions. Due to these conditions evapotranspiration is higher for FQS. This more than compensate for the difference in yield which is in favour of the FQS and would make its water footprint lower. The other two metrics represent a quite low fraction of the overall water footprint. The grey water footprint of REF doubles that of FQS. Input of mineral nitrogen seem to be the major driver for this value but this difference is also due to the lower yield of REF. LCA component of WF blue is higher for REF than FQS. The latter has lower inputs of mineral nutrients but it also uses manure, while REF doesn't.

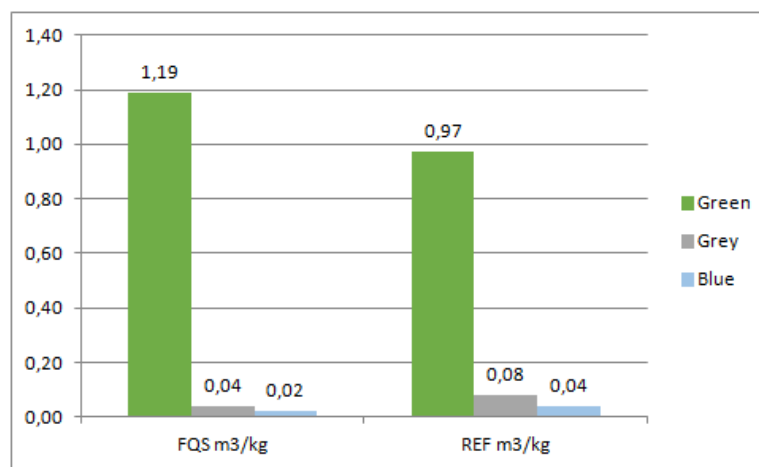


Figure 20. Water footprint of PGI Kastoria apple

3.2.1.3. Social indicators results

The social indicators analysis applied between the collected data of PGI Kastoria apple and the conventional apple of Agia. Following, the subchapter 6.3 is structured with the results of So1 and So3 indicators, 6.3.1 and the results of the So5 indicator results in 6.3.2. The So2 index could not be calculated for two reasons: a) the indicator, by construction, it is based on the assumption which considers levels in the supply chain are independent from each other. In both cases, Kastoria and Zagora, producers of the U3 level are also members of the coops (P1). Hence, the fundamental assumption of *independency* at the P1 level from the U3 level is not valid; b) Evolutions in the supply chain, and, therefore, its sustainability, mostly depend on the coops' internal strategy and organization. It then becomes very likely that calculations and interpretation of the results on the basis of available data shall be misleading.

Employment and social capital

The **labour use ratio indicator**, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope, 2001). At the farm level, it takes 214 hours to produce one ton of Kastoria apples when the reference product requires 184 hours. The difference (16%) indicates that the PDO product generates more jobs than the reference system. The **turnover-to-labour ratio indicator** provides an insight into labour productivity. The average turnover per employee is slightly less important in PDO farm than in non-PDO ones. The productivity levels are much higher at the processing level, with a relative difference of

168% in favour of the PDO-Kastoria apples. These results are mostly due to the farms/firms structure, the technical specification of the product and for a part to the geographical conditions.

The education level indicator is very low at farm level and a bit more in favour of the PDO sector. On farms producing apples in Kastoria, most workers have a primary (49%) or secondary (46%) level of education; on farms producing conventional apples, 80% of workers have a primary level. At the processing level, the education level indicator is higher and almost identical for PDO and non-PDO products, the small difference (6%) is due to 10% of employees which have at least a bachelor's degree.

Generational change and gender equity

Table 10. Generational change and gender equity for PGI Kastoria apple

Index	Kastoria Apple	Counterpart Apple
<i>U3 Stage – Apple Farming</i>		
Generational Change	250% ^a	200% ^a
Gender Inequality	0.60 ^b	0.62 ^b
<i>P1 Stage – Apple Processing</i>		
Generational Change	25%	14%
Gender Inequality	0.85	0.83 ^b
Supply Chain Average		
Generational Change	138%	107%
Gender Inequality	0.73	0.73

Notes to Table: ^avery high percentage due to data arising from a very small number of farmers interviewed (n=5). The calculated value may not reflect the industry condition faithfully; ^b indicator value calculated replacing 0 with 0.001

This evidence suggests that:

- The apple farming stage is the more sustainable of the two for both products, with Kastoria apple being more sustainable than the counterpart apple, according to the Generational Change indicator. It suggests that this stage of the supply chain of both products employs way many more young people than older ones. However, because the raw data were collected by means of direct interviews with a handful of apple farmers (7 or 8 in total), the large values of the indicator may have to be handled with care.
- Focusing on the Generational Change indicator, the Kastoria apple is more sustainable than the counterpart apple, also at the apple processing stage. However, absolute levels of sustainability are low, because the value of the indicator is low for both products. Nonetheless, this may have fairly limited implications, because of the few activities carried out at the processing stage on the fresh product.
- Looking at the Gender Inequality index, apple production – both GI and counterpart – appears largely unsustainable due to high levels of the indicator along the whole supply chain. The low level of female entrepreneurship along the supply chain and the low level of female secondary education achievements at all levels of the supply chains drive the actual value of the indicator.
- The supply chain of the Kastoria apple is more sustainable than the one for the Counterpart apple only in terms of the Generational Change indicator for the whole supply chain (average across the stages). No difference is recorded in terms of the Gender Inequality indicator. The sustainability of the supply chain of the Kastoria apple is high in terms of the supply-chain average Generational Change indicator but it is low in terms of the Gender Inequality one.

3.2.2. PGI Kaszubska strawberries (Poland)

In order to estimate sustainability of Kaszubska Strawberry, the specific methodology of Strength2Food (Bellassen et al., 2016) was applied. For the benchmarking purposes, the conventionally produced strawberry was used as the counterpart. It should be noticed that necessary data for S2F methodology were collected both from *primary sources* (conducted interviews with farmers and experts and calculations based upon available secondary sources) and from *secondary sources* (FADN, Polish Main Statistical Office).

Additionally we used secondary sources from FADN and Polish Main Statistical Office).

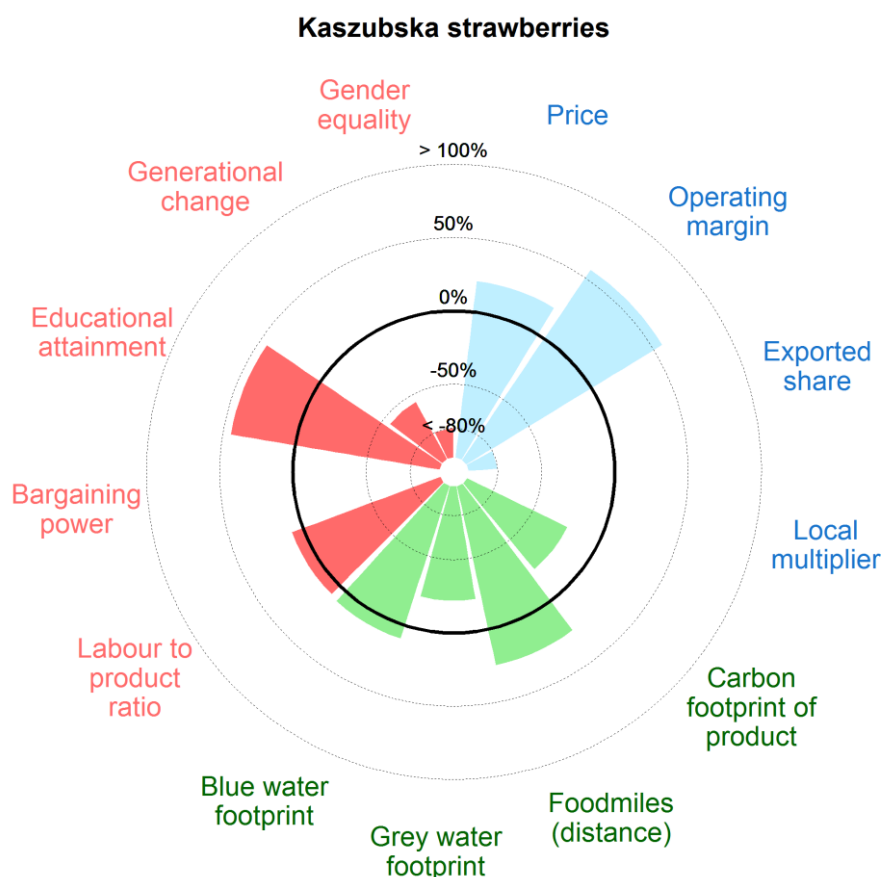


Figure 4. Sustainability performance of Kaszubska Strawberry

3.2.2.1. Economic sustainability

Table 11. Economic sustainability indicators

Short indicator name	Chain level	FQS	Reference	Difference % (FQS-REF)/REF*100%
Price	farm	1,06	0,88	20,5%
GVA	farm	84,5%	76,1%	11,1%
Net result	farm	21,1%	9,7%	117,5%
Export share		0	17,5%	-100,0%

Prices for Kaszubska strawberries are higher than the reference by 20,5%. However, as it was mentioned before in the chain description part, the reason of this difference cannot be attributed to PGI logo. , Due to later harvest than in other parts of Poland, the Kaszubska strawberry has

Strength2Food D5.1 – Assessment of the social, environmental and economic sustainability of FQS

a slightly better price than the price of conventional strawberries produced in the central part of Poland.

Profitability indicators are slightly better for Kaszubska strawberry. Regarding exports share, Kszubska strawberry, due to small quantity and demand on the local market, is mainly designated to the national sales. Exports' share in total production in case of reference is 8% but when we exclude the strawberries which go for processing, exports of fresh strawberries equals to 17,5% of production. About 60% of conventional strawberry travels to non-EU partners (Norway and Eastern Countries).

3.2.2.2. Environmental sustainability

Carbon footprint

The carbon footprint of Kaszubska strawberries is 14% higher than the reference (122 vs 107 tCO₂e ton of strawberry-1). The difference in per hectare emissions is in favour of the FQS, mainly due to the lower amount of fuel use for crop operations, but the higher yield of reference strawberries (8.9 vs 11 tons ha⁻¹) offsets this benefit. The comparison with the literature is challenging as the carbon footprint of raspberries has never been investigated to our knowledge. Our estimates are at the lower end of the 0.1-1.2 tCO₂e ton⁻¹ range reported by Warner et al. (2010). Indeed, Warner et al. (2010) finds that pesticides, plastic use for greenhouses and bags and peat use substantially weight on the carbon footprint of UK strawberries whereas they are neglected in our estimate: no fumigation is necessary so pesticide use is much lower, and peat, greenhouses and crop bags are not used.

Table 12. Carbon Footprint indicators

Indicator name	Chain level	FQS	Reference	Difference % (FQS-REF)/REF*100%
Carbon footprint of land use	farm	1086,9	1182,8	-8,1%
Carbon footprint of product	farm	121,8	107,1	13,7%
Carbon footprint of product	All, including transport			

Food Miles and emissions from transport

Table 13. Food miles indicators

Chain Level	Short indicator name	FQS	REF	Difference % (FQS-REF)/REF*100%
U3-P1	distance travelled per tonne of product (km)	3,56	11,60	-69,31%
	emissions per tonne of product (kg CO ₂ eq) CFT	1,00	3,28	-69,47%
	emissions per tonne of product (kg CO ₂ eq) interviews	1,24	3,15	-60,54%
U3-D1	distance travelled per tonne of product (km)	101,81	60,00	69,68%
	emissions per tonne of product (kg CO ₂ eq) CFT	28,80	16,98	69,63%
	emissions per tonne of product (kg CO ₂ eq) interviews	19,20	14,67	30,86%
P1-D1 (exports)	distance travelled per tonne of product (km)	0,00	511,00	-100,00%
	emissions per tonne of product (kg CO ₂ eq) CFT	0,00	51,26	-100,00%
	emissions per tonne of product (kg CO ₂ eq) interviews	0,00	13,63	-100,00%
U3-D2	distance travelled per tonne of product (km)	30,23	44,50	-32,06%
	emissions per tonne of product (kg CO ₂ eq) CFT	8,55	12,59	-32,12%
	emissions per tonne of product (kg CO ₂ eq) interviews	13,59	7,96	70,70%
P1-D2	distance travelled per tonne of product (km)	71,20	162,00	-56,05%
	emissions per tonne of product (kg CO ₂ eq) CFT	7,14	16,25	-56,03%

	emissions per tonne of product (kg CO2 eq) interviews	6,98	7,92	-11,94%
D1-D2	distance travelled per tonne of product (km)	50,90	66,00	-22,87%
	emissions per tonne of product (kg CO2 eq) CFT	14,42	18,66	-22,71%
	emissions per tonne of product (kg CO2 eq) interviews	9,34	6,92	34,97%
Domestic market only	distance travelled per tonne of product (km)	254,14	332,50	-23,57%
	emissions per tonne of product (kg CO2 eq) CFT	58,92	64,48	-8,63%
	emissions per tonne of product (kg CO2 eq) interviews	49,11	37,48	31,04%
Domestic + export markets	distance travelled per tonne of product (km)	254,14	843,50	-69,87%
	emissions per tonne of product (kg CO2 eq) CFT	58,92	115,74	-49,09%
	emissions per tonne of product (kg CO2 eq) interviews	49,11	51,11	-3,91%
Value chain	distance travelled per tonne of product (km)	257,70	855,10	-69,86%
	emissions per tonne of product (kg CO2 eq) CFT	59,92	119,02	-49,66%
	emissions per tonne of product (kg CO2 eq) interviews	50,35	54,26	-7,20%

Concerning foodmiles, Kaszubska Strawberry supply chain was compared to the conventional strawberry chain in Poland. Over the entire supply chain, from farms producing strawberries to distribution (U3-D2), Kaszubska strawberries travel distances 3 times shorter (260 vs 850 t.km t⁻¹) and generates 50% less emissions (60 vs 120 kg CO2 eq) than conventional strawberry. The FQS travels shorter distances on the domestic market, and is not exported, contrary to the reference that sells 17.5% of its production abroad. As a result, distances traveled by the FQS are clearly shorter, as well as the emissions generated that are clearly lower. The distribution level concentrates most of the kilometers embedded in the product and most of the emissions generated for transport along the value chain (i.e. more than 97%). Regarding foodmiles indicators, we can conclude that Kaszubska strawberries are more sustainable than its reference in terms of distance traveled (-70%), and in terms of emissions released at the transport stage (-50%).

Grey, blue and green water footprint

Table 14. Green, grey and blue water footprint indicators

Indicator name	Chain level	FQS	Reference	Difference % (FQS-REF)/REF*100%
Green WF	all	0,429	0,349	23,0%
Blue WF	all	0,029	0,032	-8,5%
Grey WF	all	0,072	0,059	21,5%
Total Water footprint	all	0,530	0,440	20,5%

As for the green water footprint the factors that can be responsible for the observed difference between FQS and REF are meteorological conditions and yield. Crop parameter do not vary between FQS and REF whereas meteorological conditions changed because the closest meteorological station to the areas of production are different (Hel for FQS and Torun for REF). Despite this difference the major driver of this difference is yield. The 11 ton/ha of the REF make its water footprint per unit product lesser than that of FQS, whose yield is 8.92. Multiplying the ratio between FQS and REF yield by the green water footprint of FQS renders the green water footprint of REF.

Blue water footprint on the contrary is higher for REF. This outcome is determined by the different amount of water that is employed to irrigate REF strawberries, which exceeds that

used in FQS products. It has to be noted that also the so called overheads contribute to the blue fraction at the farm level. Such overheads account for the hidden water, that is water used in the production processes of goods and services that make agricultural production possible. Such hidden water is computed by the LCA procedure, that sole method by which one can account for such impacts in water resources in terms of consumption. Fuel, pesticides and fertilizers production, water, fertilizers and pesticide distribution are the processes evaluated through LCA (coherently with the type of input data provided in the case study) for impacts in terms of water consumed. The overhead are higher for FQS and since agricultural inputs are higher in REF than FQS, this result is due to higher yield of REF. Thus the contribution to blue water footprint associated to irrigation (e.g. water directly used on strawberries) is more than enough to compensate for the higher blue water footprint computed through LCA and, overall, REF shows a higher blue water footprint.

The **grey water footprint** is higher for FQS. The amount of nitrogen applied (both through organic and mineral fertilization) is almost the same for the two products and, once again the driver of this outcome is the difference in yield.

Interesting is comparing FQS and REF with the average water footprint for the same products at the national level (Poland). National average values have been extracted for the database of the Water Footprint Network. The green and blue water footprint are higher for the average production of strawberries in Poland but the grey water footprint is higher for REF and FQS. This suggest that FQS (and REF too) should improve its impact on water resources if the level of nitrogen applied as fertilizer is made comparable with that of the average national production.

3.2.2.3. Social sustainability

Labour productivity and educational attainment

The **labour use ratio indicator**, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope, 2001). The allocation of labour to production is a bit higher for Kashubian strawberries compare to the same conventional product. The difference (8,5%) indicates that the PGI product generates more jobs than the conventional system, but is more labour intensive, due to lower yields per hectare. The **profit-to-labour ratio indicator** provides an insight into labour productivity. The average turnover per employee is 10% higher in PGI farm than in non-PGI ones. These differences are mostly due to a bit higher prices of Kashubian Strawberries comparing to counterpart due to delayed harvest (about two weeks after the peak season in the other part of Poland).

Both Putnam (2000) and Halpern (1999) identified education as key to the creation of social capital and greater educational achievement as an important outcome. The **education attainment indicator**, which refers to the highest level of education that an individual has completed, allows us to indirectly measure certain components of social capital. This indicator is close to 0 if the majority of workers have a primary education level and approaches 1 as the level of education increases. The education attainment indicator is higher for PGI-strawberries. The level of education is dominated by initial secondary (50%) and short tertiary (30%) education.

Table 15. Labour productivity and educational attainment indicators

Short indicator name	Chain level	FQS	Reference	difference (FQS-REF)/REF*100%
Labour to product ratio	farm	0,166	0,153	8,5%
Profit to labour ratio	farm	6 400,95	5 805,77	10,3%
Educational attainment	farm	0,65	0,45	44,4%

Wage level	farm	4 587,90	4 203,50	9,1%
------------	------	----------	----------	------

Generational Change Index and Gender Inequality Index in Employment

Generational Change Index: percentage ratio between the number of employees in the 15-35 age bracket and the number of employees in the 45-65 age range. A high value of the indicator (actually, a value greater than 100%) suggests that the stage of the Supply Chain considered employs more young workers than older ones. Beside indicating a higher probability of survival of the Supply Chain of the product considered in the economy, it could also indicate that the activities carried out at the stage of the Supply Chain considered could require (innovative and unique) skills and knowledge more abundant in young employees than in older ones

Gender Inequality Index in Employment: it expresses the extent of the difference in the male and female achievements in the labour market in stage of the Supply Chain considered. The higher the number, the more unequal the opportunities are for male and female participants in the labour market of the stage of the Supply Chain considered. The larger the Index, the larger the loss in (human) development potential characterising the stage of the Supply Chain considered

Table 16. Generational Change and Gender Inequality indicators

Short indicator name	Chain level	FQS	REF	Difference% (FQS-REF)/REF*100%
Generational Change	farm	133,33%	300%	-55,6%
Gender Inequality	farm	0,89	0,11	709,1%

Note to Table: ^a indicator value calculated replacing 0 with 0.001

This evidence may suggest that:

At the farm stage the Conventional Strawberry appears to be more sustainable than the Kaszubska Strawberry, because the Generational Change indicator is larger in the former than in the latter. However, because the Generational Change indicator for the farm stage of both products is higher than 100%, both products could be well performing due to a high employment level of 15-35-year-old compared to 45-65-year-old.

Based on the Gender Inequality indicator, the social sustainability of Kaszubska Strawberry seems highly endangered because of the high value of the indicator, mainly due to the extreme levels of inequality in the ownership of farms which is exclusive domain of males.

Bargaining power distribution

The indicator on bargaining power distribution cannot be calculated because, for its most part, the Kaszubska strawberry supply chain is a short supply chain, counting only one level, as the volumes' lion share is being directly sold to retailers, and only a small share is being sold through intermediaries or being processed.

3.2.3. PGI Thung Kula Rong-Hai Hom Mali rice (Thailand)

The impacts of geographical indication certification of Khao Hom Mali Thung Kula Rong-hai can be explained in three dimensions, namely economic, environmental, and social impacts. This study compares the certified Thai GI or EU PGI Khao Hom Mali Thung Kula Rong-Hai with the reference, non-certified Khao Hom Mali Thung Kula Rong-Hai, the same rice produced in the same geographical area, but not certified either under internal control system (for Thai GI) nor the external control system (for EU PGI). The share of certified product was less than 0.01% of all Hom Mali rice produced in Thung Kula Rong-Hai area. The results show

that GI Khao Hom Mali Thung Kula Rong-hai provided better impacts on environment. The GI Khao Hom Mali Thung Kula Rong-hai generally gave a better economic impact than the reference. Nevertheless, because presently there was no export of certified GI Khao Hom Mali Thung Kula Rong-hai to any parts of the world, the economic impact from contribution to export is much less than Khao Hom Mali Thung Kula Rong-hai, one of the important export commodity of the country. Overall, the social impacts of GI Khao Hom Mali Thung Kula Rong-hai were also positive compared to non-certified Khao Hom Mali Thung Kula Rong-hai except for generational change of workers (Figure 21).

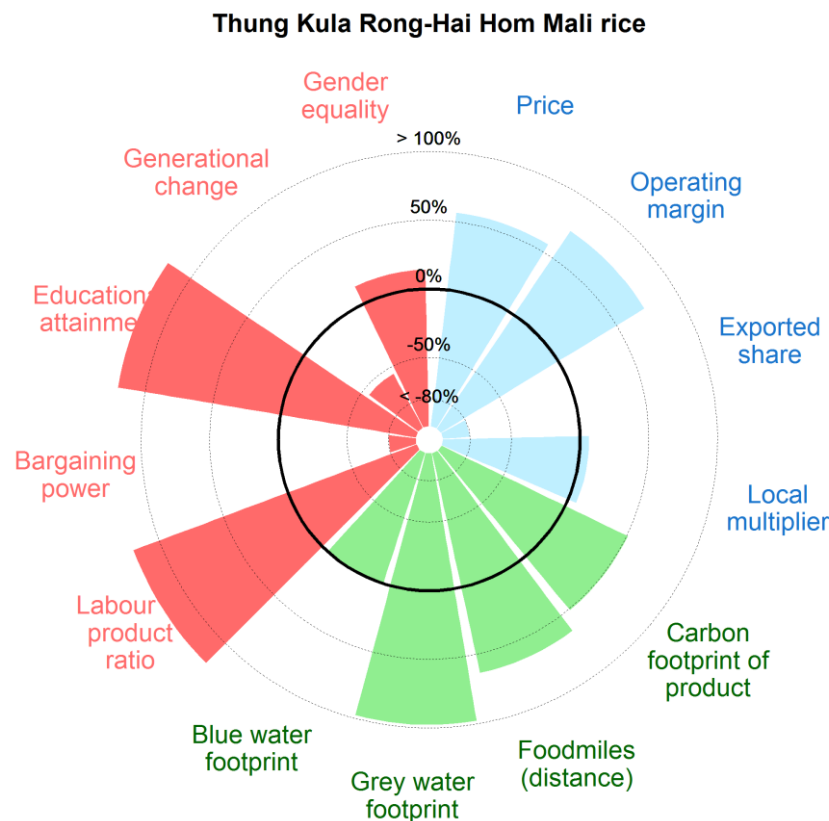


Figure 21. Sustainability diagram of certified GI Khao Hom Mali Thung Kula Rong-hai

3.2.3.1. Economic impact of certified GI Khao Hom Mali Thung Kula Rong-hai

The *price premium* was significant for all the levels of GI value chain, increasing from farmers (19%) to millers (61%) and then to retail level (90%). Concerning profitability, at farm level costs were quite similar in absolute term, but as certified GI benefited a higher price, its profitability was significantly higher in relative and absolute terms. The subsidies for organic production, which represented an important share (more than 90%) of GI production, increased this difference. At processing level, costs were higher for certified GI than for reference, but in relative terms, they represent a similar share of turnover, and GI is finally slightly more profitable at P1 level.

Concerning exports, certified GI Khao Hom Mali Thung Kula Rong-hai rice was consumed exclusively in domestic market, while 17% of non-certified one was exported, to Europe and to the rest of the world. Export volume are quite variable, as rice market faced recently several crisis and disequilibrium, and as rice is a key issues in the strategy of Thailand for both its food security and for its role in agricultural trade. Prior to 2007, Thailand was the only exporter of

Hom Mali rice to the world market, where there were two emerging competitors, namely Vietnam and Cambodia in Jasmine-type rice market since then. As rice is a thin market and depending on several factors i.e. production risks such as drought, flood, and export market competition, the export was fluctuated.

The *local multiplier effect* of certified GI Khao Hom Mali Thung Kula Rong-hai was slightly higher than its reference product: each THB of turnover for TRK rice generated 1.47 THB of responding in the same region versus 1.32 THB for the reference. The main driver of these outcomes was the location of the rice farms: for both types of rice, all the farms were located within the local area. The sensitivity analysis showed that without local rice farms, the re-spent by suppliers in local area would reduce of -48% for the TRK rice and -41% for the non-certified GI Khao Hom Mali Thung Kula Rong-hai. The second main driver was the local re-spending of farms: without local suppliers, the local multiplier would reduce by -21% for the certified GI Khao Hom Mali Thung Kula Rong-hai, and -15% for the conventional one.

3.2.3.2. Social impact of certified GI Khao Hom Mali Thung Kula Rong-hai

The *education attainment indicator*, which refers to the highest level of education that an individual has completed, allows us to indirectly measure certain components of social capital. This indicator is close to 0 if the majority of workers have a primary education level and approaches 1 as the level of education increases. The education attainment indicator is higher for the certified GI Khao Hom Mali Thung Kula Rong-hai at the farm level. The difference was 350% and was attributable to the fact that 40% of farmers had a short tertiary. These group of certified farmers are generally more advanced farmers. The difference was much less clear at processing level since many of the certified millers also produce non-certified products given the same technology and labour requirements for milling process.

The *labour use ratio*, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope, 2001). The allocation of labour to production is higher for Thailand's certified GI Khao Hom Mali Thung Kula Rong-hai than for its non-certified reference. At the farm level, it took 304 hours of work to produce a ton of rice when the reference product required only 27 hours. The difference (1026%) indicated that the certified GI products generated more jobs than the reference system. As more than 90% of certified GI products was also certified organic and the rest must be certified GAP (good agricultural practice). Labour use for organic rice was generally higher. For example, hand harvesting was still found for certified GI farming, and because organic farming did not use chemicals, weeding also took more work hours.

The relative difference was slightly less important at the process level since it took 1 hour of work to prepare a ton of certified GI rice, but 4 hours for the non-certified GI rice from TKR. Milling required labour more than just operating the machines. After the paddy was delivered, it had to be weighted, tested for quality, dried and stored. The milling was not done immediately, and normally at the time of order year round. The largest certified GI rice miller was one of the best quality producers (its products won a national award for quality *Hom Mali* too), and perhaps more efficient as the certified millers also held Good Manufacturing Practice (GMP) standards and required less labour.

The *turnover-to-labour ratio indicator* provided an insight into labour productivity. The average turnover per employee was lower for certified GI farmers than for non-certified GI ones (-89%). But at the processing level, the productivity level were much higher with a relative difference of 533% in favour of the certified GI rice. These differences are mostly due to the farming practice (organic vs non-organic), milling technology and milling standards (certified GMP vs non-certified GMP).

Generational change

Thailand is experiencing a labour shortage and aging society in the agricultural sector. Generational Change indicator of both supply chains at the farm level was very small, suggesting that this may be deemed seriously endangered in its social sustainability prospects due to the very limited employment of young workers compared to older ones. The non-certified GI rice is slightly more sustainable than the certified GI rice, according to this indicator. This could be because certified rice GI required more experienced and skilled farmers, thus, farming of certified products generally employed older farmers than the non-certified farmers. The non-certified GI rice was much more sustainable than the certified GI rice, because the value of the Generational Change indicator for the former is more than three times the one for the latter product.

Gender Inequality

On the contrary, both supply chains was characterised by some of the highest levels of social sustainability attainable according to the Gender Inequality indicator. In fact, at the farm stage of both supply chains there is almost complete equality in the opportunities granted to male and female employees and entrepreneurs. However, the non-certified GI rice has a slightly higher social sustainability, compared to the certified GI rice.

The rice processing stage of both supply chains is characterised by opposite levels of sustainability, as assessed by both the Generational Change and the Gender Inequality indicators.

While the non-certified GI rice featured a perfect equality of opportunities across genders at the farming stage, it appears characterised by extreme levels of gender inequality at the rice processing stage. In turn, this implies that the certified GI rice is more socially sustainable than the counterpart one, according to the Gender Inequality indicator. This higher level of sustainability is brought about by more similar percentages of completion of secondary education across genders and female entrepreneurship at the processing stage of the certified GI rice, compared to the counterpart one.

3.2.3.3. Environmental impacts

The carbon footprint (excluding transport) of GI rice is 51% lower than its reference (180 and 366 kgCO₂e/ton of processed rice respectively, excluding transport-related emissions). The bulk of the difference is explained by the absence of mineral fertilization in GI rice. This is related to the fact that most GI producers also have an organic or “good agricultural practices” certifications. The higher yield obtained by GI producers – possibly due to better soils and higher farming skill – reinforces the benefit from the absence of mineral fertilization. Both products are much lower than the literature range – 0.66 to 5.69 tCO₂e/ton (Clune et al., 2017; Odegard et al., 2015) because both are rain-fed whereas the literature focuses on the more common flooded rice which generates substantial methane emissions.

Regarding the *food-miles*, the certified GI Khao Hom Mali Thung Kula Rong-hai supply chain (dominated by organic product) was compared to the non-certified GI rice, from rice seeds production to milled rice retail markets. Over the entire supply chain, certified GI rice travels 65% shorter distances (1,100 vs 3,000 t.km t⁻¹) and releases 10% less emissions (135 vs 145 kg CO₂e t⁻¹) than conventional rice. This difference is mainly driven by exports. Indeed, certified GI rice is not exported, while 17% of the conventional production is sold abroad. This drives distances and emissions up for the reference product. The shorter distances travelled by the non-certified rice at the processing level (from production farms to processors) and on the domestic

market have not allowed to fully offset the longer distances travelled by exported non-certified GI rice. Similar trends explain the differential in emissions generated by transportation.

However, the benefits of shorter distances for the certified GI Khao Hom Mali Thung Kula Rong-hai was partly offset by the use of more carbon intensive transportation modes on the regional market and at the processing level, namely light vehicles, compared to less carbon intensive modes for exports of conventional rice, namely sea transport and heavy goods vehicles. The distribution level, from processors to retailers, concentrates most of the distance embedded in the product and most of the emissions generated for transportation along the value chain (i.e. more than 75%). Certified GI Khao Hom Mali Thung Kula Rong-hai is more sustainable than its reference in terms of distance travelled (-65%) and in terms of emissions released at the transportation stage (-10%).

The green water footprint has the greatest share of the total water footprint. Different yield and different final product ratio were responsible for the lower green water footprint of certified GI Khao Hom Mali Thung Kula Rong-hai in comparison with non-certified product. The green water footprint of certified GI product was 4.26 m³/kg while that of uncertified product was 5.56 m³/kg. Certified GI Khao Hom Mali Thung Kula Rong-hai production showed a higher yield (2.81 ton/ha for certified GI and 2.31 ton/ha for non-certified GI) and a better final product ratio (0.45 for certified GI and 0.42 for non certified GI). It is noted that the blue fraction of the water footprint in the case of Khao Hom Mali Thung Kula Rong-hai (certified and non-certified) that pertain the production of paddy was only that associated to the overheads, that is water consumed to make production of rice possible (e.g. water spent to produce diesel and for spreading manure). In both cases, the rice production is rainfed; thus, no irrigation was applied unlike most cases that consistent part of the agricultural blue water footprint came from irrigation

As for the grey water footprint, although yield and final product ratio are still at work to make the indicator different between certified and no-certified products, the bulk of the difference lies in the amount of nitrogen applied to certified and non-certified GI rice. The former was assumed to use only organic nitrogen (as majority of them were certified organic) although in higher amount in respect to non-certified GI rice. This latter however needs also mineral nitrogen in an amount that is one order of magnitude higher than the amount of organic nitrogen.

For certified GI rice, both the blue and the grey water footprint were negligible in comparison with the green water footprint. In the case of non-certified GI rice, the grey water footprint became more important and not negligible. Overall the non- certified GI rice production consumed more water than the counterpart, as shown by the overall value of the water footprint.

3.2.4. PGI Doi Chaang coffee (Thailand)

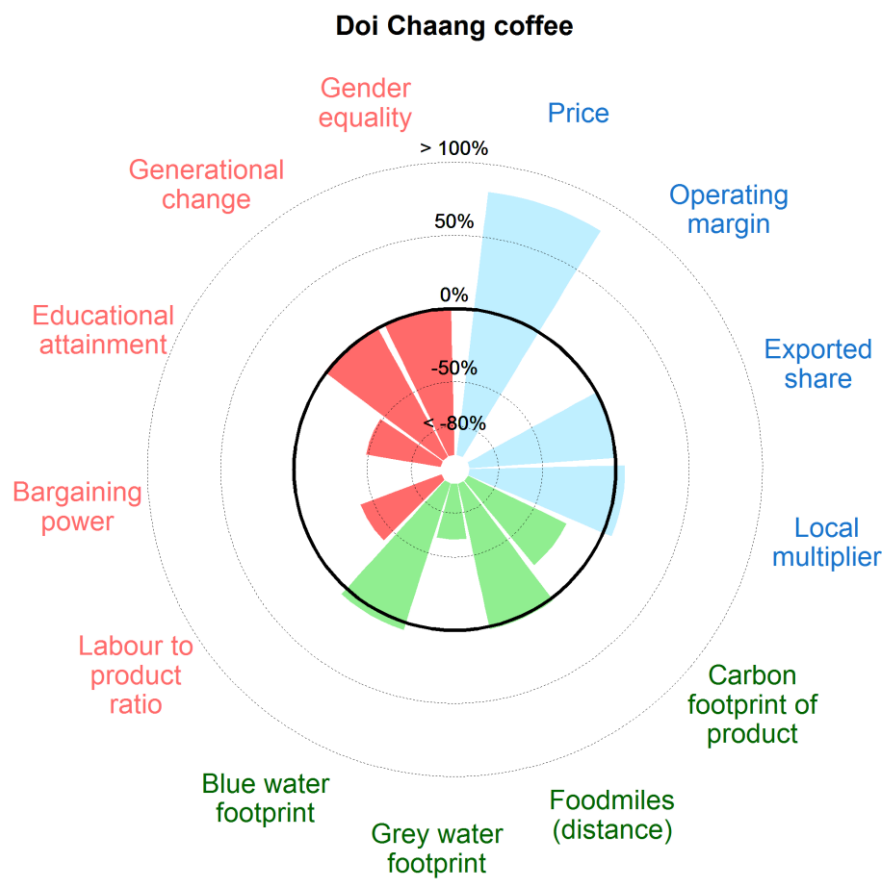


Figure 22. Sustainability diagram of PGI Doi Chaang coffee

3.2.4.1. Economic issues

Price

At the farming stage, coffee growers receive the selling price at 20-22 baht per kg of coffee cherries. At the processing stage, the selling price of single original roasted bean coffee is 1000 baht/1 kg. This selling price at processing stage depends on the distribution channels since the manufacturer provides some discounts for particular channel. The market share is mainly contributed by individual café followed by the franchise, HORECA, and retail with the average profit margin of 50%. At the downstream stage, the average selling price of roasted bean coffee is 1,100 baht/kg with the average profit margin of 30-60%, depending on the distribution channel. The price premium of PGI coffee at each stage is as follows:

U level = 10%

P level = 150%

D level = 83%

Along the chain value, the price premium is inverted U-shaped, with a low value at upstream level (10%) and a very high value at processing level (150%).

The gross operating margin (GOM) could not be estimated. The data on the cost of intermediate consumption were not revealed with expert interview at both U-level and P-level. At U-level, most coffee growers cannot provide inputs, services and energy in the monetary value. At P-

level, the manufacturer was not willing to reveal the cost of services and energy used in the production.

Local multiplier

The local multiplier effect of PGI Doi Chaang Coffee is 6.3% higher than its reference product: each euro of turnover for Doi Chaang Coffee generates 1.54 € of responding in the same region versus 1.39 € for the reference. The main driver of these outcomes is the location of the coffee cherries suppliers, i.e. coffee farmers: in both cases, PGI and non-PGI, farms are all located within the local area with a high share of responding at local level (greater than or equal to 70%). Indeed, without local cherries suppliers, the local multiplier would reduce of -50% for both the PGI and non-PGI product. If we assume, a null local responding for second tier suppliers the local multiplier would reduce of -19% for the Doi Chaang Coffee and -17% for the non-PGI product.

3.2.4.2. Social issues

Employment (Labour to product ratio)

The **labour use ratio indicator**, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope, 2001). The allocation of labour to production is lower for Doi Chaang coffee than for its non-PGI reference. At the farm level, it takes 440 hours of work to produce a tonne of Doi Chaang coffee cherries when the reference product requires 540 hours. The difference (-19%) indicates that the PGI product generates less jobs than the reference system. The difference is even greater at the processing level since it takes 202 hours of work to prepare a tonne of PGI-coffee against 563 hours for the non-PGI coffee. The **turnover-to-labour ratio indicator** provides an insight into labour productivity. The average turnover per employee is 35% greater in PGI farm than in non-PGI ones. Productivity levels are much higher at the processing level with an advantage for PGI coffees. These differences are mostly due to the better farm managements and experience of coffee growers for PGI farms compared with non-PGI farms, as well as the close relationship among coffee growers and the processing level in PGI products. Moreover, the geographical conditions for PGI farms (i.e. road, infrastructure) are more developed than that for non-PGI.

Bargaining Power

According to the monography, the same actor (i.e. Kafae Doi Chaang) controls most of the supply chain and apply a strategy of vertical integration. This means that the main structure operates at both the U3 and P1 level. As, by construction, the So2 indicator assumes that different levels of a SC are operated by different structures, this would then mean that, in this case, the calculation of bargaining power distribution would lead to misleading conclusions.

Educational attainment

The education attainment indicator is slightly lower for PGI-coffee. The level of education is dominated by initial primary (60%) and secondary (35%) education. At the processing level, the educational attainment level indicator is still much lower for PGI-coffee compared to non-PGI regional coffee.

Generational Change Index

Percentage ratio between the number of employees in the 15-35 age bracket and the number of employees in the 45-65 age range. A high value of the indicator (actually, a value greater than 100%) suggests that the stage of the Supply Chain considered employs more young workers than older ones. Beside indicating a higher probability of survival of the Supply Chain of the product considered in the economy, it could also indicate that the activities carried out at the stage of the Supply Chain considered could require (innovative and unique) skills and knowledge more abundant in young employees than in older ones

Gender Inequality Index in Employment

It expresses the extent of the difference in the male and female achievements in the labour market in stage of the Supply Chain considered. The higher the number, the more unequal the opportunities are for male and female participants in the labour market of the stage of the Supply Chain considered. The larger the Index, the larger the loss in (human) development potential characterizing the stage of the Supply Chain considered.

3.2.4.3. Environmental issues

Carbon footprint

The carbon footprint (excluding transport) of the PGI coffee is 26% higher than its reference (7.6 vs 6.1 tCO₂e ton⁻¹ of ground coffee). The bulk of this difference is due to higher yields for the reference coffee, although the higher use of fertilizers for the PGI coffee also plays a role. Because of lower yields and higher fertilizer use, these values are at the higher end of the literature range (perimeter restricted to the farming and processing stages) despite the efficient aerobic wastewater treatment: 7-8 tCO₂e ton⁻¹ of coffee parchment in Kenya where yields are almost twice higher (Maina et al., 2016), 1.68 tCO₂e ton⁻¹ of green coffee in Costa Rica (Killian et al., 2013) where yields may reach 9 ton of coffee cherries per hectare (Noponen et al., 2012).

Food miles

Concerning food-miles, PGI Doi Chaang roasted coffee bean supply chain was compared to the conventional roasted coffee beans produced in Doi Phahee in Chiang Rai province. Over the entire supply chain, from coffee cherry producers to distribution units, PGI coffee performs slightly better (-2%) than conventional coffee regarding the distances travelled and much better (-62%) as regards the emissions released at the transport stage. PGI coffee travels slightly shorter distances (1,700 vs 1,730 t.km t⁻¹) and releases much less emissions (180 vs 500 kg CO₂e t⁻¹) than the reference product. The larger emissions embedded in the conventional product can be explained by the larger emissions released per tonne of product on the domestic market since the conventional chain uses a more carbon intensive transport mode, light goods vehicles, while the FQS chain uses heavy goods vehicles. The logistics of the domestic market impacts the whole retail level since there is no export. The distribution level, from processors to retailers, concentrates most of the kilometres embedded in the product and most of the emissions generated for transport along the value chain (i.e. more than 88%). Regarding food-miles indicators, we can conclude that the PGI Doi Chaang coffee is more sustainable than its reference in terms of distance travelled (-2%), as well as in terms of emissions released (-62%) at the transport stage.

Water footprint

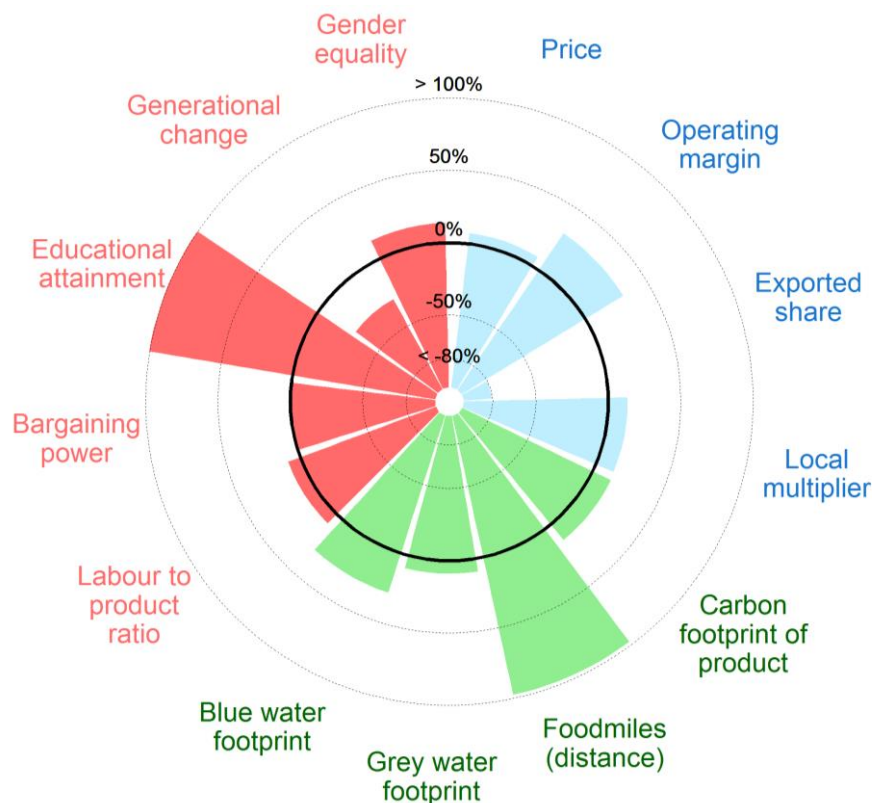
The main conclusion is that FQS shows a higher overall footprint than the REF product, and this conclusion holds for every specific fraction (green, grey, blue) of the indicator. The exception is the processing phase, for which FQS has a better performance than REF, although, as said, this fraction has a negligible share of the indicator.

To compute the indicator we used specific information for yield, nutrient, irrigation but same values were used for FQS and REF concerning meteorological data, crop parameters, soil features. Some of this information was provided by the case study conductor some was collected from already compiled default data set (e.g. CLIMWAT for wind speed, Allen et al. 1998 for some crop parameters). Due to this data set the main causes that explain the difference in water footprint are yield and final product ratio. The REF production shows a greater yield than the FQS (2.5 and 1.8 respectively) and this increases the latter's water footprint. However the final product ratio shows that FQS is a more efficient production as it produces 0,136 tons of coffee from 1 ton of cherries (0.128 for REF). This difference does not compensate

completely the effect that the different yield has over the indicator, which remains higher for FQS. Coffee that is grown in the region is not irrigated, thus both FQS and REF have $WF_{blue} = 0$ in the agricultural phase. Thus the WF_{blue} consists only in what deduced from the LCA procedure and concerns the overheads. This fraction concerns water that is consumed to produce and distribute pesticides, to produce and spread fertilizers. The REF production performs better in this respect as it shows no pesticide application and, accordingly, the production and distribution of these substances affects only the water footprint (blue fraction) of the FQS. The grey water footprint, which quantifies water request to dilute pollutants, still is higher for FQS. This outcome is explained by the higher amount of mineral fertilizers that are applied to the FQS product. There's no impact linked to tap water production and distribution because manufacturers uses water taken directly from mountain springs.

3.2.5. PGI Buon Ma Thuot coffee (Vietnam)

Figure 23. Sustainability performance⁹ of PGI Buon Ma Thuot coffee (supply chain averages)



The reference product in Buon Ma Thuot coffee case study is defined as Non-PGI coffee from Dak Lak province of Vietnam. In general, PGI Buon Ma Thuot coffee value chain slightly better performs than the reference chain, especially the food-miles and educational attainment.

3.2.5.1. Economic issues

Price Premium at fishing, processing, and distributing levels

For price premium, there is no clear difference between PGI and Non-PGI chains. The 7% higher price of PGI products is mostly driven by the higher price at processing levels. At processing level, the price of output is the price of roasted coffee and ground coffee. The higher

⁹ Each indicator is expressed as the difference between the FQS and its reference product. For environmental indicators for which lower is better, the opposite of the difference is displayed (eg. +20% when the carbon footprint is 20% lower).

price of PGI coffee is driven by the end-user orientation of PGI coffee while the market orientation of the reference products is wholesaler. At farming stage, there is no difference in the price at U3 level. The fact is that the differential between PGI and Non-PGI green coffee beans is 100-300VND per kg of commercial PGI coffee. Thus, the driver of high price premium is the specific value chain organisations itself instead of the technical specification of PGI.

Profitability and Value Distribution

For profitability and value distribution, the larger operating margin is mostly driven by the difference at downstream level. This is due to lower rent cost in Dak Lak than Ho Chi Minh city, rather than the technical specification of PGI. At farm level, the higher operating margin of PGI coffee farmers due to higher subsidies. PGI coffee farmers are usually trained by PGI-certificated cooperatives or processors with subsidies such as financial supports, technical training, fertilizers, farm tools while Non-PGI farmers have fewer subsidies. At processing level, the higher operating margin of PGI coffee processors due to lower marketing cost. It is driven by the smaller scale of PGI coffee processors than the Non-PGI. It stems from the fact that PGI coffee lack of commercial promotion and marketing activities and large-scale marketing campaigns on mass media, especially on international market thus the customer awareness of PGI Buon Ma Thuot coffee is still very low.

International trade

For international trade, the lower exported share is driven by the fact that PGI product is only for domestic market in crop year 2016-2017 while 25% of Non-PGI product is sold on European market and 33% on extra European market.

Local multiplier

The local multiplier effect of PGI Buon Ma Thuot Coffee is 13.3% higher than its reference product: each euro of turnover for Buon Ma Thuot Coffee generates 1.30 € of re-spending in the same region versus 1.03 € for the reference. The main driver of these outcomes is the location of the unsorted green coffee beans suppliers, i.e. coffee farmers: in both cases, PGI and non-PGI, farms are all located within the local area with a high share of re-spending at local level (100% in both cases). Indeed, without local coffee beans suppliers, the local multiplier would reduce of -22% for the PGI coffee and -18% for the non-PGI product. The second main driver is the local payroll: in both cases without local workers local multiplier would reduce of -11%. The higher local multiplier effect is driven by the higher share of the turnover spent for local core input suppliers (coffee farmers) and the higher share of the turnover spent for local non-core input suppliers of PGI coffee processors. The first driver directly stems from the technical specifications since PGI Robusta coffee have to be grown inside the territory while 13% of conventional Robusta coffee was purchased outside the province. The second one is mostly driven by the difference in marketing costs which provided by non-local suppliers. The PGI marketing cost depends on the scale of PGI processors which are usually smaller than Non-PGI coffee processors and the driver, thus, stems from the scale of enterprise itself instead of the technical specifications.

3.2.5.2. Environmental issues

Carbon footprint

For carbon footprint, the carbon footprint of the PGI coffee is 19% lower than its reference (2.1 vs 2.6 tCO₂e ton⁻¹ of ground coffee). Most of the difference comes from the lower use of mineral fertilizers in the PGI which is largely due to farmers belonging to PGI-associated cooperatives. These cooperatives provide advice on optimizing fertilization and substituting mineral fertilizers with organic ones. This effect is reinforced by lower electricity use to roast the coffee in the PGI, explained by the larger and more modern facilities than the reference.

These differences between PGI and Non-PGI chains, however, are not directly and clearly from the PGI technical specifications. Both values are comparable to the 2.43 tCO₂e ton⁻¹ of packaged roasted coffee reported by Killian et al. (2013), using the same 0.75 kg roasted coffee per kg green coffee ratio as in Buon Ma Thuot coffee.

Food miles

Concerning food-miles, PGI supply chain was compared to the conventional coffee chain in Dak Lak province, Vietnam. Over the entire supply chain, from green coffee beans to ground coffee, PGI ground and roasted coffee beans travel distances 40 times shorter (210 vs 8,400 t.km t⁻¹) and releases almost three times less emissions (90 vs 250 kg CO₂e t⁻¹) than the Non-PGI product. The distribution level concentrates most of the kilometres embedded in the product and most of the emissions generated along the value chain (i.e. 90%) for both the PGI and Non-PGI products. The longer distance embedded in the Non-PGI coffee is explained by the longer distance travelled by exported ground coffee and, to a smaller extent by the longer distance travelled on the domestic market. Distances for exports significantly impact the results as 56% of the Non-PGI production is exported. Similarly, the higher emissions embedded in the Non-PGI product can be explained by the emissions resulting from exports. On the domestic market, PGI ground coffee travels distances four times shorter (200 vs 770 t.km t⁻¹) and emits 30% less emissions (90 vs 125 kg CO₂e t⁻¹) than Non-PGI coffee. The lower food-miles is due to three drivers. Firstly, the PGI green coffee beans are not exported to the foreign markets in crop year 2016 – 2017 as the promotion activities Geographical Indication and Buon Ma Thuot brand is not strong and effective enough although enterprises have introduced, advertised and exported about 17,000 tons of PGI coffee beans after registering PGI. Secondly, PGI coffee travels distances shorter than Non-PGI coffee as the coffee shops or their own retail shops are mostly located in Dak Lak province. However, PGI retailers use light goods vehicles which are more carbon intensive than the heavy goods vehicles used for the reference product as the small amount of the coffee for each trip. Thirdly, there is no distance and no emission involved for the Non-PGI, while the PGI travels 13.5 km at the roasting stage owing to the difference in the supply chain organization itself: the PGI coffee processors and the PGI coffee roasters are separate actors whereas the Non-PGI coffee processors and Non-PGI coffee roasters are usually combined in one entity.

Water footprint

In overall, Non-PGI coffee requires more water than PGI coffee. The green water footprint has the greatest share of the overall footprint for both PGI and Non-PGI, and the former requires a little more water to compensate for the evapotranspiration processes. There is no clear difference between the green fraction of the indicator due to the similar yield that characterizes the two productions (2.6 t/ha PGI; 2.58 t/ha Non-PGI) and the similar final product ratio (0.74 PGI and 0.75 Non-PGI). The grey water footprint, according to the most recent developments and recognized approaches in the literature, was computed using the amount of nitrogen fertilizers (both organic and mineral). Non-PGI production employs 327.9 Kg/ha of nitrogen whereas PGI makes use of a slightly lower amount: 294.9 Kg/ha. This higher nitrogen input makes Non-PGI impact on water quality higher, a difference that reflects in its higher grey water footprint. In terms of blue water footprint, the higher value shown by the Non-PGI production is due to the higher amount of water added as irrigation water (1,350 m³/ha Non-PGI; 1,223 m³/ha PGI). Also, the agricultural blue water footprint depends on water used to produce the various inputs to the system, such as fertilizers (production of), fuel (production of) for farming operations, electricity consumption. The higher amount of P and N mineral fertilizers that are employed in Non-PGI production is mostly responsible for the higher blue water footprint value referring to the overheads, that is water needed to produce these substances used for production. What is mostly responsible for the final outcome is the different

amount of inputs, that make PGI production less demanding in terms of water requested. Thus, the difference in water footprint is mostly driven by the fact that PGI coffee farmers are encouraged to use more organic fertilizer and pesticide while less inorganic ones which have higher nitrogen component.

3.2.5.3. Social issues

Employment

For labour requirements, the higher labour to product ratio is mostly driven by the fact that more labour is required by PGI coffee farmers than Non-PGI coffee, especially in harvesting and hand-weeding. While this driver stems from the technical specifications, the higher labour/production ratio of PGI processor is explained by smaller business scale of themselves. For labour productivity, there is no clear difference in the turnover to labour ratio between PGI and Non-PGI coffee. This is mostly driven by the higher price of PGI than Non-PGI. Thus, PGI coffee has a similar labour productivity with Non-PGI in spite of its higher labour requirement.

Educational Attainment

For educational attainment, the higher level of education is mostly driven by the differences at the farming stages. PGI farmers are usually households who are more aware of environmental and social effects than Non-PGI farmers, some PGI farmers hold key positions in their communities such as the director of cooperative, the head of supervisory board of cooperative, the president of the commune... They usually have a higher secondary education degree. At processing level, direct labours in both supply chains have lower educational attainment than indirect labour but most of the labours of coffee processors are skilled labours, some firms even require all their labour to have a secondary school degree or higher.

Bargaining power distribution

For bargaining power equality, there is no clear difference between PGI and Non-PGI products. Bargaining power is very evenly distributed along the PGI supply chain, even though the processing levels of the PGI supply chain are slightly advantaged over the farm level. This advantage is mainly due to the fact that processors are much fewer than farmers, although farmers also take advantage of the level of specificity of their production. Besides, all levels of the PGI achieve high average scores, thus giving evidence that bargaining power positions are robust along the FQS supply chain. On the Non-PGI side, bargaining power is very evenly distributed along the supply chain. There is however a slight advantage of processing levels over upstream levels, thanks to the fact that they are much fewer than coffee beans farmers. Finally, a comparison of the bargaining power distribution indicators between the PGI and the Non-PGI indicates that bargaining power is almost as evenly distributed in the GI as in the Non-PGI supply chain (ratio FQS/ref = +/-1). This would indicate that the PGI would not benefit from any sustainability advantage over the Non-PGI.

Generational Change and Gender Equality

For age balance, both products appear faring well in their sustainability prospects due to a high employment level of 15-35-year-old, compared to 45-65-year-old. At processing level in both supply chains, there are few workers over 45 years old, some enterprises even have no employees over 45 as direct labours in coffee plants require the strength and the stamina of young labour. Most of direct labours are young while indirect labours may be over 45 years old. However, Non-PGI Coffee appears to be more sustainable than PGI Coffee. What drives the difference is higher employment level of 15-35-year-old of PGI green processors because PGI green processors need more experienced employees which is largely due to their focusing more on export markets rather than domestic markets.

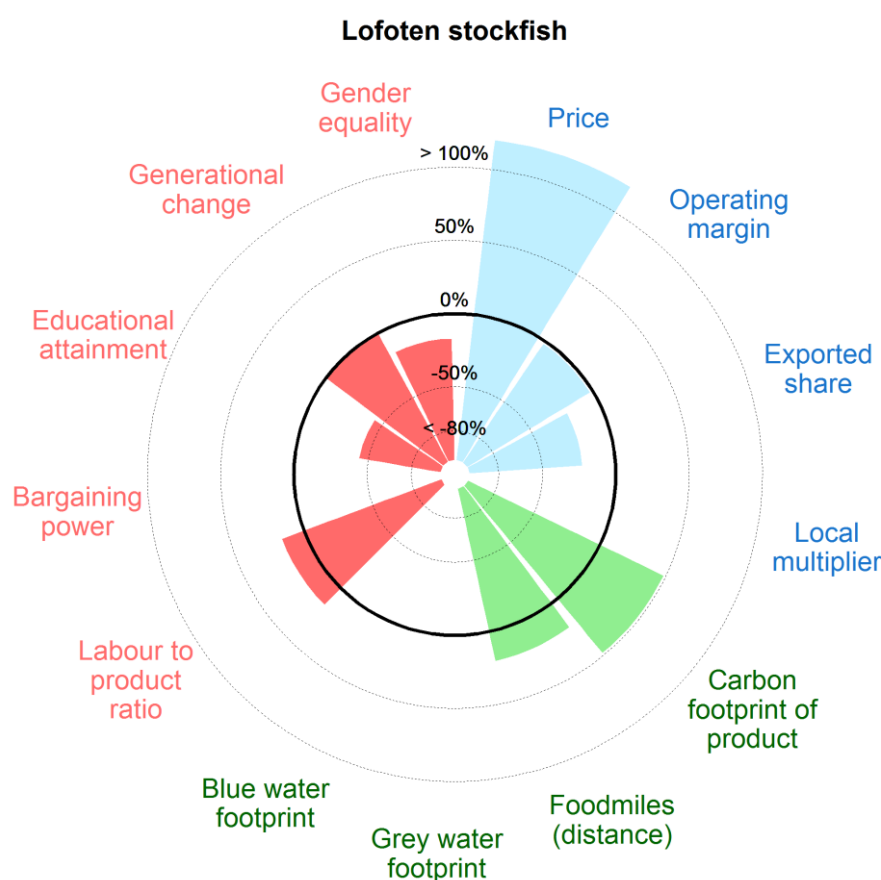
For gender balance, the higher gender equality is mostly driven by the difference at processing stage. Most of owners of Non-PGI processing firms are males. At other levels, the gender equality is relatively similar between PGI and Non-PGI.

3.3. Unfed seafood and fish

3.3.1. PGI Lofoten stockfish (Norway)

Several indicators have been collected and merged to give a precise overview of the economic, social, and environmental sustainability aspects of the PGI stockfish from Lofoten. The value chain of stockfish from Lofoten has been compared with the value chain for clipfish along several indicators based on the three named dimensions of sustainability, which are summarized in the following diagram (Figure 24).

Figure 24. Sustainability diagram for the PGI stockfish from Lofoten



3.3.1.1. Economic sustainability

Price and margin

With regard to price, which can be considered as the main economic indicator, the PGI Lofoten Stockfish received a price premium. Compared to clipfish, it has a premium of 288% at processing and 88% at retail level. However there is no significant difference considering the fishers level, mainly because of regulations which are such that fishermen are secured a minimum price regardless of fish destination. Profitability is therefore also similar for fishers in both case, as costs are alike. At processing level, the relative gross added value are slightly higher for PGI (10% of the turnover) compared to reference product (9%). But in absolute

Strength2Food D5.1 – Assessment of the social, environmental and economic sustainability of FQS

terms, higher costs (wages and intermediate consumption) for PGI are compensated by the price premium.

Export

Both products, the PGI Lofoten Stockfish and the reference clipfish, are mainly exported, even if the national market represents a higher share for PGI (12%) compared to the reference product (less than 1% of the volume is sold in Norway). While exports shares of clipfish are almost fairly distributed between Europe and non-European countries, 72% of the PGI Lofoten Stockfish are sold in Europe. Italy is the main traditional destination for stockfish, where in some of the regions it has been part of the gastronomy heritage for a long time. However, the PGI label is not commonly used in the Italian market at retail level. Both the PGI and the reference get higher prices in Europe than in other export destinations, as the ratio exported value/exported volume is above 1 for European countries and below 1 for other destination.

3.3.1.2. Environmental sustainability indicators

Carbon footprint

The carbon footprint of the PGI is 48% lower than its reference – 0.68 and 1.31 tCO_{2e} ton edible (rehydrated) fish⁻¹ respectively. The PGI fishermen use 33% less fuel to capture the fish because of the shorter distance to the fishing area. The technical specifications request that they fish “around Lofoten and Vesterålen”. Moreover, thanks to the shorter fishing distance, they do not refrigerate the fish, neither on board nor when landed, whereas for the reference product, we estimate that half the fish is cooled on boats. This results in additional 0.31 tCO_{2e} ton edible (rehydrated) fish⁻¹ from the production of refrigerant liquid for the reference. Sun and wind drying of the PGI does not improve substantially its carbon footprint as drying is only a minor component of the footprint and because the Norwegian electricity mix is dominated by hydropower. Both values are close to the carbon footprint obtained by Winther et al. (2009) for Norwegian clipfish (2.06 tCO_{2e} ton edible (rehydrated) fish⁻¹ without transport but with all fish refrigerated).

Food-miles

Concerning food-miles, the PGI Lofoten stockfish supply chain was compared to the Norwegian clipfish chain from processing to distribution units. Over the entire supply chain, the FQS performs 20% better than its reference as regards distances travelled, but 35% worse as regards emissions released at the transportation stage. PGI stockfish travels shorter distances (7,000 vs 9,000 t.km t⁻¹) but releases more emissions (650 vs 470 kg CO_{2e} t⁻¹) than clipfish. This difference is entirely driven by export destinations (Europe vs outside Europe), and by the transportation mode used for exports (road vs sea transport). The rather long distances and large emissions embedded in both value chains can be explained by the large share of exports (85% for the FQS vs 99% for its reference). Export request long distances due to the fringe location of Norway, and export to European countries relies for a large part on carbon intensive transportation modes (road). The fringe location combined with the importance of road transport on the domestic and international markets reinforce the large CO₂ emissions allocated to the FQS. Regarding food-miles indicators, we can conclude that PGI Lofoten stockfish is more sustainable than clipfish in terms of distance travelled but less sustainable in terms of emissions released at the transportation stage.

3.3.1.3. Social sustainability indicators

Labour

The “labour use ratio indicator”, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope, 2001). In our case the allocation of labour to production is lower for Lofoten stockfish than for its non-PGI reference (Clipfish from

Norway). At the fishermen level, it takes 10 hours of work to harvest a ton of fish when the reference product requires 36 hours. This difference might be explained by at least two factors: First, the ratio builds on numbers of vessels, on the one hand in Lofoten and on the other hand in Norway. Secondly, the season for “skrei” (the specific winter cod used in the PGI product) is limited to four months a year, due to the perfect fishing conditions where huge amounts of “skrei” is cached. The short fishing season might also explain the clear difference (-73%) between the PGI and the reference system when we see at numbers of jobs generated. The relative difference is not at the advantage of PGI-product at the process level since it takes 90 hours of work to prepare a ton of fish against 44 hours for the non-PGI product.

The “*turnover-to-labour ratio indicator*” provides an insight into labour productivity. The average turnover per employee is 261% higher in the PGI sector than in non-PGI ones. Productivity levels are much higher at the processing level but the relative difference between the PGI Lofoten Stockfish-product and the non-PGI one is smaller than on “harvest” level. These differences are mostly due to the “farms/fishermen” structure, material and tools, as Lofoten fishing vessels on average have more sustainable fishing practices than fishing vessels in general.

Education

The level of education for the PGI product is lower compared to what is observed for the reference sectors. The majority of employees in the PGI sector (60%) have only a primary level of education compared to the employees of the reference sector who have a secondary level (54%). Here again we have to remind that we used here numbers of process workers, on the one hand for the stockfish from Lofoten and on the other hand generally in Norway, and that the winter cod fishery dedicated to the PGI product is seasonal, including season workers.

Bargaining power

The *bargaining power* is for the benefit of the upstream levels for both the PGI Lofoten Stockfish and the reference product clipfish. This is due to the fact that the fishermen coop holds a regulatory power over the price of fish. By way of contrast, the supply chain for the reference sees a much more balanced distribution of bargaining power, which is due to the existence less specific resources and the absence of any dominant actor at the considered level.

Without considering the impact of the monopoly position held by the fishermen coop, individual bargaining power scores obtained at each level of the FQS supply chain indicate that each level holds strong bargaining power position: the weakest score is 0,62 for the U3 level of fishermen and the highest score is 0,93 for the P1 level of processing. This indicates that a breach in the monopoly and regulatory position of the fishermen coop would significantly benefit to processors. By way of contrast, the bargaining power scores obtained by individual levels of the reference supply chain are much weaker, thus indicating that decreases in the bargaining power of the dominant level (P1) would not significantly affect the bargaining power distribution of the supply chain

Finally, a comparison of the bargaining power distribution scores of the FQS and of the reference supply chain indicates a clear advantage of the FQS over the reference. Indeed, BP is much more evenly distributed in the FQS than in the reference supply chain (ratio FQS/ref <<1).

Generational Change Index

The whole supply chain of the Lofoten Stockfish is, on average, slightly more sustainable than the one of the Counterpart Clipfish, based on the generational change indicator. This is due to the very high value of the generational change indicator for the processing level of the Lofoten Stockfish supply chain, driving the average result for the supply chain(s). The processing stage

(P1) of the production of dried and salted fish, whether the one for the Lofoten stockfish or the Clipfish, is more sustainable than the fishing stage (U3) with respect to the generational change indicator. Moreover, the fishing stage of the supply chain for the counterpart dried and salted fish is more sustainable than the one for the Lofoten Stockfish. On the contrary, the processing stage of supply chain of the Lofoten Stockfish employs roughly as many young people as older ones. This is positive with respect to the transmission of knowledge from the older to the younger generations of how to prepare the Lofoten Stockfish, more than for the Counterpart product. In fact, the values of the indicator are higher at the processing stage of both supply chains, than at the fishing one.

Gender Inequality Index in Employment

Regarding the Gender Inequality indicator, the fishing stage of both the Lofoten Stockfish and of the clipfish, respectively, are characterised by high levels of Gender Inequality. Although the fishing stage (U3) of the Lofoten Stockfish supply chain is slightly more sustainable than the fishing stage of the clipfish supply chains, differences are almost negligible. The high values of gender inequality arise from the very limited female share in the workforce and in entrepreneurs. This may be largely due to fisheries traditional has been dominated by men, thus, a cultural barrier against women to enter these professions (as it is physically demanding activities to be a boat crewmember or owner, as for example heavy lifting).

The processing stage of the supply chain of the Lofoten Stockfish is also marked by a very high value of the Gender Inequality indicator, largely due to the absence of female entrepreneurs. The processing stage (P1) of the supply chain of dried and salted clipfish seems to provide more entrepreneurial opportunities to females, generating a much lower value of the Gender Inequality indicator. This result may have to be interpreted with care considering that the indicator has been calculated assuming that the level of female entrepreneurship in leading positions in the clipfish supply chain is equal to the one in the fishing and aquaculture industry as a whole (18% of females in leading positions) . On average, the supply chain of the Lofoten Stockfish is much more socially unsustainable than the one of the counterpart Clipfish, according to the Gender Inequality indicator.

4. ORGANIC PRODUCTS

4.1. Animal products

4.1.1. Organic fresh pork meat (Germany)

Sustainability assessment of organic pork meat in Germany was implemented through the specific methodology of Strength2Food (Bellassen et al., 2016). The key indicators of the performances are depicted in Figure 25.

Some of the indicators were elaborated by using values coming from the whole German organic sector, since sectorial (pork meat production) values were not available.

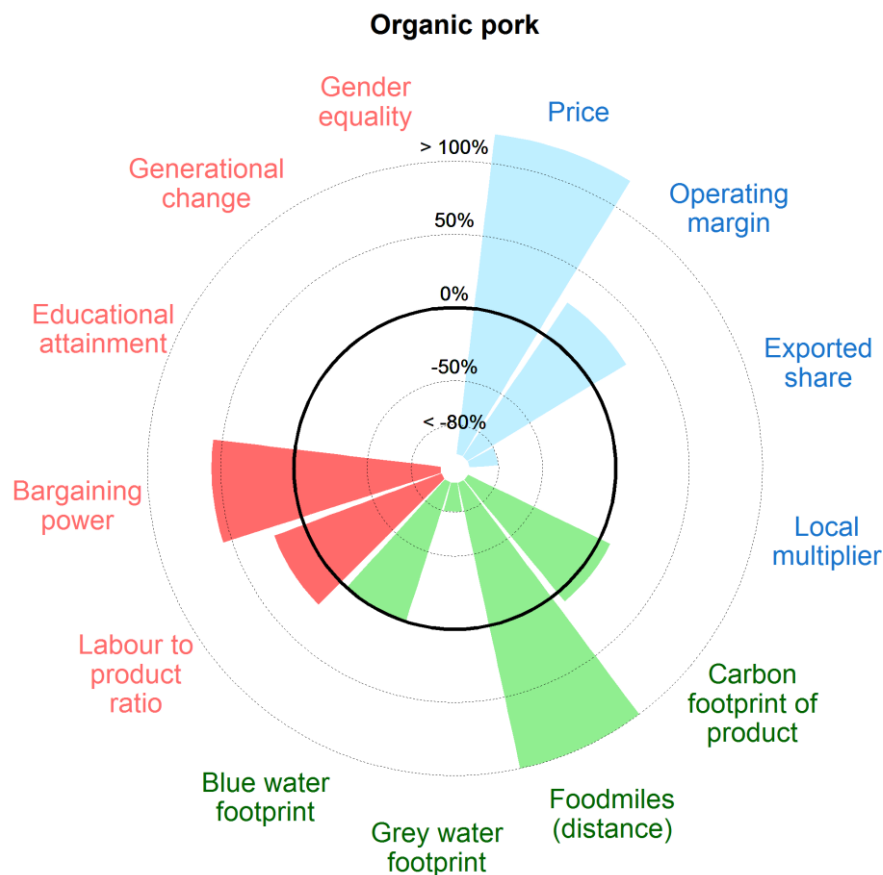


Figure 25. Sustainability performance¹⁰ of German organic pork (supply chain averages)

4.1.1.1. Economic indicators

Regarding economic indicators, the assessment revealed a significant price premium between organic and conventional pork at all level of the supply chain, and that reaches almost 100% according to the Strength to food calculation. The study also shows that the operating margin at farm level is 27% higher in the organic sector than in the conventional sector, but this result should be nuanced as it only takes into account costs of wages of employed workers and not the cost of all workers. To that respect, FADN data show a better productivity of work by animal in the conventional sector than in the organic.

4.1.1.2. Social indicators

As we just said, the organic system is more intensive in work per animal. The labour use ratio indicator, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope, 2001). The allocation of labour to production is higher for organic pork than for its non-organic reference (conventional pig farms in Germany). At the farm level, it takes 39 hours of work to produce a ton of pigs when the reference product requires only 32 hours. The difference (22%) indicates that the organic product generates more jobs than the reference system. The turnover-to-labour ratio indicator provides an insight into labour productivity. The average turnover per annual work unit is 131% higher in organic pig systems than in conventional ones. This difference is mainly due to the difference in price between

¹⁰ Each indicator is expressed as the difference between the FQS and its reference product. For environmental indicators for which lower is better, the opposite of the difference is displayed (eg. +20% when the carbon footprint is 20% lower).

organic and conventional pork. This estimation of turnover to labour ratio was obtained by making the assumptions that all pig farms were specialized in pig production (in both conventional and organic). In reality, less organic pig farms are specialized than in conventional, which may affect the turnover to labour ratio difference. Our data unfortunately were not sufficient to test and fully quantify this assumption.

The indicators on educational attainment, generational change and gender equality are not available for this case study. Indeed, specific statistics on work in the organic pork farms are not available in Germany. Furthermore, experts were not able to make assumptions on such invariables. A sample of companies in the processing industry (P1 and P2 levels) was contacted, but were not able to provide us with estimations on the differences between the organic and the conventional sector, the two being handled by the same operators in many cases.

The assessment indicates that bargaining power is evenly distributed among levels for both the FQS and the reference, even though one can witness a small advantage of the organic chain over the conventional one. This small advantage is mostly due to the fact that the organic supply chain is better organized, benefitting from the existence of a professional union at the farm level. However, both supply chains are characterized by an advantage of processors over farmers. This difference is essentially due to the fact that the leading processor companies concentrate a significant share in the market, in both organic and conventional chains.

4.1.1.3. Environmental indicators

So as to the environmental dimension of sustainability, according to the Strength to Food methodology, the carbon footprint (excluding transport) of organic pork is 8% higher than its conventional reference (3.7 vs 4 tCO₂e ton⁻¹ pork meat). These values are in the lower range of the literature which ranges from 2.1 to 11.9 tCO₂e ton⁻¹ pork meat (Clune et al., 2017; Meier et al., 2015). The small net difference between organic and conventional pork results from two balancing differences. On the one hand, the carbon footprint of organic feed is twice lower per ton of dry matter, thanks for the absence of mineral fertilizer and the use of waste fishmeal. On the other hand, total intake is 40% higher, and emissions from enteric fermentation and manure management are also substantially higher, because fattening pigs live longer and are more active, and because of the lower pigs/sows ratio. A similar tradeoff is also reported by Kool et al. (2009) and by Basset-Mens and van der Werf (2005): both studies report a lower carbon footprint per ton of feed for the organic chain although the carbon footprint of feed as a category is almost the same between organic and conventional as organic pigs require more feed per ton of final product. The difference in performance between organic and conventional is within the literature range of -11% to 73% (Kool et al., 2009; Meier et al., 2015). It is lower than the 35% found by Kool et al. (2009) for Germany, despite many similarities in input data for three main reasons: 31% of the diet of organic pigs comes from straw and fishmeal which are assumed to be waste and have no carbon footprint. If instead we assume that fishmeal is fished for the sole purpose of feeding pigs, then the carbon footprint of organic pork becomes 20% higher than its reference. The second reason is that Kool et al. (2009) uses the IPCC Tier 1 approach to estimate N₂O emissions from fertilizer use which results on average in 30% higher estimates (Carlson et al., 2016). Finally, Kool et al. (2009) uses lower pigs/sows ratio of 6.6 (organic) to 7.3 (conventional) which increases the weight of sows emissions per ton of meat and consequently increases the feed/meat ratio.

Concerning food-miles, organic pork supply chain was compared to the conventional pork chain in Germany. We only have available data regarding exports. There is a significant difference between the FQS and its reference. Indeed, exports of organic pork meat is considered as negligible since offer is much higher than domestic demand, while 52% of the

German conventional pork meat production is exported. On average, the FQS travels 0 t.km t^{-1} while its reference travels $6,500 \text{ t.km t}^{-1}$ for exports, and $3,500 \text{ t.km t}^{-1}$ at the distribution level, from processors to wholesalers, assuming 0 t.km t^{-1} distance for products distributed nationally. The FQS releases much less emissions ($0 \text{ vs } 110 \text{ kg CO}_2\text{e t}^{-1}$) than the reference. The higher emissions embedded in the reference can be explained by the emissions resulting from exports. We can conclude from the sustainability diagram (Figure 25) that the organic pork is more sustainable than its reference in terms of distance travelled (-100%) and carbon emissions related to the transport stage (-100%).

The Water footprints of the organic and conventional pork chains at farm level were also investigated. The FQS product shows higher green and grey water footprints but lower blue water footprint than the conventional product.

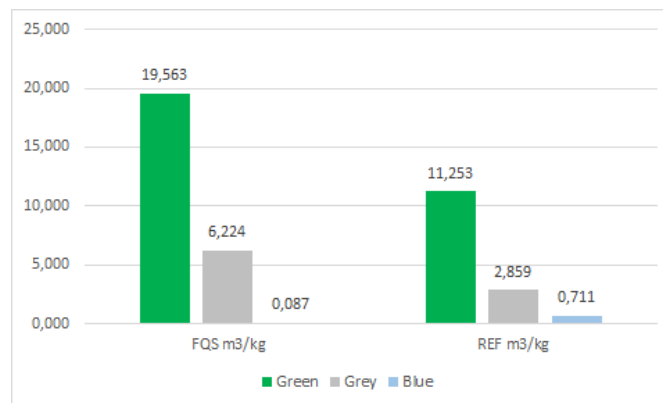


Figure 26. Water footprint of organic pork per ton of product

The difference in the green water footprint depends on different factors. Some crops that enter the diet composition of both products show higher yield in the REF production system than in FQS (e.g. Wheat, Rapeseed). Since water footprint is a per unit product indicator, yield affects its value in a way that the higher yield the lower the indicator. Also the different composition of the various items in the animal diet matters, as different proportion of crops possessing different green water footprint contribute together with the difference in yield to make green water footprint higher for FQS.

The grey water footprint considers the impact of nitrogen based fertilizers, and the higher value shown by FQS depends on the amount of fertilizers used but also on the yield of the crops. For example, the amount of nitrogen applied to wheat is the same for the two productions and the difference in the grey water footprint for this item is due to the different yields that characterize wheat in the two production systems.

The blue water footprint is higher for REF. Water used to grow crops is used in higher on not locally grown items, such as sugarcane molasses, soy cake and soy oil. The greatest share of the agricultural blue water footprint is for blue LCA water footprint. This quota is one order of magnitude higher for the REF for the locally grown crops.

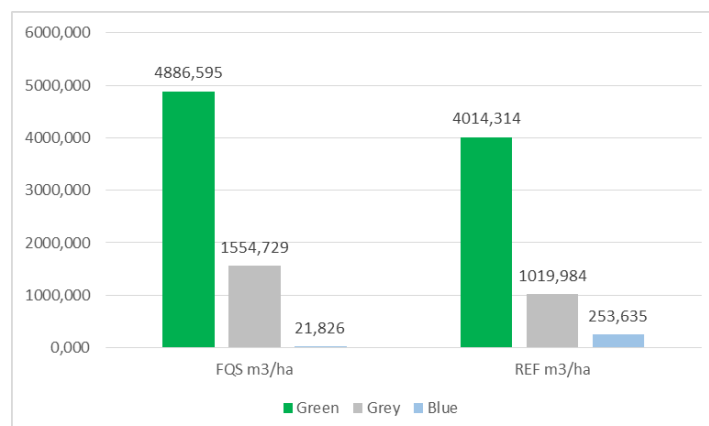


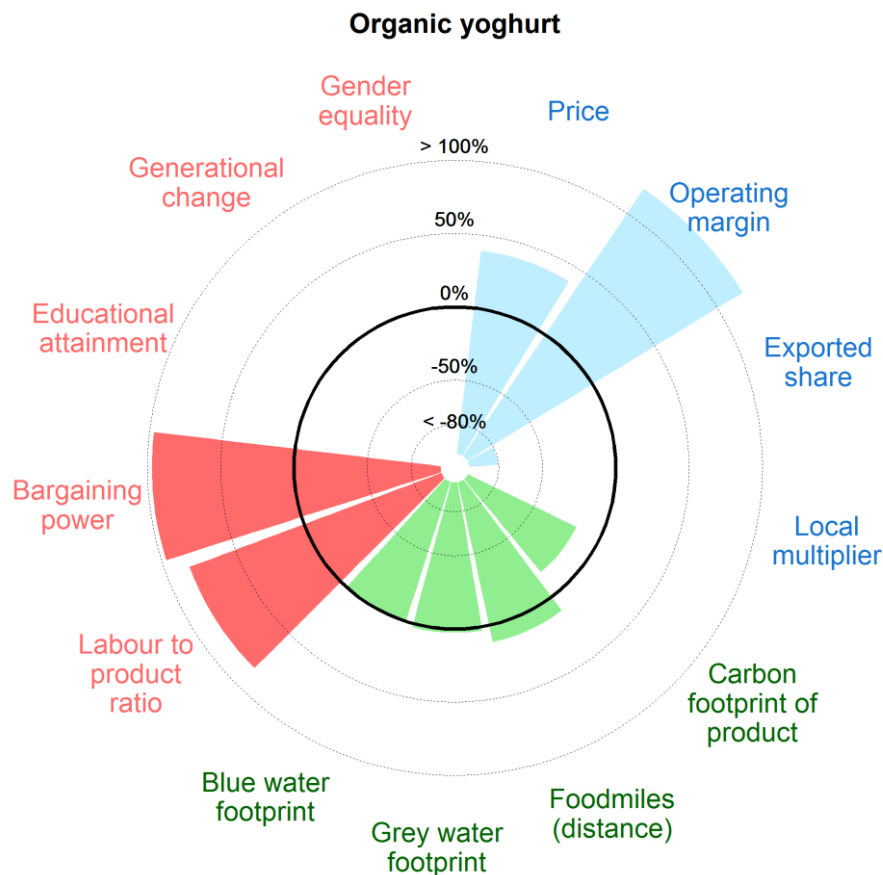
Figure 27. Waterfootprint of organic pork per hectare

In addition to these results per ton of product, a “per ha” perspective is worth being explored. If we take into account the land coverage for both organic and conventional pork systems, the difference in water footprint is much more nuanced, and still in favour of the reference. The difference still relies on the slower animal growth and reproduction cycle in the organic system as well as the type of feed employed.

4.1.2. Organic yoghurt (Germany)

Sustainability assessment of organic yoghurt in Germany was implemented through the specific methodology of Strength2Food (Bellassen et al., 2016). Some of the indicators were elaborated by using values coming from the whole German organic sector, since sectorial (milk production) values were not available.

In the yoghurt case, it was not possible to calculate the indicators gender equality, generational change, educational attainment as well as local multiplier. The main reason for this was missing statistical data or statistical data not accessible. In some cases, we were able to generate empirical data by own surveys, but not on all levels of the value chain, since this case study concerns appr. 4,000 organic farms and 130 dairies over whole Germany. For some indicators like for instance generational change or educational attainment, empirical data production was not available at processing level and experts and interviewees did not feel confident enough to provide an expert estimate that would be valid for the whole sector.

Figure 28. Sustainability performance¹¹ of German organic yoghurt (supply chain averages)

Price premium is positive and significant all along the value chain. Farm level has the higher price premium level, with 81%, followed by retail level (21%) and processing level (8%). If price premium appears to be lower at downstream level, especially on processing level, we should also consider the quantitative flow of product, with processing and retail more concentrated in FQS and so accumulating a significant premium.

Profitability is also higher for organic at farm level. If intermediate consumption and wages are both very high in both organic and conventional sectors, it is important to note that conventional production is not economically viable by itself, i.e. without subsidies. Moreover, organic farms are both more profitable in terms of cost/benefits relations and because they receive a higher level of subsidies. This higher level should be balanced considering also that organic farms are less productive and more labour-intensive, while conventional milk farms lay down on a strategy of higher volumes at lower prices. There is no data available at processing level on costs, but we can make the hypothesis that costs are quite similar (at least considering the same scale of production). In FQS, there are no inputs at processing level, whereas in REF, often technical processing aids are used. The yields at processing level are the same. The costs for collection can be higher for organic, as production units are smaller and more frequently located in mountain areas. Moreover, organic farms are less densely concentrated than conventional ones.

¹¹ Each indicator is expressed as the difference between the FQS and its reference product. For environmental indicators for which lower is better, the opposite of the difference is displayed (eg. +20% when the carbon footprint is 20% lower).

Finally, situation regarding exports is quite different between FQS and reference. While 21% of conventional milk is sold in Europe, with a higher price than in the national market (because share of value > share of volume), the share of organic milk exported is low, and the valorisation seems to be the same in domestic and export market (share of volume = share of value). This could be explained by a higher ratio demand/supply for organic milk compared with conventional milk. Sales prices into export markets are not automatically higher than those for domestic markets; we assume that they are the same for natural yoghurt, which is a "basic product" (compared to other high value added milk products exported). Furthermore, export is sometimes just a way to get rid of extra quantities without getting significant higher prices.

The carbon footprint of organic yoghurt is 18% higher than its conventional reference, with 1.48 and 1.25 tCO₂e ton⁻¹ yoghurt respectively. Most of this difference is explained by the 18% lower feed-to-milk conversion efficiency of organic cows. The second most important contributing factor is the higher allocation to meat in the conventional system: if 100% of the footprint is allocated to yoghurt, the organic system is only 13% higher. This mostly stems from the price premium of organic milk being much higher than the price premium of organic cull cows. The carbon footprint of feed is slightly lower for organic feed, despite the higher amount required per ton of yoghurt. But the carbon footprint of feed is only 7-9% of the total carbon footprint of yoghurt and it is offset by a higher share of more digestible grains in the diet of conventional cows. The carbon footprints at farm level are within the 0.52-2 tCO₂e t of milk⁻¹ literature range (Meier et al., 2015). Lindenthal et al. (2010) find however a lower carbon footprint for organic yoghurt in Austria. Their results are largely driven by the accounting of land-use related emissions and sequestration: 400 kgCO₂/ha sequestration for organic feed (excluding grassland) while conventional feed fields emit an average 202 kgCO₂/ha.

Concerning food-miles, over the entire supply chain, from farms to distribution units, organic yoghurt travels 12% shorter distances (4,500 vs 4,400 t.km t⁻¹) and releases 30% less emissions (125 vs 175 kg CO₂e t⁻¹) than conventional yoghurt. The shorter distance embedded in organic yoghurt is mainly due to a lower share of exports compared to conventional yoghurt (3.8% vs 21.5%), and to a more Europe-oriented export market. Similarly, the smaller emissions embedded in the FQS can be explained by the smaller emissions resulting from exports. Exported products travel longer distances and generate more emissions than products sold on domestic market. Therefore, a lower share of exports for organic yoghurt leads to less emissions released at the transport stage. Moreover, the reference product is exported outside Europe, which drives the distance up, and by plane, which drives emissions up since air transport is a far more carbon intensive mode than road transport used for exports to Europe.

The distribution level, from yoghurt producers to retailers, concentrates most of the kilometres embedded in the product and most of the emissions generated along the value chain (i.e. more than 75%). Regarding food-miles indicators, we can conclude that organic yoghurt is more sustainable than its reference both in terms of distance travelled (-12%) and in terms of emissions released at the transport stage (-30%).

The green water footprint has the greatest share of the water footprint indicator. The difference among the FQS and REF production for this sub-indicator depends on the different yield of the various crops used in the two production schemes. Differences in the green water footprint could not be ascribed to differences in meteorological conditions. Since nearly 2/3rd (65%) of the total organic milk production is located in the two southern Länder Bavaria and Baden Württemberg, we considered the most reliable meteorological located between this two areas (Ulm) and used these data for both productions. Also crop parameters were considered similar for correspondent crops in the two production schemes. The different proportions of the various crop in the diet of the animals further increased the difference between the green water footprint

values in favor of the REF product. The different crops variously enter in the composition of animal diet. To make this impact clearer consider two crops: grass and maize silage. The former shows a green water footprint of 635 m³ per ton of product in the FQS and 546 m³ per ton of product in the REF (yield difference). And FQS animals consume some 23 tons of grass per year whereas in REF production each animal consumes 13 tons per year. On the other hand REF animals consume more silage maize than FQS animals (9.24 t/year the former, 2-25 t/year the latter) but because silage maize has a higher green water footprint in the FQS scheme the higher amount consumed in the REF production does not compensate for the difference in the green water footprint and, above all, it does not alleviate the difference due to grass consumption.

All the raw materials included in the animal diet are not irrigated, so differences in the WF are essentially due to the WF green.

The LCA component of WF_{blue} of grass, maize silage, triticale, soft wheat and rapeseed, is higher for REF than FQS. This is due to higher inputs of nutrients and pesticides.

The grey water footprint is slightly higher for REF production. Crops used for REF productions in fact consume more nitrogen although also FQS uses nitrogen inputs in the form of manure (organic nitrogen such as manure).

The phases identified as breeding, stable, beverage and processing (yoghurt production) require water as blue footprint. This amount is a little higher for FQS than REF in breeding, stable and beverages phases, whereas milk processing to make yoghurt uses same amount of water in the two production schemes. However, as shown by the following charts the share of the overall water footprint expressed by these fractions is quite negligible.

The **labour use ratio indicator**, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope, 2001). The allocation of labour to production is higher for organic yoghurt than for the reference product (German dairy farms). At farm level, it takes 17 hours of work to produce a ton of milk when the reference product requires 9 hours. The difference (84%) indicates that the organic product generates more jobs than the reference system. The **turnover-to-labour ratio indicator** provides an insight into labour productivity. The average turnover per employee is a higher in organic farm than in reference ones, with a relative difference of 6%. These differences are mostly due to higher sales prices at U3 level as well as higher financial support (subsidies to organic farms); we further assume, that staff costs (payment/remuneration) is similar in both value chains.

The lack of specific data for the organic sector does not allow the identification of a possible specificity. On German dairy farms (conventional and organic), the very large majority of employees exceed the secondary level, with one-third having a short tertiary degree.

Bargaining power in the FQS supply chain is very evenly distributed between farmers and processors (value of 0,002), although one can notice a small advantage of the latter. This can be explained by the fact that processors are much fewer in number than farmers (as it is in REF as well), but mainly by the following factors:

- strong consumer demand, which makes processors compete for raw matter
- vertical long lasting contracts between farmers and processors
- better relations between farmers and processors and shared values along the supply chain. On the other hand, this advantage is partially offset by the fact that the contribution of farmers (by producing organic milk) is key for the differentiation of the end product (ie. $prod_proc = 2/3$ and $spec_res=2/3$). Put differently, the downstream level of processing enjoys

a bargaining power advantage related to a more favorable competition landscape (ie. fewer competitors), but this advantage is partially offset by the key contribution of farmers to the specificity of the end product (ie. produced milk is organic and producing organic milk requires specific agricultural practices and a specific organization of the farm).

Finally, bargaining power positions in the FQS can be considered as average, as evidenced by the average bargaining power scores obtained at each level, the weakest level being that of milk production. This means that the whole supply chain can be considered as moderately vulnerable against any major changes affecting the supply chain (entry of new competitors, change in the market structure...).

Our results show that bargaining power is well distributed in the reference, although one can notice a small advantage in the bargaining power hold by processors (P1), at the expense of farmers (U3), which is attributed to the fact that they are fewer. Still, this result has to be moderated by the fact that both U3 and P1 levels achieve very low bargaining power scores (0,19 and 0,33 respectively). Those low scores would also suggest that the supply chain is very vulnerable to significant changes: entry of new competitors, changes in the market structure...

All in all, our results suggest that the FQS supply chain enjoys a strong sustainability advantage over the reference, as our calculations show that bargaining power is far more evenly distributed along the supply chain for the FQS than for the reference (index ratio is of 0,03). This finding is also supported by several characteristics of the supply chain that are not grasped by our variables. The organic yoghurt supply chain is characterized by more stable relations between farmers and processors and by the fact that milk prices are more stable and much higher than for their counterparts.

4.1.3. Organic farmed salmon (Norway)

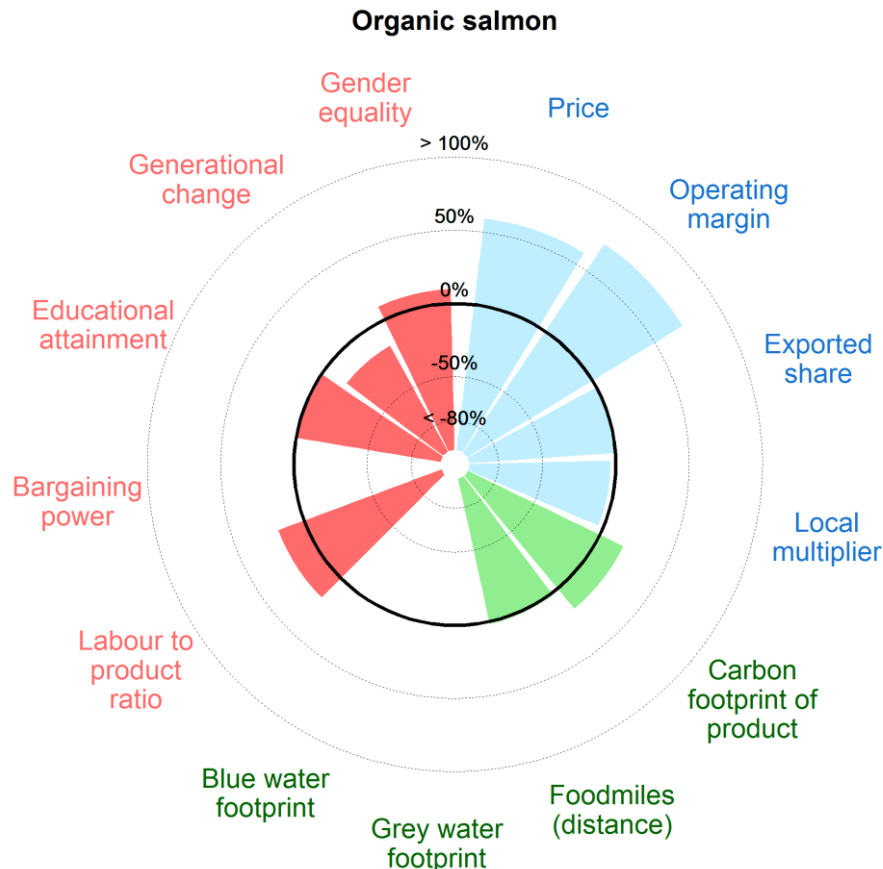


Figure 29. Sustainability performance¹² of German organic pork (supply chain averages)

4.1.3.1. Economic sustainability indicators

Profitability and exports

Data indicates that both prices and profitability are higher for organically farmed salmon. At U3 level, intermediate consumption are higher, but represents a smaller share of turnover than conventional production. Wages cost are quite similar, but higher prices for organic results in smaller share for wages in total turnover. Concerning exports, both organic and conventional salmon have the same share of value and volume exported.

Local economy impact of organic salmon

The local area assumed for the local multiplier calculation is the Møre og Romsdal and Senja regions considering them as a unique and contiguous region. Organic and Conventional salmon supply chains show the same or very similar local economy impact. This would mean that the organic and conventional supply chains present an organization comparable in terms of actors involved and their territorial distribution. The local multiplier effect of organic salmon is 3.7% lower than its conventional reference: each euro of turnover for organic salmon triggers 1.07 euro of re-spending in the same administrative region versus 1.15 euros for the reference. The main driver of this difference is the location of salmon farms. If we assume that salmon originates outside the local area, local multiplier would show a 30% reduction for the organic salmon and 33% for the conventional product. The second main determinant is due to the location of intermediate inputs suppliers.

4.1.3.2. Social sustainability indicators

Two indicators have been calculated for the aquaculture/breeding and processing stage of the supply chain for both organic and conventional salmon production in Norway; a Generational Change Index and a Gender Inequality Index in Employment.

Age and gender composition of staff

Index	Organic Salmon	Conventional Salmon
<i>U3 Stage – Aquaculture/Breeding</i>		
Generational Change	66%	64%
Gender Inequality	0.12	0.42
<i>P1 Stage – Salmon Processing</i>		
Generational Change	66%	106%
Gender Inequality	0.12	0.44
Supply Chain Average		
Generational Change	66%	85%
Gender Inequality	0.12	0.43

¹² Each indicator is expressed as the difference between the FQS and its reference product. For environmental indicators for which lower is better, the opposite of the difference is displayed (eg. +20% when the carbon footprint is 20% lower).

As a whole, the supply chain for conventional salmon is slightly more sustainable than the one for organic salmon, according to the average – across the stages – value of the Generational Change indicator. However, both products appear somewhat endangered in their opportunities to transmit the skill and knowledge associated to their production from one generation to the next. In fact, both supply chains record Generational Change indicators, which are smaller than 100%. On the other hand, the entire supply chain of organic salmon is more sustainable than the one of the conventional salmon, according to the average value – across the stages of the supply chain – of the Gender Inequality indicator. In fact, the value of the Gender Inequality indicator for the former is markedly lower than the one for the latter. In absolute terms, both supply chains are fairly sustainable in terms of the equality of opportunities, because the value of the Gender Inequality index for both supply chains is rather modest.

Labour and education

Regarding labour and education, several indicators have been calculated. The labour use ratio indicator, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope, 2001). The allocation of labour to production is lower for organic salmon than for its non-organic reference (Norwegian Atlantic salmon). According to the indicator, it takes about 8 hours of work to harvest a ton of fish when the reference product requires 11 hours at the farm level. The difference (-23%) indicates that the organic product generates less jobs than the reference system. The relative difference is on advantage of the organic product at the process level since, according to the calculated indicator, it takes approximately 9 hours of work to prepare a ton of fish against 6 hours for the reference product.

The turnover-to-labour ratio indicator provides an insight into labour productivity. According to this calculated indicator, the average turnover per employee is 98% higher in organic farm than in the reference sector. The productivity levels is much higher at the processing level. Differences observed are mostly due to the farms/firms structure (as organic farming employs far less workforce compared to conventional), the technical specification of the product (organic salmon farming requires more labour use due to several strict regulations they must adhere to) and in part due to the geographical conditions (organic salmon farming is highly concentrated within only two national producers).

There is no difference in the profile of education levels between producers of organic salmon and those of the reference sector. In both, the level of education is dominated by primary and secondary degree.

Short indicator name	SC level	FQS	Reference	% difference
Labour to product ratio	farm	0.0046	0.0059	-23%
Labour to product ratio	proc	0.0050	0.0031	60%
Profit to labour ratio	farm	1 798 303.63	909 296.03	98%
Profit to labour ratio	proc	1 982 290.41	610 272.68	225%
Educational attainment	farm	0.36	0.37	-3%
Educational attainment	proc	0.34	0.33	2%
Wage level	farm	53 949.11	55 467.06	-3%

		59	37	
Wage level	proc	468.71	226.63	60%

Bargaining power

Bargaining power could not be estimated due to the structure of the organic salmon supply chain. The underlying assumption for calculating this indicator is that two consecutive levels (i.e., U3 and P1) have to be run by independent firms. The supply chain of organic salmon is characterized by vertical integration, meaning that the two organic salmon firms both produce and process the fish. Thus, the underlying assumption could not be met for this particular social sustainability indicator.

4.1.3.3. Environmental sustainability indicators

Carbon footprint

One indicator has been calculated regarding carbon footprint. Similarly to previous studies (Pelletier and Tyedmers, 2007; Winther et al., 2009), feed production concentrates the lion's share of farmed salmon's carbon footprint. The carbon footprint (excluding transport) of organic salmon is 14% smaller than its conventional reference, with 0.89 vs 1.03 tCO₂e ton gutted fish⁻¹. This is driven by the absence of mineral nitrogen fertilizers for feed production (12-57% lower footprint of organic feed), although the lower feed yields and, more importantly, the higher use of fishmeal largely offset this benefit. These results are at the lower end of the 1.5 – 6.6 tCO₂e ton live fish⁻¹ range in the literature (RIAS Inc., 2016), due to the use of Bouwman's equation for the estimation of N₂O emissions (Carlson et al., 2016) instead of the more simple IPCC Tier 1 method. These results rely heavily on the assumption that fishmeal is composed of fish captured for the sole purpose of feeding salmons, rather than composed of trimmings from fish processing. In the latter case, the carbon footprint of organic salmon would be half that of its reference, although both footprints would be much lower than the current estimates.

Food-miles

Concerning food-miles, the organic supply chain was compared to the conventional salmon chain from salmon farms to distribution units. Over the entire supply chain, the FQS performs slightly better than its reference. Organic salmons travel slightly shorter distances (5,500 vs 5,600 t.km t⁻¹) and releases slightly less emissions (990 vs 1,100 kg CO₂e t⁻¹) than conventional salmons. The difference is in support of organic salmon, in the range of 1.5% for distances and of 10% for emissions. This difference is entirely driven by the value chain organization, and more precisely by exports, since organic salmons are to a larger extent exported within Europe, implying shorter distances and more road transport, a less carbon intensive mode than air transport used for exports outside Europe. The rather long distances and large emissions embedded in both value chains can be explained by the large share of exports (98%), that implies long distances due to the fringe location of Norway, and that relies on carbon intensive transportation modes (road and air). The distribution level, from conditioners to wholesalers, concentrates most of the kilometres embedded in the product and most of the emissions generated for transportation along the value chain (i.e. more than 95%). Regarding food-miles indicators, we can conclude that organic salmons are slightly more sustainable than its reference in terms of distance travelled and emissions released at the transportation stage.

4.2. Vegetal products

4.2.1. Organic flour and bread (France)

As part of the Strength2Food project, Bellassen et al. (2016) designed a method to evaluate the sustainability performance of food quality schemes. A series of indicators cover the three pillars of sustainability: economy (price premium and profitability), environment (carbon footprint,

water footprint, and food miles) and society (employment, bargaining power distribution, educational attainment, gender equality).

The aim of this chapter is to assess the sustainability of the French organic soft wheat sector, comparing the results of the indicators applied to the French conventional soft wheat flour and bread supply chain and to the French organic soft wheat flour and bread supply chain. The data comes from published articles and reports, and from interviews with stakeholders of the value chain.

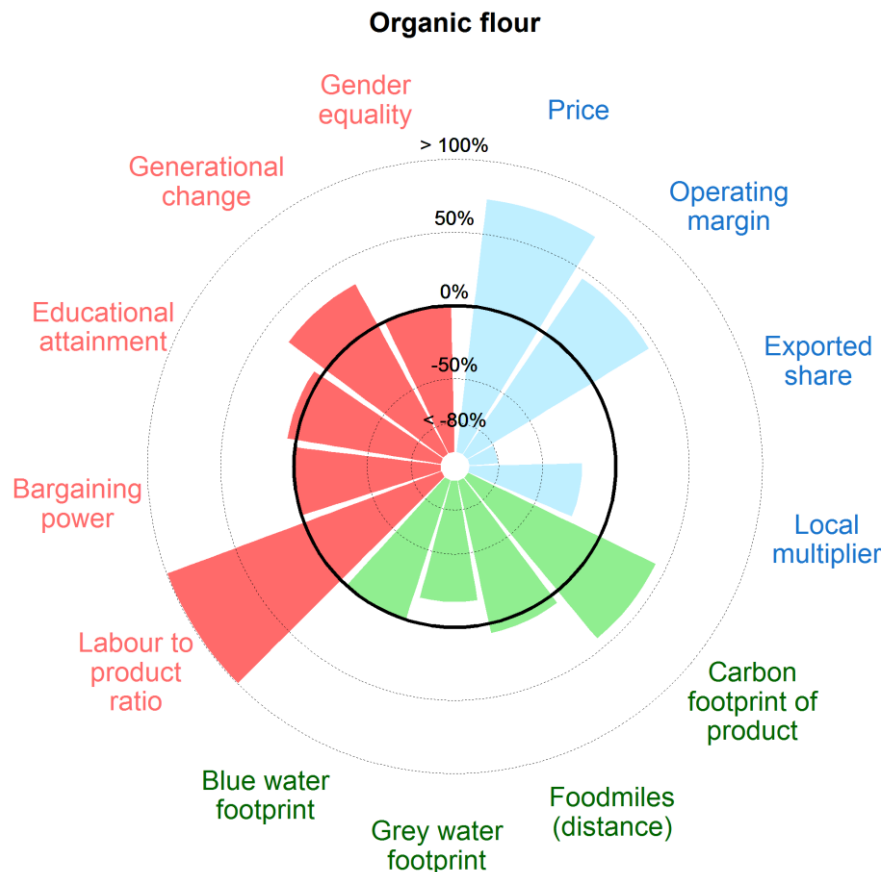


Figure 30. Sustainability performance¹³ of French organic bread (supply chain averages)

Considering the three pillars of sustainable development, the diagram (Figure 30) shows that organic bread is not necessarily more sustainable than its reference. The comparison shows that organic bread is less sustainable on some of the environmental components of sustainability that are explored by the Strength to Food project (carbon footprint and water footprint), but more sustainable on most of the economic and social components studied here.

4.2.1.1. Economic indicators

Four indicators have been investigated: the price premium, the net result, the gross operating margin, and the local multiplier. The price premium expresses the difference between the selling price of the organic and that of the conventional product. The net result and the gross operating margin are accounting indicators that express the difference between turnover and

¹³ Each indicator is expressed as the difference between the FQS and its reference product. For environmental indicators for which lower is better, the opposite of the difference is displayed (eg. +20% when the carbon footprint is 20% lower).

production costs. The main difference between these two is that the second one takes subsidies into account. Results for the economic indicators are presented in Table 17.

Table 17. Economic results for organic and conventional flour and bread production

	FQS	Reference	Difference
Price (€ kg⁻¹)			
Farm level	0.37	0.15	+146%
Processing level	0.51	0.43	+19%
Retail level	5.43	3.47	+56%
gross value-added (% of turnover)			
Farm level	72.9	58.3	+25%
Processing level	24.6	26.4	-6.8%
gross operating margin (% of turnover)			
Farm level	107.1	82	+31%
Processing level	11.8	7.4	+59.5%
Net result (% of turnover)			
Processing level	9.0	3.1	190%

There is a price premium at each level of the value chain: 146% at farm level, 19% at milling level and 56% at bakery level. This means that intermediaries and consumers at all levels of the value chain perceive the organic label as more valuable. The much lower premium at milling level than at farm level is somewhat surprising and may put the profitability of millers at risk. At the farm level, as long agronomic rotations are necessary in organic farms, this high premium may however be partly offset by lower premiums on other crops than wheat.

At farm level, both the gross value added and operating margin are higher for organic production. The weight of intermediate consumption is very high for conventional flour. Subsidies magnify the difference between organic and conventional cereal farmers. Indeed, farmers receive additional subsidies for organic farming.

At processing level, due to a higher percentage of intermediate consumption for FQS product, the gross value added is smaller for this product than for reference product. The other profitability indicators are rather weak, but more favourable for the FQS product than for the standard product.

The export shares have been rebuilt and aggregated along the supply chain (wheat, flour and bread). The conventional chain relies more heavily on exports (50%) than the organic chain (17%). The local multiplier effect of organic flour is 26% lower than its conventional reference: each euro of turnover for organic flour triggers 70 cents of re-spending in the same administrative region versus 1.30 euros for the reference. The main driver of this difference is the location of wheat producers: only 33% are within the same region as the mill in the organic case, versus 85% for the reference. This is related to the overall shortage of organic wheat producers in France as a whole.

The local multiplier effect of organic flour is 23% lower than its conventional reference: each euro of turnover for organic flour triggers 65 cents of re-spending in the same administrative region versus 1.15 euros for the reference. The main driver of this difference is the location of wheat producers: only 33% are within the same region as the mill in the organic case, versus 85% for the reference. This related to the overall shortage of organic wheat producers in France as a whole. Under the hypothesis that wheat grain originates outside the local area, local multiplier would reduce 21% for the organic product and 39% for the conventional one.

4.2.1.2. Environmental indicators

The three environmental indicators computed are the carbon footprint, the food miles and the water footprint. These indicators have many variables in common such as yield and input amounts for carbon and water.

Carbon footprint

The carbon footprint (without transport) of organic bread is 34% lower than the reference (162 vs 246 kgCO_{2e} ton of bread⁻¹). The difference in per hectare emissions is even higher, mainly due to the absence of mineral fertilizers, but the much higher yield of conventional wheat (4 vs 7.6 tons ha⁻¹) partly offsets this benefit. On a per hectare basis, the difference would likely be even higher if one accounts for emissions at rotation level, which must include low-carbon legumes in the case of organic wheat. These results are consistent with Meisterling et al. (2009) which also finds a better carbon footprint for organic flour. Note that the carbon footprint we find for conventional bread is almost equal to the value reported by Meisterling et al. (2009) and slightly lower than Espinoza-Orias et al. (2011).

Food miles

The indicator « food miles » measures the distances travelled and estimates the emissions released considering the transportation modes and the logistics. Results for the food miles indicators are presented in Table 18.

Table 18. Food miles for organic and conventional flour production

	FQS	Reference	Difference
Distance travelled (ton.km ton⁻¹)			
Processing level	676	115	+488%
Retail level	1288	2099	-39%
Value chain	1964	2214	-11%
Carbon emissions related to the transportation stage (kg CO_{2e} ton⁻¹)			
Processing level	36	8	+350%
Retail level	73	30	+143%
Value chain	109	104	-5%

Over the entire supply chain, from farms to distribution units, organic products (soft wheat, flour and bread) travel 11% shorter distances (1,964 vs 2,214 t.km t⁻¹) and release 5% less emissions (109 vs 104 kg CO_{2e} t⁻¹) than conventional products. This difference is mainly driven by the smaller share of exports of the FQS (16% vs 50%) that implies shorter distances and less emissions than for the reference product. However, the larger share of imports of raw products

Strength2Food D5.1 – Assessment of the social, environmental and economic sustainability of FQS

(cereals) (35% vs 3%) and the larger catchment area of mills handling organic soft wheat (340 km vs 50 km) offset part of the benefits (although not all), as they contribute to add kilometres and emissions to the bill. The distribution level, from millers to bread-makers, concentrates most of the kilometres embedded in the product and most of the emissions generated for transportation along the value chain (i.e. more than 60% for the organic chain and up to 95% for the conventional chain).

Regarding food-miles indicators, we can conclude that organic bread is more sustainable than its reference in terms of distance travelled (-11%) and emissions released at the transportation stage (-5%).

Water footprint

The blue water footprint measures the gross consumption of water, while the green water footprint measures the net consumption of water. The grey water footprint measures the water pollution, i.e. the water necessary to dilute the pollutants used as fertilizers and pesticides. Results for the water footprint indicators are presented in Table 19.

Table 19. Water footprint for organic and conventional flour production

	WF (m3/t wheat)		WF (m3/t bread)		WF (m3/Kg bread)	
AGRICULTURE	FQS	REF	FQS	REF	FQS (m3/Kg bread)	REF (m3/Kg bread)
WF green	536.74	284.47	633.32	335.66	0.633	0.336
WF blue - WFN	8.19	4.34	9.67	5.12	0.010	0.005
WF blue - LCA	1.47	31.86	1.73	37.59	0.002	0.038
WF grey	195.47	166.58	230.64	196.56	0.231	0.197
WF tot agriculture	741.87	487.26	875.37	574.94	0.875	0.575
Milling			7.88	7.88	0.008	0.008
Baking			55.70	55.70	0.056	0.056
			938.95	638.52	0.939	0.639

The grey water footprint is 17% higher for organic bread than for conventional bread. Indeed, although organic wheat requires less nitrogen (no mineral fertilizers and 100 kgN/ha from organic sources versus a total of 161 kgN/ha for the reference), its lower yield more than offsets this benefit when the indicator is expressed on a per ton basis.

As for the blue water footprint, the bulk of it is generated by the production of fertilizers and pesticides – which mostly occurs in the conventional case – and at baking stage which requires the same amount of water in both value chains. Hence the overall 30% lower value is driven by organic bread.

The green water footprint – use of rainwater by the crop – mainly stems from the difference in yield.

4.2.1.3. Social indicators

The social indicators computed are distributed into four components: employment, bargaining power, educational level and gender equality.

Employment

Employment is investigated using two indicators: the labour intensity of production, expressed in working units per ton of product, and labour productivity expressed in euro of turnover per working unit. The labour use ratio indicator, calculated on the basis of output, reflects labour

requirements for a unit of physical output (Just and Pope, 2001). Results for the employment indicators are presented in Table 20.

Table 20. Employment for organic and conventional flour production

	FQS	Reference	Difference
Labour-to-production ratio (AWU.t⁻¹)			
Farm level	0.002	0.001	+65%
Processing level	0.004	0.002	+120%
Retail level	0.078	0.037	+114%
Turnover-to-labour ratio (€.AWU⁻¹)			
Farm level	158,095	105,181	+50%
Processing level	142,623	264,179	-46%
Retail level	59,362	60,498	-2%

The allocation of labour to production is higher for organic products than for their non-organic references (French cereal farms). At the farm level, it takes 4 hours of work to produce a ton of cereals when the reference product requires only 3 hours. The difference (+65%) clearly indicates that the organic product generates more jobs than the reference system. The organic sector employs more people at the processing level (+120%). It takes 6 hours to produce one ton of organic flour compared to 3 hours for conventional flour. The relative difference is of the same order for retail level, but with greater absolute difference since the sale of one ton of processed products requires 141 hours of work compared to 66 hours for conventional products.

The turnover-to-labour ratio indicator provides an insight into labour productivity. The average turnover per employee is 50% higher in organic farm than in conventional ones. The productivity ratios are better for non-organic firms at the processing and retail levels, with a greater difference for processing. These differences are mostly due to the farms/firms structure (organic millers have smaller structures than conventional ones and thus benefit less from economies of scale), the technical specification of the product (the higher difficulty to find feedstock and the necessity to sort and assemble lots based on their protein content require more labour in the organic chain) and for a part to the geographical conditions (the supply basin of organic soft wheat is large and dispersed, which generates longer distances travelled to address the market demand).

Bargaining power

The bargaining power distribution indicator reflects the balance of bargaining power between the different levels of the value chain. It combines a simplified Herfindhal index with other more qualitative elements. It varies between 0 – perfect equality – and 1 where one level of the value chain dictates its will to the other levels. Results for the bargaining power indicator are presented in Table 21.

Table 21. Bargaining power for organic and conventional flour

	FQS	Reference	Difference
--	-----	-----------	------------

Bargaining power			
Farm level	0.67	0.67	0%
Processing level	0.56	0.56	0%
Retail level	0.38	0.38	0%
Bargaining power distribution			
Value chain	0.024	0.024	0%

The bargaining power is very evenly distributed among levels in both value chains, although one can witness a small advantage of the farm level of wheat producers over other levels. By way of contrast, distribution (mostly industrial and craft bakeries) suffer from the weakest position. Discrepancies in bargaining power may be explained by the fact that retail level counts a very high number of independent bakeries in comparison with processing level (flour mills) and farm level (grain coops), although no market leader clearly emerges at the latter level. The advantage of coops over other levels may also be explained by their capacity to mobilize highly specialized resources (wheat not easily replaceable by foreign wheat), and is reinforced by their vertical integration. Cooperatives often integrate the farming, collector and miller levels. This is particularly visible in the organic sector because the shortage of organic wheat compared with flour demand reinforces the bargaining power of farming level. However, vertical integration is not considered in this indicator, as it concerns a limited number of stakeholders. There is no difference between the organic and the conventional chains as regards bargaining power. Indeed, the organization of these value chains is similar: both include producers level as cooperatives, both have less millers than bakeries and more millers than cooperatives.

Educational attainment

Results for the educational attainment indicator are presented in Table 22.

Table 22. Educational attainment for organic and conventional flour

	FQS	Reference	Difference
Educational attainment			
Farm level	0.61	0.58	+6%
Wage level (€.AWU⁻¹)			
Farm level	22,639	9,382	+141%

This indicator is close to 0 if the majority of workers have a primary education level and approaches 1 as the level of education increases. The education level indicator is slightly in favour of organic production at farm level. This is explained by a higher proportion of staff who have reached an upper education degree (probably short tertiary diplomas rather than bachelors or masters): 50% compared to 42% among conventional producers. At the same time, the share of primary education is a bit higher on organic farms (28% versus 24%). However, this result has to be tempered by the data: these different values come from a small sample of producers, which may not be that representative. On the other hand, the reference takes into account only farmers under 50 years, so with maybe more educational attainment than the global population of farmers. According to this, the difference between organic and reference may remind

meaningful. Similarly, the wage level is higher for organic farmers than for conventional farmers in the soft wheat industry. The idea that a higher educational attainment leads to higher wages is therefore confirmed in this study.

Generational change and gender equality

Regarding generational change and gender equality, the organic supply chain was compared to the conventional supply chain from the farming to the retail stage. However, due to data availability in the organic chain, results can only be compared at farm level. Results for the generational change and gender equality indicator are presented in Table 23.

Table 23. Generational change and gender equality for organic flour and its reference

	FQS	Reference	Difference
Generational change (%)			
Farm level	33	25	+32%
Processing level	-	61	-
Retail level	-	239	-
Value chain	-	108	
Gender inequality (%)			
Farm level	0.18	0.30	-40%
Retail level	-	0.09	-

At the farm stage (wheat growing), organic soft wheat production appears to be more sustainable than the conventional one, both in terms of Generational Change (33% vs 25%) and Gender Inequality (0.18 vs 0.30). However, because the Generational Change indicator is smaller than 100%, the farm stages of both supply chains appear somewhat endangered in their sustainability prospects due to a rather limited employment of 15-35-year-old, compared to 45-65-year-old. Moreover, what drives the difference regarding the gender inequality is the higher level of female entrepreneurship at the farm stage of the organic supply chain, compared to the conventional one.

At the processing stage, the value of the Generational Change indicator indicates an improvement in the social sustainability levels, although it remains lower than 100%.

The retail stage seems very well poised in terms of sustainability because the Generational Change indicator is much larger than 100% (i.e. allowing for generational renewal) and the Gender Inequality indicator is very close to 0 (i.e., absence of inequality). The very small value of the Gender Inequality indicator is driven by employment being 50% male and 50% female as well as by very similar gender-based educational achievements by the workforce. A marked difference in gender-based ownership of retailing firms is the only source of inequality.

Overall, the supply chain for conventional flour and bread is sustainable in terms of generational change (108%), but only because the retail stage largely allows for generational renewal.

4.2.2. Organic processed tomatoes (Italy)

The sustainability performance of Organic Tomato has been assessed using the Strength2Food method (Bellassen et al., 2016). For economic indicators, the reference to which Organic

Tomato is compared to the conventional tomato produced within the district of North Italian processed tomato. All the index calculations are based on primary data collected from supply chain members (Northern Italy processed tomato, processed tomato industries, tomato farms) and secondary data extrapolated from scientific and technical literature, agricultural handbooks and agricultural databases (e.g. Italian FADN).

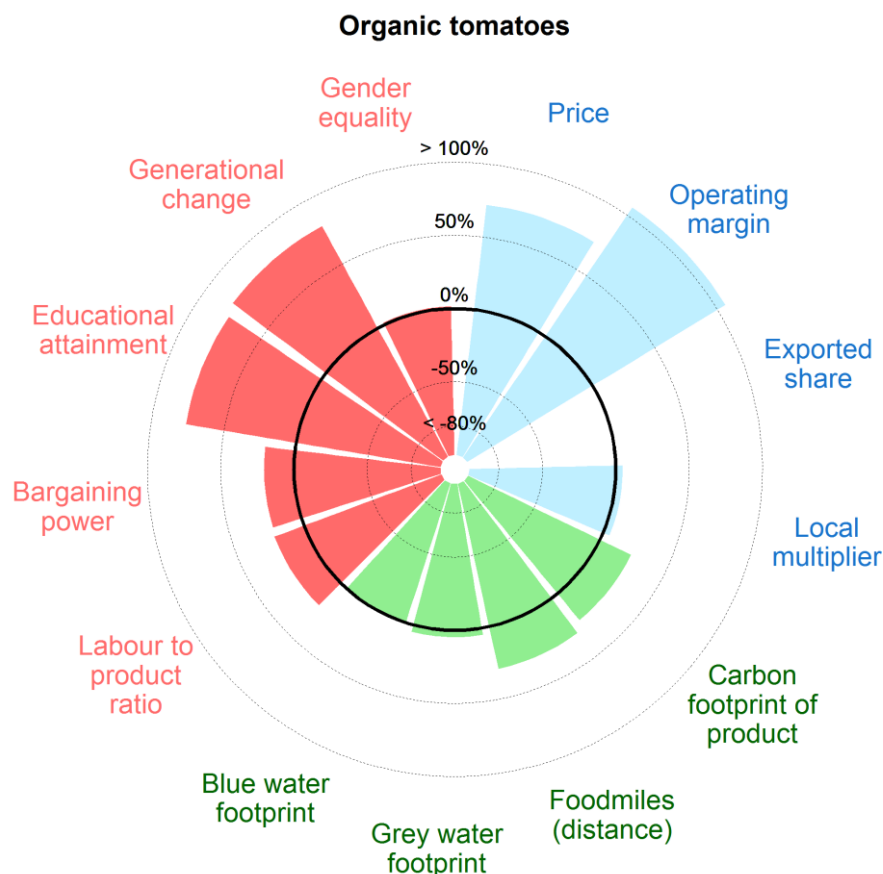


Figure 31. Sustainability performance¹⁴ of Italian organic processed tomatoes (supply chain averages)

4.2.2.1. Economic indicators

Price premium, profitability and value distribution

The price of organic tomatoes is 63% higher than the reference, both at farm and processing level; the low yield per hectare and small acreage are the main reasons explaining this difference. At distribution stage, the organic production amplifies the difference with the counterpart (about the double). The gross value added is higher at farm level (77%) and at P1 (44%). The gross operating margin is higher at farm level (55% vs. 39%) and slightly lower at P1 (28% vs. 30%). Organic processed tomato based product is less exported than the counterpart (35% vs 60%). This has implications for the food miles impact. Organic processed tomato benefits from an increasing market demand with prices that are in average higher than the conventional products. Since the processing technology adopted for organic tomato is the

¹⁴ Each indicator is expressed as the difference between the FQS and its reference product. For environmental indicators for which lower is better, the opposite of the difference is displayed (eg. +20% when the carbon footprint is 20% lower).

same used for the conventional one, the margin at processing stage for organic production is higher. At distribution level, the consumer willingness to pay for organic products plays an important role in price definition.

Local multiplier

The local multiplier for Organic Tomato is slightly higher than its reference. For both cases, the indicator exceeds the level of 2, i.e. one euro spent at processing phase generated more than one euro of extra financial flows within local area. Indeed, for organic tomato the local multiplier is equal to 2.06, whereas for the reference 2.05. All the raw tomato originates from the same area, both in the case of the organic product and in the case of the conventional one. The main determinant of this result is the geographical origin of tomato. The location of tomato farms is therefore a key variable that contributes to the high local multiplier for both the products. If we assume that tomato originates outside the local area, the local multiplier would reduce in both cases of more than 50%. The second main determinant is represented by the payroll that accounts for more than 13% in the indicator composition. In this respect, the seasonal labour at processing stage appears as the main factor affecting payroll weight in local multiplier.

4.2.2.2. Environmental indicators

Carbon footprint

The carbon footprints of fresh organic tomatoes and their reference, 18 and 34 kgCO₂e ton⁻¹ respectively, are lower than the literature range of 150-6,000 kgCO₂e ton⁻¹ (Clune et al., 2017). This large literature range is focused tomatoes grown in heated greenhouses where most of the carbon footprint comes from greenhouse construction and heating (Almeida et al., 2014; Rööß and Karlsson, 2013). Open field Italian tomatoes are thus logically below the range. The bulk of the 48% difference between organic and conventional tomatoes is explained by the absence of synthetic nitrogen fertilizers for organic tomatoes. This gain is only marginally offset by the 13% lower yield of organic tomatoes. The integration of processing diminishes the difference, the carbon footprint of processed organic tomatoes being 18% lower than their reference, with 147 and 180 kgCO₂e ton⁻¹ respectively.

Extended food miles

Concerning food-miles, the organic supply chain was compared to the conventional processed tomato chain of Northern Italy (Emilia Romagna region) from tomato farms to distribution units. Over the entire supply chain, organic tomatoes travel 30% shorter distances (2,000 vs 2,800 t.km t⁻¹) and releases 20% less emissions (130 vs 165 kg CO₂e t⁻¹) than conventional tomatoes. This difference is mostly driven by the differential in the distribution between export and domestic markets: 35% of organic processed tomatoes are exported, against 60% of conventional processed tomatoes. As it is exported to a smaller proportion, the FQS travels shorter distances and emits less emissions than its reference. Otherwise, the FQS exhibits similar patterns as its reference: it is exported in the same proportions to similar export countries and sold on similar proportions throughout Italy, whether organic or conventional. A somewhat larger share of conventional products is distributed to the Northern Italy market, which implies shorter distances and less emissions, but this is not enough to offset the longer distances and larger emissions of the reference product on the export market. The distribution level, from processors to wholesalers, concentrates most of the kilometres embedded in the product and most of the emissions generated for transportation along the value chain (i.e. more than 90%). Regarding food-miles indicators, we can conclude that organic processed tomatoes are more sustainable than its reference in terms of distance travelled and emissions released at the transportation stage.

Water footprint

Overall the FQS show a higher water footprint. Yield represented the major cause for the difference in the green fraction. In fact, crop parameters and meteo conditions were exactly the same. The grey water footprint is slightly higher for the reference crop. This depends on the higher amount of nitrogen that is used: both mineral and organic fertilizers are applied to the reference products whereas only organic fertilizer is applied to FQS. However in terms of tons of substance that is applied the difference is only equal to 25 kg /ha (adding up both mineral and organic nitrogen fertilizer).

Blue WFs of tomatoes used for producing FQS (32.6 m³/t) and REF (28.5 m³/t) are comparable to the regional and country average values (32.9 m³/t; 30.7 m³/t). The green WF of the studied products is lower than the regional and national values.

LCA component of Blue WF is higher in REF (2.74 m³/t) than FQS (2.33 m³/t) and this is essentially due to the higher inputs of nutrient and the use of pesticides, that are forbidden in the organic production. The processing phase are exactly the same and this reflects on the same amount of blue water request for the two products.

4.2.2.3. Social indicators

Employment

The labour use ratio indicator, calculated on the basis of output, reflects labour requirements for a unit of physical output. The allocation of labour to production is higher for organic tomatoes than for its non-organic reference (conventional production). At the farm level, it takes 4 hours of work to produce a tonne of tomatoes when the reference product requires 3 hours. The difference (43%) indicates that the organic product generates more jobs than the reference system. The turnover-to-labour ratio indicator provides an insight into labour productivity. The average turnover per employee is a bit higher in organic farm than in conventional ones. The productivity levels are much higher at the processing level, with a relative difference of 63% in favour of the organic tomatoes. This is due to more beneficial conditions of organic products market than the conventional one (higher consumers' WTP).

Bargaining power

The FQS supply chain is characterized by the domination of a leading player at the processing level (market share at processing level is qualified as very strong), whom influence is although counterweighted by the existence of a producer organization gathering tomato producers. Bargaining power can therefore be qualified as rather evenly distributed along the supply chain, even though one could note a persisting advantage of the downstream over the upstream level, which is still due to a more favourable concurrential position, as processors enjoy a transactional advantage over producers, because they enjoy a higher degree of contractual flexibility with downstream levels than do producers with processors. This bargaining power advantage is, in turn, partially offset by institutional factors.

On its side, bargaining power can also be considered as rather evenly distributed along the reference supply chain, even though, one can detect an advantage of the processing level over producers (farm level), which can be attributed, once again, to more favourable transactional environment (processors enjoy higher degrees of contractual flexibility). This bargaining power advantage is, in turn, partially offset by institutional factors.

Overall, as the bargaining power distribution scores of the FQS and of the reference are quite close to each other thus leading to the conclusion that, in this case, the FQS does not provide a significant sustainability advantage over the reference.

Finally, when comparing the bargaining power position of the weakest level for both supply chain, results show average bargaining power scores obtained at the farm level for both supply chains (0,45 for the FQS and 0,44 for the reference), what suggest that those levels can be considered as rather vulnerable to significant changes (changes in the concurrent structure, in the market position...) affecting their respective supply chains.

Educational attainment

The education attainment indicator is higher for the employees of organic farms. The difference is 153% and is attributable to the fact that 38% of producers have employees have at least a licence (bachelor) or equivalent level. There is no difference at processing level.

Generational change and gender equality

At the farm stage, Organic Tomatoes appear to be more sustainable than the Conventional ones, because the Generational Change indicator is larger in the former than in the latter. However, because the Generational Change indicator for the farm stage of both products is smaller than 100%, both products could be deemed endangered in their sustainability prospects due to a high employment level of 45-65-year-old, compared to 15-35-year-old. Likewise, at the farm stage of the supply chain, tomato growing for Organic Tomatoes is more sustainable than for the Conventional one, due to a lower value of the Gender Inequality indicator. This is due to the higher level of female employment and female education at the farm stage of the supply chain for Organic Tomatoes, compared to the Conventional one.

At the processing stage, both products have the same value of the Generational Change and Gender Inequality indicators because the organic and conventional produce is processed in the same plant, with the same personnel. The Generational Change indicator is much larger than 100%, indicating that a higher number of young individuals is employed at the tomato processing stage, than older ones. This may reflect the higher, than other sectors', reliance on seasonal labour provided by students who want to earn some money over the summer. Based on the Gender Inequality indicator, the social sustainability of both products at the processing stage seems highly endangered because of the high value of the indicator, mainly due to the extreme levels of inequality in the ownership of processing firms which is exclusive domain of males. The penalty females experience in firm ownership is not compensated by the high – and equal across gender – share of employees with higher than secondary education levels at the processing stage of the tomatoes supply chain. The evidence concerning the high level of education of employees at the processing stage is consistent with its reliance on employing a large number of young seasonal workers who are students at other times of the year. Because this type of seasonal work is very popular with university students, they would report to have completed the upper secondary education, contributing to raising one of the components of the indicator.

Overall, the supply chain of Organic Tomatoes is more sustainable than the Conventional one. While the positive difference is noticeable when focusing on the Generational Change indicator, any difference is marginal with respect to the Gender Inequality indicator. In absolute terms, the Conventional Tomatoes supply chain is – on average – socially unsustainable due to a smaller than 100% Generational Change indicator and a sizeable value of the Gender Inequality indicator. The Organic Tomatoes supply chain is barely socially sustainable only because the Generational Change indicator slightly exceeds 100%.

4.2.3. Organic pasta (Poland)

In order to estimate sustainability of organic pasta, the specific methodology of Strength2Food (Bellassen et al., 2016) was applied. For the benchmarking purposes, the conventionally produced pasta was used as the counterpart. For the farm level the counterpart we used the

model conventional farms with the same structure of production as our case-study organic farms, but producing grains in conventional way. Additionally we used secondary sources from FADN and Polish Main Statistical Office). The processing level comparison we based on the data from real conventional pasta producer who provided technical and economic data for pasta production. We also extracted data from the secondary sources (Main Statistical Office and market reports).

The key indicators of the performances are depicted in Figure 32.

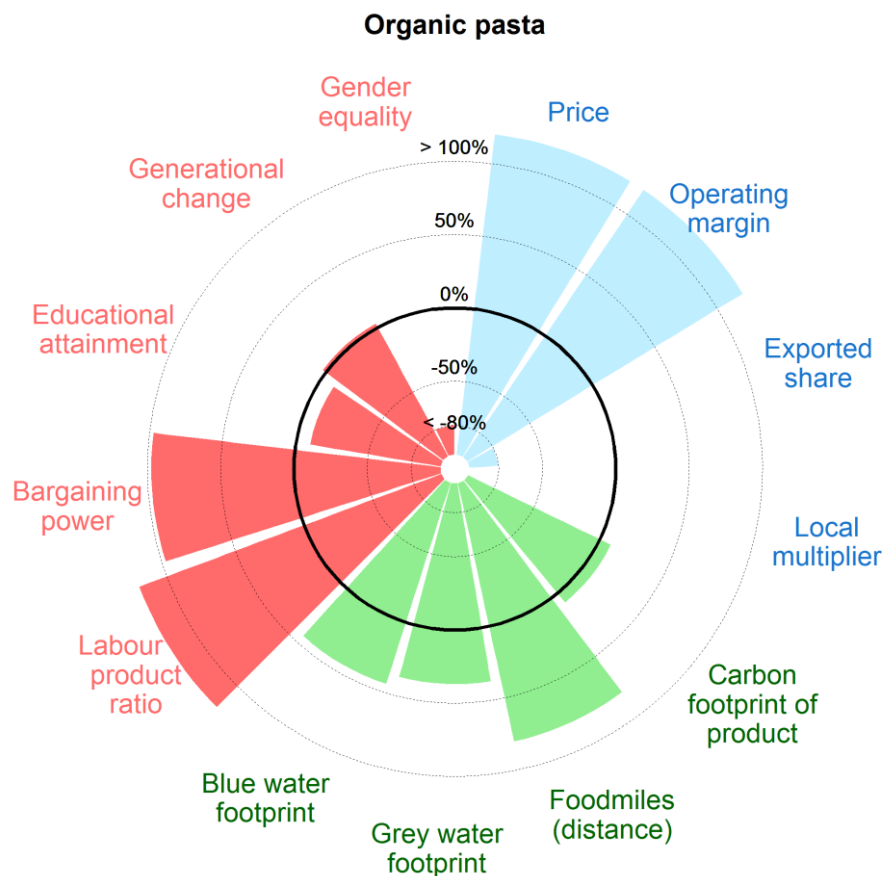


Figure 32. Sustainability performance¹⁵ of Polish organic pasta (supply chain averages)

4.2.3.1. Economic sustainability

Price premium for organic pasta production is substantial at both farm and processing level, with a value of 95% and 275% respectively. It reaches 500% at retail level. In the FQS wheat price (0,43 €/kg), compared with 0,22 €/kg of conventional wheat, a premium for organic product is included. This premium is additionally relatively high because of the old varieties of wheat used by organic pasta producer which usually are very low performing (have lower yields). Unique is also close relationship between pasta producer and farmers, which enhance extra premium for supplying very specific products to processor.

¹⁵ Each indicator is expressed as the difference between the FQS and its reference product. For environmental indicators for which lower is better, the opposite of the difference is displayed (eg. +20% when the carbon footprint is 20% lower).

Table 24. Economic indicators for Polish organic pasta

Short indicator name	Chain level	FQS	Reference	Difference % (FQS-REF)/REF*100%
Price	farm	0.43	0.22	95
Price	proc	1.89	0.50	278
Price	retail	4.28	0.71	503
GVA	farm	73.8	50.1	47
GVA	proc	38.8	13.9	179
Net result	farm	99.5	57.1	74
Net result	proc	24.3	2.6	835
Export share	proc	3%	13%	-69

Profitability indicators are also better for organic pasta compared to conventional pasta. At farm level, intermediate consumption are almost similar in absolute term, and so represents a lower share of turnover for organic wheat (as prices are higher than in conventional production). If wage costs are higher for organic, higher prices and subsidies allows a superior profitability for organic wheat, regardless of the indicators (GVA, GOM or Net Result). Considering processing level, the high prices also allows to compensate additional costs of organic production, and profitability is better for organic pasta both in relative and absolute terms.

Regarding exports share, organic pasta are mainly designated to the national market. Exports' share in total production is about 3%, from which 67% travels to the EU countries (Germany, UK, Greece, France) and 33% to non-EU partners (USA and Norway). In case of conventional pasta company export is much higher and reaches 13% of production. Export is mainly designated (75%) to Eastern European counties and China.

4.2.3.2. Environmental sustainability

Carbon footprint

Table 25. Carbon Footprint of Polish organic pasta

Indicator name	Chain level	FQS	Reference	Difference % (FQS-REF)/REF*100%
Carbon footprint of land use	farm	541.48	1004.64	-46
Carbon footprint of land use	proc	969.68	2061.20	-53
Carbon footprint of product	farm	290.29	345.78	-16
Carbon footprint of product	proc	831.03	864.60	-4
Carbon footprint of product	All, including transport	913.32	933.45	-2

Excluding transport, the carbon footprint of organic pasta is 33% lower than its reference (0.98 and 1.25 tCO₂e ton⁻¹ of pasta respectively). Most of this difference is driven by the absence of mineral fertilization for organic wheat. However, the lower yield of organic wheat partly offset these benefits. Processing represents 39% of the emissions of organic pasta. Although the lower size of the organic facility makes it require more energy per ton of output, the higher use of Polish coal-based electricity for the reference facility makes its emissions higher. Both products are at the higher end of what is found in the literature for the field to distribution carbon footprint: 0.9 (Okö-Institut), 1.3 (Ruini et al., 2013) or 0.5 (Röös et al., 2011) tCO₂e ton⁻¹ of pasta. The farm-level footprint is similar to (Röös et al., 2011) and about half the values from

(Ruini et al., 2013), which can be explained by the relatively low amount of mineral fertilizer use.

Food Miles

Concerning food-miles, organic pasta supply chain was compared to the conventional pasta produced by the model conventional farms. Over the entire supply chain, from farms producing cereals to pasta retailers, organic pasta travels distances 3 times shorter (480 vs 1,500 t.km t⁻¹) and generates 20% more emissions (115 vs 100 kg CO_{2e} t⁻¹) than conventional pasta. First, the difference in terms of distances is mainly explained by the shorter distances travelled by the FQS on the domestic market, which concerns most of the production (97% for FQS, 87% for its reference). Second, organic pasta are to a smaller extent exported outside Europe (20% vs 77% of exported pasta are sold outside Europe). However, the shorter distances travelled by organic pasta are entirely offset by the carbon intensive mode used for extra European exports. Indeed, organic pasta sold outside Europe relies on air transport, a very carbon intensive mode, whereas conventional pasta sold outside Europe relies on sea transport, a much more carbon extensive mode. As a result, distances travelled by organic pasta are clearly shorter, but on the other side, the much larger emissions generated by the 3% of exports more than offset the environmental benefits from the 87% of domestic market. The distribution level, from pasta producers to retailers, concentrates most of the kilometres embedded in the product and most of the emissions generated for transport along the value chain (i.e. more than 80%). Regarding food-miles indicators, we can conclude that organic pasta is more sustainable than its reference in terms of distance travelled (-68%), but less sustainable in terms of emissions released at the transport stage (+18%).

Green, grey and blue water footprint

The following table reports a summary of the values obtained for the fractions of the indicator water footprint for organic pasta (FQS) and its REF production. They are provided as m³/kg of product.

Table 26. Green, grey and blue water footprint of Polish organic pasta

Indicator name	Chain level	FQS	Reference	Difference % (FQS-REF)/REF*100%
Green WF	all	1,582	0,764	107,1
Blue WF	all	0,012	0,022	-45,5
Grey WF	all	0,175	0,273	-35,9
Total Water footprint	all	1,768	1,059	66,9

REF performs better than FQS for **green water footprint**. In the lack of meteorological data for the specific production areas we selected the meteorological station closest to the production area of FQS. Toruń station from CLIMWAT database was chosen. The selected meteorological data were used for both FQS and REF so the specificity of local climate on wheat production could not be accounted for. Also crop parameters were the same for both productions. Accordingly that the only drivers that played a role in determining the observed difference in green water footprint are yield and final product ratio that relates wheat to pasta (0,57 FQS; 076 REF). The differences in the values of these two parameters alone account for the differences in the green water footprint in favour of the REF product.

FQS production shows a better performance as for **grey and blue water footprint**. Although yield is still a factor that tends to increase the water footprint for FQS, the highest amount of nitrogen based fertilizers employed in REF augments this latter's grey water footprint above that of the FQS production. In particular it is the mineral surplus of Nitrogen which determines the difference in the grey water footprint. The phosphorus based fertilizers are employed in the

REF production but they do not enter the computation of the grey water footprint. This is because in the literature there is a tendency to focus on nitrogen only to make comparisons much easier. However we considered phosphorus based fertilizers in the LCA approach through which the blue water footprint was calculated. This blue water is the water requested to support agricultural production as it is used to produce fertilizers, and pesticides, diesel fuel, electric, and other items that serve agricultural production. In particular, this blue water footprint is the only blue water that the two productions require as irrigation is equal to zero for both FQS and REF. FQS performs better than REF in this respect: what makes REF performing worse than FQS is the production and distribution of fertilizers and pesticides, and the highest amount of diesel fuel.

Processing requires for both productions a low amount of water, which is however higher for REF than FQS. The pie chart below shows the share (as %) of the water footprint by the two main phases of pasta production: agriculture and manufacturing.

The water required by REF in the processing phase is by one order of magnitude higher than the amount needed by the FQS. This is due to the higher amount of electricity and fuel (although FQS uses also coal as source of energy) but above all the water consumption is strongly higher (1440 m³/year for REF and 150 m³/year for FQS).

4.2.3.3. SOCIAL SUSTAINABILITY

Labour productivity and educational attainment

The **labour use ratio** indicator, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope, 2001). The allocation of labour to production is higher for organic pasta (organic wheat production at a farm level) than for its non-organic reference (Polish cereal farms). At the farm level, it takes 198 hours of work to produce a tonne of wheat when the reference product requires only 143 hours. The difference clearly indicates that the organic wheat is a bit more (by 39%) labour intensive than the reference conventional wheat. The reason here could be that, despite of fewer fertilization and plant protection activities, the yields of organic wheat are much lower, which decreases productivity as per labour unit. The organic pasta production is also more labour intensive than conventional - it takes 100 hours to produce one tonne of organic pasta compared to 10 hours in the conventional sector. It is reasonable since in case of organic production the company scale is much smaller and many activities are done manually instead of machines.

Table 27. Labour productivity and educational attainment of Polish organic pasta

Short indicator name	Chain level	FQS	Reference	difference (FQS-REF)/REF*100%
Labour to product ratio	farm	0.110	0.079	39
Labour to product ratio	proc	0.055	0.006	896
Profit to labour ratio	farm	3 784.92	2 802.99	35
Profit to labour ratio	proc	40 293.04	90 685.70	-56
Educational attainment	farm	0.53	0.53	0.2
Educational attainment	proc	0.48	0.60	-20
Wage level	farm	4 137.02	2 596.33	59
Wage level	proc	18 368.73	9 461.79	94

The **turnover-to-labour ratio indicator** provides an insight into labour productivity. The average turnover per employee is 35% higher in organic farm than in conventional ones. The difference in case of farm can be explained by the higher prices obtained by organic wheat producer, which, despite of high labour intensity, upraise the labour productivity measured by

value of sales per employee. The productivity level is much higher at the processing level in case of conventional production, which has a ratio of twice the ratio of the organic sector. The difference is due to the large scale of production of conventional pasta producer and high mechanization of production process comparing to almost handmade pasta of organic company.

There is no difference in the profile of education levels between producers of organic flour, at farm level, and those in the conventional sector. The level of education is dominated by secondary degree (80-84%). In case of processing, the level of education is slightly higher in conventional than organic pasta producer and it can be explained by case specific structure of employment. It can be different in other companies.

Bargaining power

Bargaining power is very evenly distributed among levels of the FQS, as evidenced by the very low value taken by the BPD index (0,01). However, one may detect a small bargaining power advantage of the downstream level of pasta processing (P1), at the expense of the upstream level of wheat production. Key to this advantage are factors pertaining to the concurrential environment at the P1 level (num_compet and marketshare1 variables), especially the existence of a strong market leader that is able to weight in potential negotiations. On the other hand, this advantage of the P1 level is partially offset by the fact that the U3 level can rely on a better position than P1 players in terms of transaction costs (prod_proc, spec_res, prop_contract variable): they mobilize specific resources in their activity, their contribution is key to the specificity of the end product and they are, on the other hand not bound by long term contract with downstream levels.

However, the **bargaining position of the whole supply chain** can be considered as quite weak. The weakest level is that of producers (U3), with a bargaining power score of 0,40. Although this level may rely on strong transactional factors for sustaining their position, this weakness mainly results from a nil score obtained at both level for the institutional factors (unionFSC and union_others factors). This means that the institutional environment is insufficiently developed for supporting vertical relations within the supply chain. The overall weakness observed at the supply chain level may indicate that FQS are likely to be quite weak against major changes affecting the supply chain (entry or exit of actors, change in the market conditions, etc.).

By way of contrast, bargaining power is very unevenly distributed in the reference. In this case, the supply chain is characterized by a strong domination of the players at the P1 level. Due to the existence of a very weak institutional environment (institutional variables take 0 values at both levels), this domination is mainly explained by the strong concurrent position of P1 players: they are much fewer than U3 farmers and another key factor comes from the domination of the market leader at the P1 level.

The reference supply chain is also very weak, as evidenced by the very low score obtained at the U3 level of the reference supply chain (0,095). This very low score is due to the existence of a very weak institutional and competitive environment (the average score of those factors is 0), combined with a poor performance in terms of transaction costs (average score of 0,22). This supply chain can therefore be considered as highly vulnerable to any kind of changes likely to affecting it.

All in all, the organic pasta supply chain can be considered as having a strong sustainability advantage over the reference, as evidenced by the fact that bargaining power is much more evenly distributed than for the reference (ratio FQS/Reference = 0,026 so FQS is by 97% lower ratio BPD)

Generational Change Index and Gender Inequality Index in Employment

Indicators have been calculated for the farming and processing stages of both supply chains. However, only the simplified version of the Gender Inequality indicator, which accounts for gender differences in entrepreneurship and employment levels only, could be calculated, due to limited data availability. Furthermore, calculation of the latter relies on replacing a few zeros with very small numbers (0.001).

This evidence suggests that:

At the farm stage (wheat growing), Conventional Pasta appears to be slightly more sustainable than the Organic one, because the Generational Change indicator is larger in the former than in the latter. However, because the Generational Change indicator for the farm stage of both products is smaller than 100%, both products could be deemed endangered in their sustainability prospects due to a high employment level of 45-65-year-old, compared to 15-35-year-old.

Likewise, at the farm stage of the supply chain, wheat growing for Conventional Pasta is much more sustainable than for the Organic one, due to a much lower value of the Gender Inequality indicator. This is due to the higher level of female entrepreneurship at the farm stage of the supply chain for Conventional Pasta, compared to the Organic one.

At the processing stage, Organic Pasta manufacturing is more sustainable than Conventional Pasta, because it employs more young employees than older ones. Conventional Pasta manufacturing is in perfect generational balance, considering that the same amount of young and older people is employed at this stage of this supply chain. However, because the value of the Generational Change indicator for both products is greater or equal to 100%, the social sustainability of the processing stage for both supply chains appears preserved.

Based on the Gender Inequality indicator, the social sustainability of both products at the processing stage seems highly endangered because of the high value of the indicator, mainly due to the extreme levels of inequality in the ownership of processing firms which is exclusive domain of males. The penalty females experience in firm ownership is not compensated by the higher levels of female employment at the processing stage of Organic Pasta, than of the Conventional one. In comparative terms, Organic Pasta is slightly more sustainable than the Conventional one, because of a lower value of the Gender Inequality indicator, but differences are minor.

Overall, the supply chain for Organic Pasta is more sustainable than the Conventional one, according to the Generational Change indicator. The opposite is true according to the Gender Inequality one. In absolute terms, neither supply chain seems to be sustainable according to both indicators.

4.2.4. Organic raspberries (Serbia)

In order to estimate the sustainability of Serbian organic raspberry, the specific methodology of Strength2Food (Bellassen et al., 2016) was applied. For the benchmarking purposes, the conventionally produced Serbian raspberry was used as the counterpart. The key indicators of the performances are depicted in Figure 33. Some, most relevant, will be underlined in the next paragraphs.

It should be noticed that necessary data for S2F methodology were collected both from the primary sources (conducted interviews with farmers and experts and calculations based upon available secondary sources) and from the secondary sources (SORS, FADN, Republic Hydro-meteorological Service of Serbia, FP7 GLAMUR project and Agromarket).

It is observable that the profitability is higher for the organic raspberry than for the conventional one. However, surprisingly, the price is only 20% higher for the organic than for the conventionally produced raspberries, which is explained by the differing bargaining powers of actors on various stages of the value chain. Exported organic raspberry records mark-up of 60%. As previously said, it should be noted that both organic and conventional raspberries are export-oriented products. Serbian organic raspberries perform worse than its reference regarding profit to labour ratio.

The carbon footprint of organic raspberries is 5% lower than the reference (316 vs 333 kgCO₂e ton of raspberry⁻¹). The difference in per hectare emissions is much higher, mainly due to the absence of mineral fertilizers, but the much higher yield of conventional raspberries (2.7 vs 5.7 tons ha⁻¹) largely offsets this benefit. Relatively large processing emissions due to freezing, which are the same for organic and conventional products, also reduce the advantage of organic raspberries in relative terms. The comparison with the literature is challenging as the carbon footprint of raspberries has never been investigated to our knowledge. Our estimated are within the 0.2-0.8 tCO₂e ton⁻¹ literature range for red fruits. In the food miles case, organic raspberry has almost the same performance than its reference, while significantly better performance is recorded in the water footprint dimension because of the differences related to the production technology (organic vs conventional).

The allocation of labour to production is lower for organic raspberries than for its non-organic reference (conventional raspberries). At the farm level, it takes 145 hours of work to produce a ton of raspberries when the reference product requires 192 hours. The difference (-25%) indicates that the organic product generates fewer jobs than the reference system. The turnover-to-labour ratio indicator provides insight into labour productivity. The average turnover per employee is 60% higher in the organic farm than in conventional ones. These differences are mostly due to the farm's structure, the technical specification of the product and for a part to the geographical conditions. As for the other indicators linked to the social dimension, bargaining power is described in section 2.2, “Bargaining power of farmers and intermediaries”. Lack of bargaining power of farmers about the intermediaries is the same typical obstacle for farmers in both cases (organic and conventional). However, it seems that it is less severe for the organic production.

The education attainment indicator, which refers to the highest level of education that an individual has completed, allows us to measure certain components of social capital indirectly. This indicator is close to 0 if the majority of workers have a primary education level and approaches one as the level of education increases. There is no difference in the profile of education levels between producers of organic product and those of conventional sector. The level of education is dominated by primary (40-42%) and secondary (51-50%) degree. Actually, the educational structure is almost the same for the focused products.

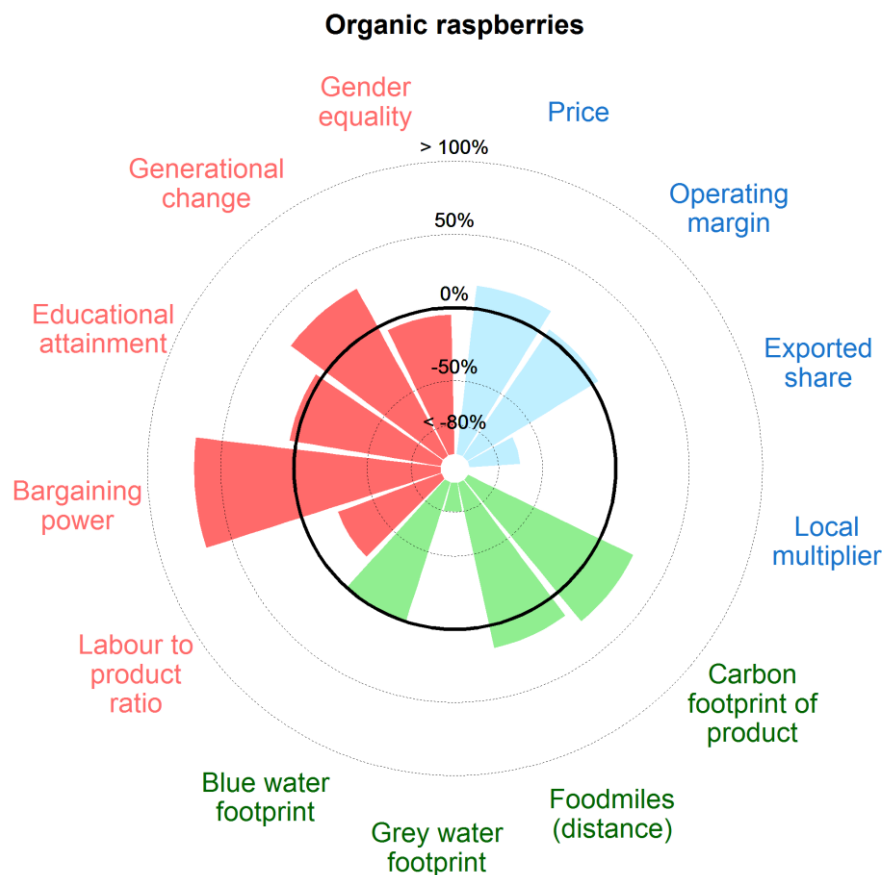


Figure 33. Sustainability performance of Serbian organic raspberries ¹⁶

In the end, it should be noticed that the number of raspberry producers continues to grow, with the same trend in the organic raspberry sector. The producers emphasised that the main challenges they face in keeping up with this trend are:

- (1) non-sufficient preparation for the changeable weather conditions;
- (2) the unplanned increase of the growing areas, which usually have negative effects to yield and income;
- (3) difficulties to find labour during picking season
- (4) a lack of the seedlings of the good quality.

The food safety institutional framework exists, but the implementation of food safety rules is still in its infancy in Serbia. Future improvements could be expected shortly. Both of the mentioned products are faced with this issue. Therefore, the traders, as well as the processors in the food chain, strongly argue for the strict implementation of the internationally standardised rules. The international standards are completely adopted by major exporters in Serbia.

4.2.5. Organic rice (France)

The sustainability assessment of organic PGI rice was implemented through the specific methodology of Strength2Food (Bellassen et al., 2016). The indicators were elaborated by using conventional Camargue rice production as a reference for the economic and the social

¹⁶ Each indicator is expressed as the difference between the FQS and its reference product. For environmental indicators for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower).

dimensions. Environmental indicators were based on a comparison with the non-organic PGI rice chain.

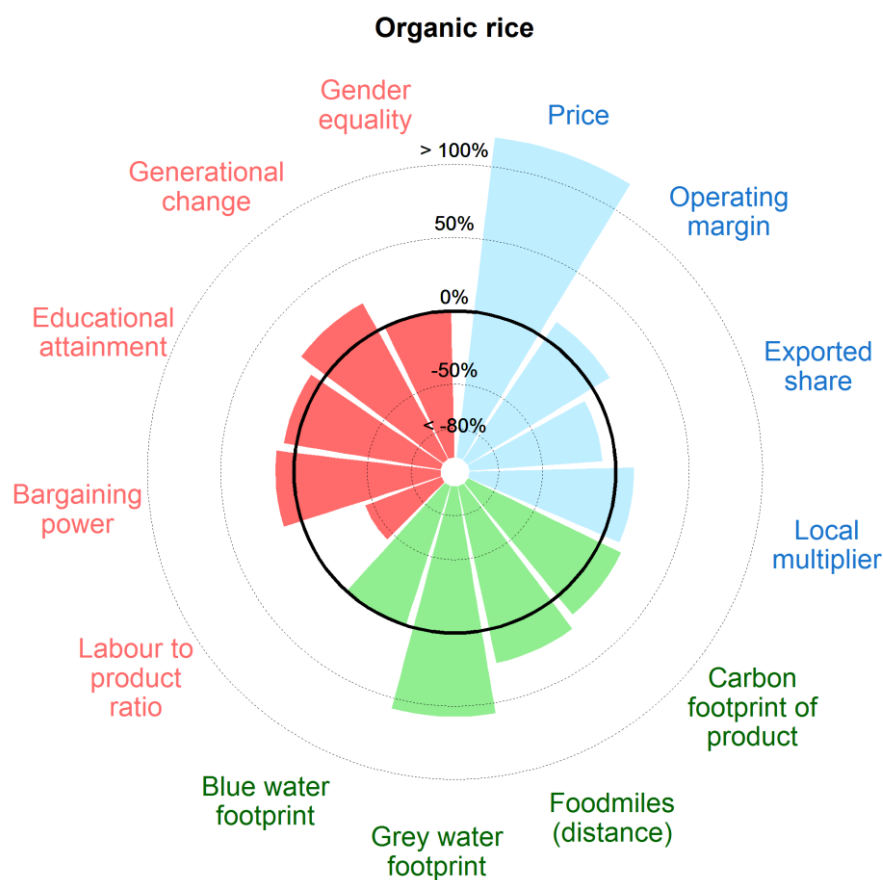


Figure 34. Sustainability performance¹⁷ of organic rice (supply chain averages)

4.2.5.1. Environmental indicators

Carbon Footprint

Considering the environmental indicators investigated in the Strength to Food project, the carbon footprint of organic rice is 16% lower than its reference (0.86 and 1.03 tCO₂e/ton of processed rice respectively). The bulk of the difference is explained by the lower use of fertilizer in organic rice, and in particular the absence of mineral fertilizers banned in the technical specifications. Both products are in the lower part of the literature range – 0.66 to 5.69 tCO₂e/ton (Clune et al., 2017; Odegard et al., 2015) – which is explained by flooding which is only intermittent in Camargue and by the crop-specific estimate of N₂O emissions we use. Indeed, the rice-specific N₂O emission factor is much lower than the default emission factor used in most existing LCAs. Hokazano et al. (2012) find a 33% higher carbon footprint for organic rice in Japan, explained by much higher methane emissions from the flooding techniques which weighs more on the lower yield organic rice. Besides, research programs are underway to refine the understanding of methane emissions linked with the specific rice production system in the Camargue Delta. Further investigation on an extended comparison to

¹⁷ Each indicator is expressed as the difference between the FQS and its reference product. For environmental indicators for which lower is better, the opposite of the difference is displayed (eg. +20% when the carbon footprint is 20% lower).

the whole crop cycle would also be worthy, as conventional and organic systems are based on completely different rotations and lead to different impacts at regional scale.

Food-miles

Concerning food-miles, the organic supply chain was compared to the conventional rice chain of Camargue, France, rice production units to distribution units. Over the entire supply chain, organic rice from Camargue travels 20% shorter distances (1,400 vs 1,700 t.km t⁻¹) and releases 20% less emissions (140 vs 170 kg CO₂e t⁻¹) than conventional rice. This difference is mainly driven by the difference in the supply chain organization on the domestic market. Indeed, organic rice from Camargue is conditioned locally, whereas conventional rice is conditioned farther away. However, the shorter distances travelled by the FQS on the domestic market are partly offset by the larger share of exports of the FQS (20% against 12% for the reference), since the export markets imply longer distances than the domestic market. Similar trends explain the differential in emissions generated by transportation. The distribution level, from rice conditioners to retailers, concentrates most of the kilometres embedded in the product and most of the emissions generated for transportation along the value chain (i.e. more than 95%). Regarding food-miles indicators, organic rice from Camargue is more sustainable than its reference in terms of distance travelled and emissions released at the transportation stage.

Water footprint

Agriculture represents more than 99% of total WF of Camargue rice, therefore processing represents only a negligible part of WF. The organic rice (FQS) has a higher water footprint than the conventional rice (REF), which is mainly explained by the difference in yield per ha between the two systems.

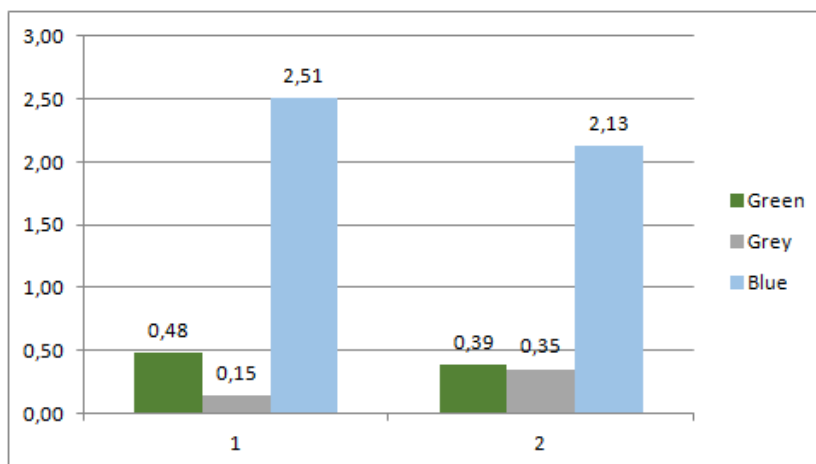


Figure 35. Water footprint of organic rice

The great part of blue water footprint in the indicator is clearly due to the great amount of water that rice requires (Figure 35). The highest value shown by the FQS cultivar in respect to REF is primarily due to the different yield of the two cultivars. Irrigation is lower for FQS than REF and water consumed to make rice cultivation possible (production of fertilizers, pesticides, fuel and so forth) is greater for the reference, but these differences don't compensate the difference in yield.

The grey water footprint is higher for REF. More nitrogen is in fact applied to this cultivar: FQS uses 50 kg/ha of organic nitrogen whereas REF makes use of 150 kg/ha of mineral nitrogen based fertilizers.

The green water footprint is higher for FQS. Being meteorological data and crop parameters assumed to be similar the only factor that contributes to increase this fraction of the indicator for FQS is the lower yield.

Besides the key learnings of the water footprint indicator, it may be underlined that impacts of intensive rice systems on water quality in the Delta is more and more scrutinized by nature protection actors in Camargue. Rice production systems have significantly improved their practices regarding water management in volume according to experts, but the use of pesticides directly impacts natural humid areas where water flux converge and where very high pollution concentration is measured. That is one key reason why low input rice systems raise interest to territorial and natural management institutions.

4.2.5.2. Social indicators

The labour use ratio indicator, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope, 2001). The allocation of labour to production is lower for organic rice than for its non-organic reference (conventional rice in Camargue). At the farm level, it takes 17 hours of work to produce a ton of rice when the reference product requires 25 hours. The difference indicates that the organic rice production generates less jobs than the reference system. Nevertheless, this difference should be nuanced as it only takes into consideration the rice production system. We couldn't take into account in our estimations the fact that farms producing organic rice are more diversified, combining various crops (sunflower, alfalfa etc.) and cattle breeding systems, that generate more employment on the farms.

The turnover-to-labour ratio indicator provides an insight into labour productivity. The average turnover per employee is a bit higher in organic farm than in conventional ones. The productivity levels are much higher at the processing level, with a relative difference of 37% in favour of the organic rice. These differences are mostly due to the price of organic rice, which compensates for the lower yields at the production level.

The profiles of education levels are almost identical between operators of organic rice and those of conventional rice. The level of education is dominated by primary and secondary (60-69%) degrees.

Enterprises interviewed (both organic and conventional millers), particularly underlined the challenges related to education and training of employees in the rice milling sector. Very few cursus specialized on rice exist in France as it represents a small sector at national level, and most employees are trained inside the enterprises. Many enterprises tackled the challenge of transgenerational transmission of knowledge by establishing specific intern programs (mentoring, trainings etc.).

Bargaining Power

The sustainability assessment also explored the bargaining power (BP) along the chain. The organic chain is dominated by the two levels of input suppliers (U1) and storers/millers (P1), which concentrate almost the entire market share. This domination is reinforced by the fact that one of the actors at the U1 level is also operating at the P1 level.

Furthermore, without considering the oligopoly situation at U1 and P1, one can notice the high bargaining power scores obtained at all levels, suggesting that bargaining power positions at all levels are strong. This would imply that changes in the concurrent structure of the U1 and P1 levels wouldn't necessarily translate into a significant evolution in the distribution of bargaining power along the supply chain.

Aside from the supply chains' particular concurrent structure, a decomposition of BP scores shows that the institutional context (existence of supply-chain specific unions or of other professional unions) play a key role for explaining the bargaining of each levels for both the FQS and the reference. On the other hand, factors linked to transaction costs, both in terms of flexibility (prop_contract) and of asset specificity (prod_proc; spec_res), provide a significant contribution at the U1 and U3 levels of for the FQS (with values of 0,67 and 0,78 respectively). The contribution of transaction costs related variables is less significant at the P1 level of the FQS. By way of contrast, the contribution of this category of variables is relatively weak for the reference, excepted at the U3 level (value of 0,67). Similar conclusions apply for the reference, although the domination of leading actors at the U1 and P1 levels is less marked than for the FQS.

Generational change and Gender equality

As regard to the Generational Change and Gender, no separate values could be calculated at the farming stage (U3) for the organic and conventional rice. Based on the evidence that many farms either produce both types of output or have been recently converting their production from conventional to organic, the values of the indicators are assumed to be equal across the Supply Chains or to be not significantly different. However, this evidence should be taken as the result of researchers' hypotheses mainly rather than being completely backed by the opinion of the experts interviewed during the data collection process.

At the farming stage, the values of the indicators calculated suggest that this stage of the supply chains suffers from a limited involvement of young workers, with respect to the older ones. It is a well-known issue that is being addressed through the training of interns and the promotion of sponsorship programs, which are aimed at overcoming the lack of formal training provided by the educational system. Because this transmission of knowledge is de-facto a form of "on-the-job-training", it still requires the involvement of experienced workers in large numbers. The value of the Gender Inequality indicator suggests that rice farming is characterized by limited entrepreneurial and employment opportunities for females.

At the processing stage, the supply chain for organic rice appears to be more sustainable than the one for the conventional product based on both indicators. 15-35 years old are more employed in the organic chain than 45-65 ones. Besides, gender discrimination appears to be much lower in the organic chain, with an equal employment of males and females as well as higher percentages of women achieving secondary education. At the processing level, women are overrepresented in office jobs although their involvement in operational activities has increased over the years, also due to technological progress which has diminished the reliance on physical endurance on the job. One major company in the organic sector

4.2.5.3. Economic indicators

Organic Camargue rice benefits from a price premium all along the value chain. It is quite stable from farmers to retailers, around 130%. It appears to be higher at processing level (158%), but it was not possible to collect information on cost at this stage. At the processing stage (cleaning and milling steps), yields are lower for organic rice but no precise data could be collected as it is considered strategic data by processors. Despite these lower yields and the small size of processing units (and thus higher costs), we can make the hypothesis that profitability remains quite similar to the conventional chain at processing level. At farm level, costs are quite similar in absolute terms, for both intermediate consumption and wages, so considering higher prices and considering slightly higher subsidies for organic rice, profitability is much higher at the crop system level. Moreover, organic rice production is less dependent on subsidies than conventional systems.

These results are nuanced: at the whole rotation level, they may be less differentiated between organic and conventional, as rice is only included every 4 to 5 years in organic against every 1 to 3 years in conventional. Organic alfalfa covers 2 to 3 years in the rotation and provides low margin. Quiedeville 2013 showed that the advantage of the organic system stays slightly positive at rotation level. Since 2013, the profitability of the other crops in organic rotations has sharply increased (high price of organic wheat, sunflower etc.), which is likely to enhance organic comparative profitability at rotation level and to a certain extent explains the high number of organic conversions in the past years.

Concerning exports, organic rice has a higher share of production exported to Europe, twice the conventional one.

The local multiplier effect of Organic Camargue rice is 12.3% higher than its reference product: each euro of turnover for Organic Camargue rice generates 1.29 € of re-spending in the same region versus 1.04 € for the reference. The main driver of these outcomes is the location of the rice farms: for the organic product all the farms are located within the local area; while for the conventional farms, a share of 65% carries out the agricultural activity in the local area. Without local rice farms, the local multiplier would reduce of -34% for the organic rice and -25% for the conventional product. The second main driver is the location of the “other inputs and services” suppliers: without local suppliers, local multiplier would reduce of -14% for the organic rice, and -18% for the conventional one.

REFERENCES

- ADEME, 2017. Agribalyse v1.3 [WWW Document]. URL <http://www.ademe.fr/expertises/produire-autrement/production-agricole/passer-a-l'action/dossier/levaluation-environnementale-agriculture/loutil-agribalyser>
- Almeida, J., Achten, W.M.J., Verbist, B., Heuts, R.F., Schrevens, E., Muys, B., 2014. Carbon and Water Footprints and Energy Use of Greenhouse Tomato Production in Northern Italy: Carbon and Water Footprints, and Energy Use of Tomato Production. *Journal of Industrial Ecology* 18, 898–908. <https://doi.org/10.1111/jiec.12169>
- Basset-Mens, C., van der Werf, H.M.G., 2005. Scenario-based environmental assessment of farming systems: the case of pig production in France. *Agriculture, Ecosystems & Environment* 105, 127–144. <https://doi.org/10.1016/j.agee.2004.05.007>
- Bellassen, V., Giraud, G., Hilal, M., Arfini, F., Barczak, A., Bodini, A., Brennan, M., Drut, M., Dubois de Labarre, M., Gorton, M., Hartmann, M., Majewski, E., Muller, P., Monier-Dilhan, S., Poméon, T., Tocco, B., Tregear, A., Veneziani, M., Vergote, M.-H., Vitterso, G., Wavresky, P., Wilkinson, A., 2016. Methods and indicators for measuring the social, environmental and economic impacts of food quality schemes, Strength2Food project, deliverable 3.2. INRA, Dijon, France.
- Carlson, K.M., Gerber, J.S., Mueller, N.D., Herrero, M., MacDonald, G.K., Brauman, K.A., Havlik, P., O'Connell, C.S., Johnson, J.A., Saatchi, S., West, P.C., 2016. Greenhouse gas emissions intensity of global croplands. *Nature Climate Change* 7, 63–68. <https://doi.org/10.1038/nclimate3158>
- Clune, S., Crossin, E., Verghese, K., 2017. Systematic review of greenhouse gas emissions for different fresh food categories. *Journal of Cleaner Production* 140, 766–783. <https://doi.org/10.1016/j.jclepro.2016.04.082>
- Espinoza-Orias, N., Stichnothe, H., Azapagic, A., 2011. The carbon footprint of bread. *Int J Life Cycle Assess* 16, 351–365. <https://doi.org/10.1007/s11367-011-0271-0>
- Halpern, D. (1999). *Social capital: The new golden goose?* Institute for Public Policy Research, London.
- Hillier, J., Walter, C., Malin, D., Garcia-Suarez, T., Mila-i-Canals, L., Smith, P., 2011. A farm-focused calculator for emissions from crop and livestock production. *Environmental Modelling & Software* 26, 1070–1078. <https://doi.org/10.1016/j.envsoft.2011.03.014>
- Iribarren, D., Moreira, M.T., Feijoo, G., 2010. Revisiting the Life Cycle Assessment of mussels from a sectorial perspective. *Journal of Cleaner Production* 18, 101–111. <https://doi.org/10.1016/j.jclepro.2009.10.009>
- Just, R. E. and R. D. Pope (2001). The agricultural producer: Theory and statistical measurement. *Handbook of Agricultural Economics*, 1, 629–741.
- Killian, B., Rivera, L., Soto, M., Navichoc, D., 2013. Carbon Footprint across the Coffee Supply Chain: The Case of Costa Rican Coffee. *Journal of Agricultural Science and Technology B* 3 151–170.
- Kool, A., Blonk, H., Ponsioen, T., Sukkel, W., Vermeer, H.M., Vries, J.W. de, Hoste, R., 2009. Carbon footprints of conventional and organic pork. Assessments of typical production systems in the Netherlands, Denmark, England and Germany. *Blonk Milieu Advies [etc.]*, Gouda [etc.].
- KWIN (2015). KWIN-AGV 2015 report
- Lesschen, J.P., van den Berg, M., Westhoek, H.J., Witzke, H.P., Oenema, O., 2011. Greenhouse gas emission profiles of European livestock sectors. *Animal Feed Science and Technology* 166–167, 16–28. <https://doi.org/10.1016/j.anifeedsci.2011.04.058>

- Lindenthal, T., Markut, T., Hörtenhuber, S., Rudolph, G., Hanz, K., 2010. Klimabilanz biologischer und konventioneller Lebensmittel im Vergleich. *Ökologie und Landbau* 153, 51–54.
- Lončar, D. & B. Ristić (2011), “Analysis of Competition and Market Concentration in the Dairy Sector in Serbia”, *Ekonomika preduzeća*, Vol. 59, No. 1-2, pp. 125-142.
- Maina, J., Mutwiwa, U., Gareth, K., Githiru, M., 2016. Evaluation of Greenhouse Gas Emissions along the Small-Holder Coffee Supply Chain in Kenya 2, 111–120.
- Meier, M.S., Stoessel, F., Jungbluth, N., Juraske, R., Schader, C., Stolze, M., 2015. Environmental impacts of organic and conventional agricultural products – Are the differences captured by life cycle assessment? *Journal of Environmental Management* 149, 193–208. <https://doi.org/10.1016/j.jenvman.2014.10.006>
- Meisterling, K., Samaras, C., Schweizer, V., 2009. Decisions to reduce greenhouse gases from agriculture and product transport: LCA case study of organic and conventional wheat. *Journal of Cleaner Production* 17, 222–230. <https://doi.org/10.1016/j.jclepro.2008.04.009>
- Noponen, M.R.A., Edwards-Jones, G., Hagggar, J.P., Soto, G., Attarzadeh, N., Healey, J.R., 2012. Greenhouse gas emissions in coffee grown with differing input levels under conventional and organic management. *Agriculture, Ecosystems & Environment* 151, 6–15. <https://doi.org/10.1016/j.agee.2012.01.019>
- Odegard, I., Bijleveld, M., Naber, N., 2015. Food Commodity Footprints. Global GHG footprints and water scarcity footprints in agriculture. CE Delft, Delft, The Netherlands.
- Pelletier, N., Tyedmers, P., 2007. Feeding farmed salmon: Is organic better? *Aquaculture* 272, 399–416. <https://doi.org/10.1016/j.aquaculture.2007.06.024>
- Putnam R.D. (2000) *Bowling Alone: America’s Declining Social Capital*. In: Crothers L., Lockhart C. (eds) *Culture and Politics*. Palgrave Macmillan, New York.
- RIAS Inc., 2016. Comparing the Environmental Footprint of B.C.’s Farm-Raised Salmon to Other Food Protein Sources. BC Salmon farmers association.
- Rinaldi, S., Barbanera, M., Lascaro, E., 2014. Assessment of carbon footprint and energy performance of the extra virgin olive oil chain in Umbria, Italy. *Science of The Total Environment* 482–483, 71–79. <https://doi.org/10.1016/j.scitotenv.2014.02.104>
- Röös, E., Karlsson, H., 2013. Effect of eating seasonal on the carbon footprint of Swedish vegetable consumption. *Journal of Cleaner Production* 59, 63–72. <https://doi.org/10.1016/j.jclepro.2013.06.035>
- Röös, E., Sundberg, C., Hansson, P.-A., 2011. Uncertainties in the carbon footprint of refined wheat products: a case study on Swedish pasta. *The International Journal of Life Cycle Assessment* 16, 338–350. <https://doi.org/10.1007/s11367-011-0270-1>
- Ruini, L., Ferrari, E., Meriggi, P., Marino, M., Sessa, F., 2013. Increasing the Sustainability of Pasta Production through a Life Cycle Assessment Approach, in: Prabhu, V., Taisch, M., Kiritsis, D. (Eds.), *Advances in Production Management Systems. Sustainable Production and Service Supply Chains*. Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 383–392. https://doi.org/10.1007/978-3-642-41263-9_48
- SARF, 2012. Carbon Footprint Of Scottish Suspended Mussels And Intertidal Oysters (No. SARF078). Scottish Aquaculture Research Forum.
- Wang, X., Zou, C., Zhang, Y., Shi, X., Liu, J., Fan, S., Liu, Y., Du, Y., Zhao, Q., Tan, Y., Wu, C., Chen, X., 2018. Environmental impacts of pepper (*Capsicum annuum* L) production affected by nutrient management: A case study in southwest China. *Journal of Cleaner Production* 171, 934–943. <https://doi.org/10.1016/j.jclepro.2017.09.258>
- Warner, D.J., Davies, M., Hipps, N., Osborne, N., Tzilivakis, J., Lewis, K.A., 2010. Greenhouse gas emissions and energy use in UK-grown short-day strawberry (*Fragaria xananassa*

Duch) crops. The Journal of Agricultural Science 148, 667–681.
<https://doi.org/10.1017/S0021859610000493>

Winther, U., Ziegler, F., Skontorp Hognes, E., Emanuelsson, A., Sund, V., Ellingsen, H., 2009. Carbon footprint and energy use of Norwegian seafood products (No. SFH80 A096068). SINTEF.



The Strength2Food project in a nutshell

Strength2Food is a five-year, €6.9 million project to improve the effectiveness of EU food quality schemes (FQS), public sector food procurement (PSFP) and to stimulate Short Food Supply Chains (SFSC) through research, innovation and demonstration activities. The 30-partner consortium representing 11 EU and four non-EU countries combines academic, communication, SMEs and stakeholder organisations to ensure a multi-actor approach. It will undertake case study-based quantitative research to measure economic, environmental and social impacts of FQS, PSFP and SFSC. The impact of PSFP policies on nutrition in school meals will also be assessed. Primary research will be complemented by econometric analysis of existing datasets to determine impacts of FQS and SFSC participation on farm performance, as well as understand price transmission and trade patterns. Consumer knowledge, confidence in, valuation and use of FQS labels and products will be assessed via survey, ethnographic and virtual supermarket-based research. Lessons from the research will be applied and verified in 6 pilot initiatives which bring together academic and non-academic partners. Impact will be maximised through a knowledge exchange platform, hybrid forums, educational resources and a Massive Open Online Course.

www.strength2food.eu

