Long-term sustainability assessment of market-gardening farms involved in short supply chains: a case study in South of France

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Abstract

In France, one market-gardening farm in two is nowadays involved in short supply chains (SSC). Involvement in SSC has been proved to be a driver of farming system modifications and can therefore affect farm sustainability. Impacts of SSC at farm scale have been however little assessed at medium and long term. Our study aimed therefore at analysing why and how market-gardening farms involved in SSC evolved over time and at assessing current farm sustainability. Comprehensive interviews were conducted from April to July 2015 in 28 market-gardening farms located in two areas of South of France to describe and analyse their evolution trajectories from the time when they were first involved in SSC up to nowadays. Current functioning was analysed as well and combined with a sustainability assessment. We fund that farm strategies and evolution trajectories differed mainly by the intensity of SSC use, the complexity of the marketing strategy, the level of crop diversity and the intensity of input use. Farms the most involved in SSC displayed the better agro-ecological sustainability and a higher contribution to local economy and life. The economic assessment resulted in contrasted scores depending on farm types and sustainability components but the available farming income was a share issues within the surveyed farms. The social assessment highlighted mediocre working conditions but life quality was assessed as correct to good by the farmers. We highlighted a high diversity of situations, regarding evolution trajectories and current farm functioning, and this diversity affected sustainability assessment results.

1. Introduction

Short supply chains (SSC), defined as chains based on no to one intermediary between the producer and the consumers, have known a significant development over the past fifteen years and represent according to the sources 6 to 15% of food purchases nowadays in France (Allain, 2015; Chiffoleau, 2016). One farm in five is today involved in SSC and this share achieves one in two regarding market-gardening farms (Rosenwald, 2012). In addition, one market-gardening farm in three markets at least three quarters of its production through SSC (Rosenwald, 2012). Social and economic sustainability at the territorial scale are generally emphasized (Traversac & Kébir, 2009; Kneafsey *et al.*, 2013): a higher multiplier effect on local economies is described, as well as impacts on maintaining local employment. On the other hand, environmental sustainability remains discussed: for instance, local appears not to be a sufficient feature to ensure a reduction in greenhouse gas emissions (Redlingshöfer, 2008; Kneafsey *et al.*, 2013). Impacts at farm scale remain discussed as well: for example SSC are said to allow to retain a higher share of value added, whereas higher labour inputs and possible higher production costs are described (Chiffoleau, 2008; Traversac & Kébir, 2009; Kneafsey *et al.*, 2013). Moreover, involvement in SSC has been proved to be a driver of farming system modifications and affect therefore farm sustainability (Navarrete, 2009; Aubry *et al.*, 2011; Lamine *et al.*, 2014; Navarrete *et al.*, 2015). Producers involved in SSC combine different activities (at least production, marketing and promoting) and combine often different marketing chains (including long and short supply chains) (Kneafsey *et al.*, 2013) making farm management more complex and increasing workload. In addition, in market-gardening farms, a growing involvement in SSC is said to go hand in hand with crop diversification in order to provide a range of products fitting consumer requirements (Navarrete, 2009; Aubry *et al.*, 2011). Such a crop diversification also adds complexity to farm management but can result in crop management simplification (Aubry *et al.*, 2011). Besides, marketing standards are said to be more flexible regarding cosmetic standards but more demanding regarding taste, which can foster changes in crop management (Bressoud, 2010). Combined with crop diversification, this has been described in some cases to lead directly or indirectly to input use reduction (Navarrete, 2009; Bressoud, 2010; Aubry et al., 2011; Petit, 2013). All these observations remain scattered and were not assessed at medium and long term: there is a lack of baseline and horizontal data to discuss thoroughly the benefits and drawbacks of SSC at different scales (Kneafsey *et al.*, 2013). Our studies aimed therefore (i) at analysing why and how market-gardening farms involved in SSC evolve over time and (ii) at assessing their current sustainability.

2. Material and Method

2.1 Data collection: surveys on market-gardening farms in the south of France

Comprehensive surveys were conducted from April to July 2015 in 28 market-gardening farms located in two areas of South of France which represented different dynamics: the Roussillon plain (1), located around Perpignan (urban area of about 305 900 inhabitants), and the peri-urban area around Toulouse (urban area of 1 270 800 inhabitants) (2). The Roussillon plain, located in the Eastern Pyrenees plain used to be a major market-gardening production basin in France and hosts the Saint Charles international hub for marketing, transport and logistics of fruits and vegetables. The production basin is however nowadays in decline. The peri-urban area of Toulouse is influenced by the presence of a major urban area and by the presence of a national wholesale market. Farms were sampled according to the following criteria: (i) market-gardening represented a significant share of the farm income generating activity (at least 50% of the

revenue), (ii) farmers managed the farm for at least five years. In addition, the sample was built to cover a range in marketing strategies (SSC with no intermediary, SSC with one intermediary, long supply chain (LSC)) and in crop management styles (conventional, low input, organic farming). Farm sampling in the Roussillon plain benefited from surveys carried out in 2006 (Godard, 2006) or 2010 (Demarque, 2010).

Figure 1: Location of the studied areas. 1: the Roussillon plain, 2: the Toulouse peri-urban belt.
(Source : © Geoportail)

Table 1: Main characteristics of the sampled farms

	1: Roussillon plain	2: Toulouse peri-urban belt
Average farm size		
Total	9 ha	15.5 ha
In market-gardening	2.9 ha	4.8 ha
Under shelters[1]	1.1 ha	0.4 ha
Number of workers (Annual Work Unit AWU)	3.6 AWU	2.9 AWU
Other farming activity	Arboriculture (73%) Viticulture, Livestock: poultry, pigs; Plantlet production; Aromatic plants	Grain crops (38%) Arboriculture Plantlet production Horticulture
Crop management style		
Organic farming	8	6
Low input	0	3
High input	7	5
Marketing chains		
Direct SSC	10	12
SSC with one intermediary	7	9
LSC	9	5

[1] unheated high plastic tunnels or multispan plastic greenhouses with soil cultivation

The interviews were semi-structured in order to collect both quantitative and qualitative data. They lasted from 1 to 2.5 hours and were recorded. We characterized the current functioning regarding farming systems, labour organization, and marketing outlets with factual data. We also examined farmers' reasons for the current situation. We characterized as well how and why the farm evolved since SSC were first used. Four main topics were questioned as follows. (i) The overall characteristics of the farm were described: general history, objectives, family, main activities. (ii) The various marketing chains were described by their type, relative importance and distinctive features (e.g. number of intermediaries, location, standards, use of resale, etc.). (iii) The market-gardening cropping systems were described by the cropped species, the spatial and temporal organisation and the crop technical management. Pest and disease management was recorded in more detail because it is a major bottleneck of market-gardening with a focus on four species: tomato, cucumber, melon and lettuce. (iv) Production means, including land, equipment and labour, were questioned. Information on labour included the number and types of workers and labour organisation. In addition, specific questions were asked to assess current farm sustainability regarding (i) working conditions: workload, peak work periods and satisfaction at work, (ii) economic results: current farmer income, satisfaction regarding treasury and financing ability. Farmers were questioned as well about the main difficulties they faced (technical, economic, organisational, etc.) and about their projects for the farm (regarding production, commercialisation, equipment, etc.).

2.2 Analysis of farming systems and farm sustainability assessment

a. Analysis of farming systems

We built a farm typology to characterize current farm functioning (Landais, 1998; Alavarez *et al.*, 2014). Based on the surveys, each farm was portrayed through three set of variables describing (i) the marketing strategy, (ii) the agronomic strategy, and (iii) the farm production means and other structural characteristics. The marketing strategy described the marketing chain or the combination of marketing chains used in the farm, as well as the main features of the chains. The agronomical strategy was defined with a focus on the market-gardening activity by the crop nature, their organization in time and space and their management. Farm production means included labour, land and equipment. Three successive multiple correspondence analysis (Baccini & Besse, 2004) were performed using R software (R version 3.1.2, package FactoMineR; R Core Team, 2014) to identify the variables that discriminate farms the most. The first analysis allowed identifying the discriminant variables regarding marketing strategy. The second analysis allowed the same regarding agronomic strategy. The third and final analysis used the previous analysis results to include variables from the three sets (Table 2). Based on the selected variables, theoretical types were identified and described.

Table 2: Variables used to describe farm functioning

	Variable	Variable description
Marketing strategy	Share of SSC	1 : SSC in minority, only direct sale, 2 : average share of SSC, 3 : SSC dominant, combined with LSC, 4 : only SSC
	Combination type	1 : only one SC, 2 : from 2 to 4 SC, combining SSC and LSC, 3 : from 2 to 4SSC, 4 : more than 5 SC, short and long
	Use of resale	0 : no, 1 : yes
Agronomic strategy regarding MG[1] crops	Crop diversity	Weak : 2 to 5 species, Average : 6 to 17, seasonal difference, High : 15 to 30, all year long, Very high : more than 30
	Crop spatial organization	Balanced, With niches, Specialized
	Use of crop rotation	None, Only for specific crops, Occasional, Systematic
	Crop protection[2]	1 : chemical pesticide only, used systematically or after detection, 2 : chemical pesticide and biological control products, used systematically or after detection, 3 : biological control products only, used systematically or after detection, 4 : biological control products used only after detection or no intervention
Structural characteristics	MG[1] area / total farming area	1 : 0 to 30%, 2 : 31 to 60%, 3 : 61 to 100%
	Sheltered crop area / MG[1] area	1 : 0 to 10%, 2 : 0.11 to 0.30%, 3 : 0.31 to 100%
	Other farming activity	None, Grain crops, Perennial crops, Diverse

[1]: market-gardening; [2:] focus on tomato, cucumber, melon and lettuce

b. Farm sustainability assessment

To our knowledge, no existing assessment methods account for the specific features of market-gardening farms (e.g. diverse production systems including protected crops, high crop diversity, lower field and farm size, diverse marketing chains, labour intensive systems , etc.). We therefore built a sustainability assessment framework based on existing French methods, namely the IDEA method (Zahm *et al.*, 2007, 2008), the GEDEAB method (Favreau, 2013) and the RefAB framework (Fourrié *et al.*, 2013). We also used the framework proposed by Navarrete *et al.* (2015) for market-gardening systems. Our assessment framework included three dimensions, the agro-ecological dimension, the economic dimension and the socio-territorial dimension, 10 components and 28 indicators, as shown in Table 3. The components and the indicators (including the scoring system) were either directly or indirectly derived from the methods and frameworks cited hereinabove. When necessary, they were adapted to the studied farming systems and to the data available from the surveys. Each indicator was quantified with a numerical score and the scores of indicators belonging to the same component were added. Assessment results were analysed in two ways: (i) scores were computed for each component and each farm and (ii) for each farm type of the functional typology.

2.3 Evolution trajectory analysis

Timelines were built for each surveyed farmer according to Moulin *et al.* (2008) to represent for each of the four questioned topics how the farming system changed, *i.e.* the evolution trajectory. Timelines displayed evolutions of the marketing strategy, of the agronomical strategy and of the production means. Interactions between marketing, agronomical and/or production means dimensions were shown as well. Coherence phases were defined on the timelines as periods where the marketing strategy and the agronomical strategy were relatively stable and consistent. Coherence phases referred therefore to a general coherence of farm organisation and management (Moulin *et al.*, 2008). We hypothesized that the evolution of marketing strategies on one hand and of agronomic strategies on the other hand were key elements to analyse farming system evolutions. We therefore built an a priori typology of evolution trajectories based on these two items. In addition, we described the main characteristics of the farms representing each theoretical type including farm overall characteristics and farm production means as well. Motor of changes, either influenced by the external environment (climatic event, price evolutions, regulations, marketing opportunities, etc.) or internal to the farming system (technical or organizational issue, change regarding the household, etc.), were identified from the farmer speech and showed on the timelines.

Table 3: Farm sustainability assessment framework

Component	Indicator	Definition	Best score	Source
Agroecological dimension				
Diversity	Diversity of annual crops	Number of annual species cropped per year at farm scale	12	1*
	Diversity of perennial crops	Number of perennial species at farm scale	8	1**
Organisation of space	Practices in favour of biodiversity	e.g.: plantation of hedges or flower strips, presence of fallow areas	6	1-4***
	Cropping pattern	Crop spatial allocation: specialised, with niches, balanced	7	1**
	Crop rotation	Type of crop rotation: none, for specific crops only, irregular, systematic	7	2-4**
Farming practices	Crop protection practices	Dependence to chemical pesticides: pesticide type, systematic use or not	12	1**
	Soil organic matter management	Frequency and type of organic matter inputs	8	1**
	Use of fossil inputs	Dependence to fossil inputs: fertilizers, plastic mulch (including recycling)	10	
Economic dimension				
Income	Farmer income	Available income per non salaried worker (compared to national legal minimum wage)	20	1**
Robustness	Production diversity	Share of the main crop	8	1
	Marketing chain diversity	Share of the main client, use of direct sale	6	1*
	Farm activity diversity	Presence of other activity/ies than market-gardening (including agri-tourism, commerce)	4	3**
Autonomy	Autonomy regarding inputs	Intensity of external input use (seeds and plantlets, fertilisers and manures, pesticides)	4	1-3***
	Autonomy regarding land	Share of land in property	2	
Independence	Treasury	Farmer satisfaction regarding the farm treasury	4	4***
	Financial ability	Farmer satisfaction regarding the farm financial ability	4	
Socio-territorial dimension				
Working conditions	Workload	Nb of hours per week (compared to 40h)	10	3*
	Work intensity	Nb of overloaded weeks per year (compared to 10)	10	1*
	Status of workers	Intensity of volunteer, family or seasonal work	5	3**
	Collective work	Use of collective equipment or services, involvement in professional networks	5	1*
Quality of life	Satisfaction	Estimation from farmer speech	10	1*
	Technical satisfaction	Estimation from farmer speech	10	
	Adaptation capacity	Farmer adaptation regarding weather or economical hazards, or other difficulties	2	3***
	Transferability perspectives	Probability of farm existence within 10 years	3	1*
Contribution to local economy and life	Contribution to employment	Land per worker; job creation for 5 years	8	1**
	Use of SSC	Share of SSC	8	2
	Multifunctionality	Presence of agri-tourism, pedagogical farm	4	1*
	Social involvement	Involvement in local professional networks, presence of on-farm direct sale	5	2*

1: Zahm *et al.*, 2007, 2008; 2: Favreau, 2013; 3: Fourrié *et al.*, 2013; 4: Navarrete *et al.*, 2015
*** indicates that the attribute targeted by the indicator was derived from previous work(s) whereas the indicator definition, calculation mode and parameters were created for our study; ** indicates that the indicator calculation mode and parameters were adapted for our study; * indicated that only the indicator parameters were adapted.

3. Results

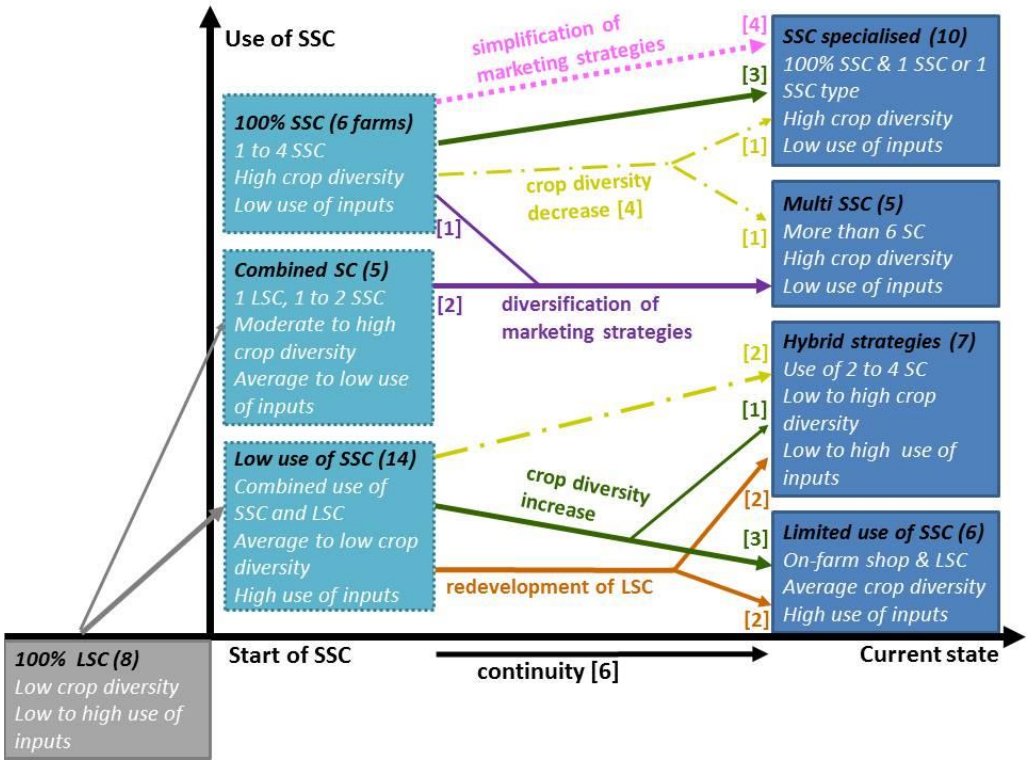

Figure 2: Evolution trajectories and current farm functioning of the 28 farms studied. Left boxes display theoretical farm types when they start to use SSC. Right boxes display current theoretical farm types. The number of farms per type is displayed between brackets. The six evolution trajectories are displayed between the boxes. The number of farms per trajectory is displayed between square brackets.

3.1 Analysis of current farm functioning and of farm sustainability

The multiple correspondence analysis highlighted six discriminant variables. Two variables described the marketing strategy: the 'combination type' and the 'share of SSC'. The others described the agronomic strategy with variables referring to the level and the organisation of crop diversity (crop spatial organisation, crop diversity, use of crop rotation) and the variable describing crop protection, which was used as an indicator of the level of input use. Four current farm types were built based on these variables (Figure 2). In addition to differences regarding marketing and agronomic functioning, they also differed regarding production means. They differed as well regarding sustainability assessment results (Table 4).

The first type, named **'Limited use of SSC'**, grouped together six farms that combined on-farm sale with LSC. They were the biggest farms of the samples regarding the total farming area (median: 18 ha) and the number of workers (median: 6.2 annual work units AWU). The share of sheltered crops was low (<15%). Another farming activity was important regarding the dedicated area or the share within the revenue: arboriculture (three farms), grain crops (two farms), and aromatic plants (one farm). Crop diversity regarding market-gardening crops on one hand and regarding perennial crops on the other hand was low to moderate. These farms used on average a high input management style. One farm had recently converted to organic farming but still relied on a high use of organic inputs. As a consequence to the cited characteristics regarding crop diversity and input use, agro-ecological sustainability results were mediocre. Socio-territorial sustainability was contrasting. Working conditions were assessed as mediocre due to high

workloads. On the opposite, the contribution to local economy was assessed as moderate and life quality was assessed as correct. Economic sustainability was contrasted as well. Autonomy was assessed as poor. On the opposite, results regarding income and economic robustness were average, and economic independence was assessed as correct.

The second type, named **'Hybrid strategies'**, grouped together seven farms that displayed a balanced combination of SSC and LSC since LSC appeared to be as important as SSC based on the farmer speech. SSC with one intermediary were frequently used and sometimes combined with direct sale (market or on-farm shop). Total farming area amounted 3.2 ha and was lower than the sample median value. Market-gardening occupied on average 50% of the total area. The number of workers amounted to 2 AWU that corresponded to the sample median value. Assessment results were closed to the one of the first group regarding agro-ecological and socio-territorial sustainability. As for economic sustainability, results were close regarding robustness and autonomy but lower regarding income and independency.

The third type, names **'Multi SSC'**, combined LSC and SSC as well but stood out since it grouped together five farms that combined various SSC including direct sale (on-farm shop, on-farm picking market) and SSC with one intermediary (grocer, collective producer shop, out-of-home catering). Total farming area (median: 11.4 ha) and number of workers (median: 4 AWU) were higher than the sample median values. The share of market-gardening area in the total farming was high and amounted 70%. On the opposite, the share of sheltered crops was low (<10%). This type included four organic farms out of five and the fifth one used low inputs. Assessment results regarding agro-ecological sustainability were therefore good. Results regarding working conditions were poor and similar to the previous types whereas life quality and contribution to local economy were good and similar or better to the previous types. As for economic sustainability, robustness and autonomy were assessed as good but income and independency were assessed as mediocre.

The fourth type, named **'SSC specialized'**, grouped together ten farms that were involved only in SSC and that used either a unique SC based on direct sale (CSA (Community Supported Agriculture) network, on-farm shop) or only one type of SSC (CSA networks, grocers). Eight farms out of ten were involved in CSA networks. Except to one farm with a large area dedicated to grain crops, they were characterized by low farming areas (median: 3.1 ha). Market-gardening occupied 50% of the total area and the share of sheltered crops was average. The number of workers amounted to 2 AWU. This type included seven organic farms and two farms using low inputs to fulfil the CSA network standards. Four farmers began their activity between four to six years ago. A particular profile was included in this group. It was a farmer close to retirement who used to combine a LSC with an on-farm shop and who currently maintained the on-farm shop only but was involved at the same time in his son business. Sustainability assessment results were closed to the ones of the previous group. The most significant difference concerned economic independence, which was assessed as better and could be related to the important presence of CSA networks in this group.

Table 4: Farm sustainability assessment results. Each score is relatively coloured from red to green based on the best scores defined for each component.

	Agroecological dimension			Economic dimension				Socio-territorial dimension		
	Diversity	Organisation	Farming practices	Income	Robustness	Autonomy	Independence	Working condition	Life quality	Local
Best score	***20***	***20***	***30***	***20***	***18***	***6***	***8***	***30***	***25***	***25***
1-Limited SSC	6	5	8	9	9	2	6	9	17	12
2-Hybrid	6	4	11	5	7	3	3	7	14	13
3-Multi SC	16	13	23	6	15	5	3	8	17	17
4-SSC specialized	12	15	21	6	14	4	5	11	20	15

3.2 Evolution trajectories

We characterized six evolution trajectories (Figure 2). Examples for each trajectory are displayed in Figure 3. Three main change drivers were identified from the evolution trajectories: opportunities (access to new chains, farm extension), dissatisfaction regarding how SC worked, difficulties regarding crop management or labour organization.

Two trajectories depicted mainly changes related to the level of crop diversity. The most encountered trajectory (seven farms) depicted **an increase in the level of crop diversity** (example in Figure 2a). Two types of farms were concerned. The first type grouped together farms that used to market through LSC only before developing an on-farm shop. They diversified crops to supply the on-farm shop but the use of SSC in the farm remained on average limited. Crop management was based on a high use of inputs all along the trajectory. They belonged currently to the types 'Limited use of SSC' and 'Hybrid strategies'. The second type grouped together farms dedicated to SSC that increased crop diversity to supply CSA networks or an on-farm shop as unique marketing chain. In that case, crop management was mainly based on a low use of inputs all along the trajectory. They belonged currently to the type 'SSC specialized'. On the opposite, four farm evolution trajectories were marked by **a reduction in the level of crop diversity** (example in Figure 2b). In these farms, SSC with one intermediary were present or dominant. They highlighted also total farming areas and market-gardening areas lower than the sample averages. In two farms, the reduction in crop diversity was related to the development of a resale activity combined with a production volume increase for the remaining crops. They belonged currently to three different types: 'Limited use of SSC', 'Hybrid strategies' and 'Multi SSC'.

Regarding marketing, three trajectories were observed. First, four farms **simplified their marketing strategy** to supply one or two CSA networks and belonged currently to the type 'SSC specialised' (example in Figure 2c). In two cases, it went along with an increase in crop diversity and a reduction in input use to fulfill the CSA network standards. On the opposite, three farms **diversified their marketing channels** (example in Figure 2d): they were from the beginning significantly or entirely involved in SSC but increased the number of SSC types in their strategies and belonged currently to the type 'Multi SSC'. They were also characterized by the use of SSC with one intermediary and/or of a LSC. They had the organic farming label or used little inputs. They highlighted total farming areas and market-gardening areas higher than the sample averages. Lastly, four farms depicted **a redevelopment of LSC** in their marketing strategy (example in Figure 2e) and currently belonged to the types 'Limited use of SSC' or 'Hybrid strategies'. Two types of farms were concerned. The first type was specialized in one crop (tomato, with several tomato types and varieties) or one crop type (aromatic plants) and took advantage of a commercial niche. Farming area was higher than the sample average. The second type stopped the use of SSC for the moment due to personal issues.

Eventually, the trajectory names 'Continuity' grouped together the remaining six farms because no noteworthy changes except adjustments were visible. Two types of farms were concerned. Most of them combined SSC and LSC, highlighted high total farming area and had another farming activity (arboriculture, horticulture or viticulture). The others were recent farms specialized in market-gardening and used mainly direct sales (CSA, market, baskets).

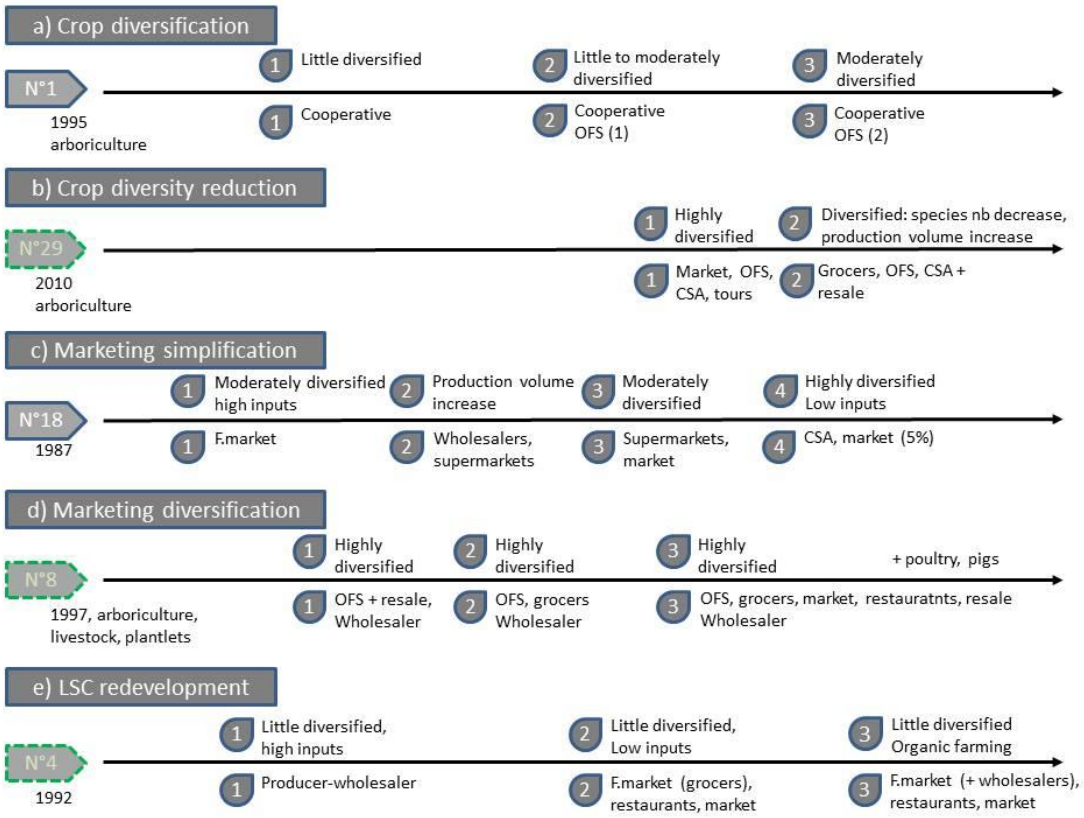

Figure 2: Examples of farm evolution trajectories. Beyond the farmer number is the installation year. Green and dashed numbers indicate organic farming. Main traits of the marketing strategy and of the agronomical strategies are displayed respectively above and under the timeline. OFS: on-farm sale; CSA: Community Supported Agriculture; F.market: farmer market within wholesale market.

4. Discussion and conclusion

Our results highlighted a high diversity of situations, regarding the evolution trajectories, the current farm functioning and the sustainability assessment results. We observed diverse configurations of involvement in SSC and in two farms out of three, one or several SSC were combined with LSC. We therefore observed a SSC-LSC continuum comparable to the local-global continuum highlighted by Brunori *et al.* (2016). Compared to the farms of the samples that used to be involved in LSC only, market-gardening farms involved in SSC were more diverse and more complex. However, the level of diversity and complexity differed strongly according to the farm profiles. Regarding marketing strategy, the less complex farms belonged to the type 'Limited use of SSC' and paradoxically also to the type 'SSC specialized', *i.e.* to opposite types regarding the involvement in SSC. Farms within these types differed also strongly regarding other criteria, with on one hand large farms with an important workforce and a limited crop diversity, and on the other hand small diversified farm with a limited workforce. Half of the farmers of the 'SSC specialized' type were involved in simplification trajectories regarding marketing or crop diversity,

which was probably related to their limited means regarding land and labour. Farmers of the 'Multi SSC' type managed the most complex marketing strategies but they described their strategies as a way to limit risks. These farms could count as well on a transitional workforce compared to the other types. We hypothesised that such a risk limitation was important for them since market-gardening occupied on average 70% of the farming area, which was relatively large. Regarding wine production, Touzard et al. (2016) observed as well at farm or cooperative level strategies mixing local and global chains that were justified by the reduction of local and global risks. 'Hybrid strategies' were actually hybrid regarding the marketing strategy and were transitional in our sample regarding the level of crop diversity and the level of input use. However, they were closed to the 'SSC specialized' type based on farm production means. It should be noted that four farmers chose to redevelop LSC, either as an economic choice, or for personal reasons. A fifth farmer went further and gave up SSC; he was therefore not included in the final sample. He was close to retirement and said that he wanted to make time for his family. There were in total five trajectories that pointed out how events from the personal and family life could affect marketing choices.

Differences in farm functioning and strategies resulted in differences in sustainability assessment results. Farms belonging to the types 'Multi SSC' and 'SSC specialized' displayed on average the best results regarding agro-ecological sustainability, economic robustness, economic autonomy and contribution to local economy. It should be noted however that there was some heterogeneous results within the types. It should be also noted that the use of SSC caused a reduction of input use in only two cases and such a reduction was related to the standards of CSA networks. On the opposite, two farms converted to organic farming to get access to LSC. Most farms strongly involved in SSC did use organic or low input management style but they did so from the beginning. We nuanced however our analysis since our surveys did not focus specifically on crop management style and was maybe too vast to track down every changes regarding crop management. In any case, diversifying crops did not appear to allow directly an input reduction. Besides diversity and crop protection, differences were noticeable as well regarding soil fertility management (studied through soil organic matter management) and were in favour of the 'Multi SC' type. This type and the 'SSC specialized' type displayed better results regarding the use of fossil resources (studied through the use of chemical fertilizers and plastic mulch). Our analysis did not include logistic aspects and their impact on the use of fossil resources. However, in the surveyed sample, SSC were local chains as well based on a 100 km radius.

As for the other sustainability dimensions, farms belonging to the types 'Multi SSC' and 'SSC specialized' displayed as well on average the best results regarding economic robustness, economic autonomy and contribution to local economy. On the opposite, regardless of the types, most farms displayed similar sustainability issues regarding income and working conditions, although life quality was assessed as correct to good. This apparent contradiction pointed out the need to put assessment results in perspective with farmers' global aspirations and with the means implemented to meet their aspirations. This is in accord with the proposition of Galli et al. (2016) to further develop the combination of hard, i.e. quantitative, and soft, i.e. qualitative indicators.

To go into the economic analysis in depth, our study would have benefited from an analysis of the economic efficiency but our survey targeted a static and a dynamic analysis carried out on complex farms and did not allow including that dimension. However, the static and dynamic analysis complemented one another and the dynamic analysis brought a different perspective to the sustainability assessment. Analysis of the evolution trajectories in our samples showed that several farms went across difficulties due to internal (technical, organisational or personal issues) or external (e.g. extreme weather event, drop in prices, land pressure) issues. They proved

however to be resilient since they were still in activity, although the future of at least one farm was seriously questioned. Yet, the main change drivers identified from the evolution trajectories referred to two types of flexibility (Chia & Marschesnay, 2008). The motor named 'opportunities' (access to new chains, farm extension) referred to a proactive flexibility. On the opposite, the motors 'dissatisfaction regarding how SC worked' and 'difficulties regarding crop management or labour organization' referred to a reactive flexibility. Within the observed trajectories, both type of flexibility frequently alternated, although some farmers could be qualified as more proactive based on the change drivers they cited. Combining the static and the dynamic analysis allowed to identify in each type and following Darnofer et al. (2010): (i) farms involved in an exploitation strategy that were in a relatively stable phase, (ii) farms involved in an absorption strategy facing external changes without modifying strongly their functioning, (iii) farms involved in an adjustment strategy, and (iv) farms involved in a transformation strategy characterised by a major realignment of their resources. Being in a exploitation or in a transformation strategy affects very probably farm sustainability and it would have been valuable to further include this aspect in our analysis.

On the whole, our study highlighted the need to account for different sources of diversity in the assessment of short food chains, especially regarding farm functioning and farm evolution. Sustainability assessment methods would be improved by including more indicators reflecting these two aspects, to account for the systemic properties of farms on one hand, and for the evolutionary character of sustainability on the other hand. However, assessment tools and frameworks will always encounter limits. As pointed out by Brunori et al. (2016), sustainability assessment can be a tool for encouraging transition. The design of an assessment tool would therefore also be improved by including at the earliest the ability of the tool to facilitate transition towards sustainability.

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