**DOCTOR OF PHILOSOPHY**

# Exploring Growers' Understanding of Sustainability and Resilience in Organic Greenhouse Horticulture

**Italy vs United Kingdom**

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# Exploring Growers’ Understanding of Sustainability and Resilience in Organic Greenhouse Horticulture

# Italy vs United Kingdom

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Coventry University

## ABSTRACT

Protected cropping is recognised as a highly productive but intensive farming system, with a covered area steadily growing worldwide, and research has been mainly looking at solutions to improve the sustainability of these productions, particularly in terms of long-term soil fertility and agrobiodiversity enhancement, which become even more relevant if production is certified organic. However, no extensive research has been dedicated to the more social aspects of this agricultural sector, therefore this study aims, through the employment of a mixed methods approach comprising online surveys and semi-structured interviews, at gaining a better understanding of how organic growers identify practices that affect their management the most, those factors of any given nature that have major influence on their decisions about improving and/or implementing these practices, and any potential benefits to it. The study also acts as a comparative analysis between two case-study countries, Italy and the United Kingdom, which will help shed light on differences and commonalities between the groups of producers, and give a better understanding of the strengths and weaknesses of each country.

Survey results showed that growers from both countries rated *fertility management* the highest in terms of importance for their management; *biodiversity conservation* and *landscape protection* were rated higher by Italian growers, while *energy efficiency* and *weed management* were considered more important by British producers. Issues like *short food supply chains*, *product traceability* and *traditional knowledge* were considered equally relevant by both groups of respondents, since most were small-scale and rooted into local economies. Face-to-face interviews revealed differences between producers within and between scales of operations, showing that the level of intensiveness they employ inside greenhouses is more varied than what literature shows, and it links up to multiple factors (e.g. crops, growing season, available technologies, scale, channels of distribution), which also have a potential influence on growers' management practices, which vary accordingly to how intensive the cropping system is.

For organic growers, employing protected structures is commonly considered a necessary step for production, regardless of business size, to shelter crops from extreme events and to place produce on the market during the yearly 'hungry' gaps, and it is a trend that is likely going to continue in the future too, with greater protected areas, higher quality production, and a more effective resources management; therefore, a policy integration of a 'greenhouse clause', in terms of coverable areas and applicable

practices, would be a step forward in setting pertinent rules for protected cropping systems.

Given the different environmental conditions from the open field, maintaining a healthy and fertile soil in protected cropping is a shared priority among organic growers along with diversification of crops, products and market channels, to reduce vulnerability and better adapt to unexpected changes. Pursuing an increasingly sustainable and resilient system would also require a wider availability of training and education for growers, the facilitation of information exchange between them and other stakeholders such as scholars and policy makers, the possibility to share values, hard work and earnings in the form of cooperatives, and the importance of protecting small holdings, whose practices are usually deeply embedded in local contexts and whose survival depends on short supply chains and community support.

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Last, to myself, for gracefully transitioning from Padawan to Jedi Master once again. Good job you did. What’s next?

*“My wandering home will have two legs*
*and my dreams will know no boundaries”*
*(Ernesto ‘Che’ Guevara)*

## GLOSSARY

**Agritourism.** A receptive structure that offers multiple services, where people can enjoy local food and accommodation, and it is usually linked to a farm that partially or totally supplies said food. Agritourisms are especially common in Italy for they tend to populate rural areas.

**GAS.** Italian acronym for “Gruppi di Acquisto Solidale”. Self-organized and born with a critical approach to food consumption, willing to apply principles of equity, solidarity and sustainability to the products they purchase. For these groups, ethics are fundamental, along with social relations and the connection to traditions (Source: Wikipedia).

**Greenhouses.** In accordance with the EU regulation, defined as “permanent structures, with or without heating, covered by glass, plastic or any material that lets light through”. For this research, used along with the expression ‘protected cropping’ to refer to “protective structures staying in the same place for several years” (IFOAM, 2013), also “sufficiently large and high for people to comfortably stand upright and work within” (Wittwer and Castilla, 1995).

**High-value crops**. For temperate climates, this expression usually identifies crops grown inside protected structures in summertime (i.e. tomatoes, aubergines, courgettes, peppers). Although there is no clear ‘definition’ for such crops, it is hypothesised that the value of a crop tends to vary from place to place and can be linked to different factors: season and location in which they are grown, types and amounts of inputs required to grow them, role they have in the local market and diet, post-harvest requirements, costs of transportation.

**Hypermarkets.** Defined as large supermarkets, situated outside the urban area in intensely-trafficked strategic points (Source: Corriere della Sera).

**IPM.** Acronym for ‘Integrated Pest Management’. It is a planning tool devised to control eventual outbreaks of pathogens within farming systems, comprising of different methods, from agronomic and mechanical, to physical and biological; chemical control is also employed, but in case of emergency.

**Plasticulture.** Term that refers to the ‘practice of using plastic materials in agricultural applications’. It includes a wide range of features, from drip irrigation systems to all type of covering films to tunnels and greenhouses. A perfect and visible example is the Campo de Dalías area, south-west of the city of Almería, Southern Spain, where such widespread use of plastic materials across over 20,000 ha had people start calling it ‘Mar de Plastico’ or ‘Plastic Sea’ (Source: Wikipedia).

**PLV.** Italian acronym for “Produzione Lorda Vendibile”. In agricultural valuations, it is the active entry of a balance sheet, comprising all goods and services produced by a business, destined to be sold and to self-consumption, and referring to market values.

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## INTRODUCTION

Recent decades of agricultural research and development have focused mainly on maximising growers' incomes through intensification of external inputs and increases in volume of production, while being less concerned with food quality and resources depletion (Raviv, 2010; Stefanelli *et al.*, 2010). Agriculture is also a major contributor to global GHG emissions and highly dependent on climatic conditions, therefore susceptible to variations, so the impacts on food security are obvious and choice of production practices can be a double-edged sword, representing both a problem and a solution to the issues deriving from climatic changes. That is why, especially in the last century, an increasingly strong need has risen for agroecosystems designed to cope with stress and adapt to changes as to improve food security and sustainable livelihoods (Scialabba and Müller-Lindenlauf, 2010).

Therefore, a shift to a more quality-focused system is preferred, opting to develop alternative and more environmentally friendly applied technologies and farming techniques, based on agroecological principles that respect biological cycles and use natural resources in a sustainable way (Altieri *et al.*, 2015). Organic agriculture has always tried to achieve this, distancing itself from conventional farming systems through the ban of agrochemicals, GMOs and other synthetic compounds (Gomiero *et al.*, 2011) and the adoption of a series of management practices seeking to make the best use of local resources and to adapt to site-specific conditions (Scialabba and Müller-Lindenlauf, 2010), thus ensuring production sustainability and preservation of natural resources for present and future generations (Ceglie *et al.*, 2016), all the while limiting the employment of external inputs in order to harness ecosystem services and increase production efficiency (Scialabba, 2013).

A currently worldwide recognized definition of **organic agriculture** was forged by IFOAM (International Federation of Organic Agriculture Movements) in the early 2000s, based on the four principles of 'care', 'ecology', 'health' and 'fairness' (IFOAM, 2005b; Luttikholt, 2007), which describes it as a *"production system that sustains the health of soils, ecosystems and people ('health'); relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects ('ecology'); combines tradition, innovation and science to benefit the shared environment ('care') and promotes fair relationships and a good quality of life for all involved ('fairness')"* (IFOAM, 2005a). Organic farming is therefore considered a management system that promotes agroecosystems health through reliance on practices that take full advantage of ecological cycles such as crop rotations, intercropping, polycultures, cover crops or mulching (Gomiero *et al.*, 2011), thus being designed to preserve soil health and long-term fertility, rationalize the use of water resources, and enhance agrobiodiversity (Altieri *et al.*, 2015).

Among all agricultural sectors, **horticulture** represents an invaluable contributor to food production, food security and agroecosystem diversity because it involves the cultivation of a wide range of high-value crops such as fruits, vegetables, nuts, mushrooms, spices and medicinal plants, which are all integral parts of a healthy human diet (Lutaladio *et al.*, 2010). This great diversity of production is globally considered a pathway to the development of more sustainable livelihoods and resilient communities, especially in poor or rural areas, because it has low start-up costs, short production cycles, high yields per unit of time, land and water, and high market value (Lutaladio *et al.*, 2010). Although it is viewed as more profitable than its conventional counterpart, organic horticulture is considered more intensive for its high requirements in labour and inputs employed (Raviv, 2010).

In these terms, even though it is safe to affirm that organic farming was born to represent a viable and less intensive alternative to conventional systems, there exists a blurred line between the two production systems, which makes it difficult to isolate one set of agronomic practices from the other. Indeed, conventional systems can be moderately input intensive, just like organic systems can be managed with a simple input substitution, if permitted by regulation, thus concurring in what literature has identified as a 'conventionalisation' process (Ceglie *et al.*, 2016). Such situation may occur more easily in the presence of **greenhouse cropping**, since the intensiveness of this production system is greater than that of open field horticulture, making it the most intensive production system with yields per unit area up to 10 times larger than those of field crops. Greenhouse horticulture has raised several contrasting views between experts, not just because of the significant amount of energy required to run the system and the large quantities of waste generated in need of disposal (Vox *et al.*, 2010). Some claim that as a production system that involves control of environmental parameters, it defies *ecology*'s principle of organic agriculture, which is the maintenance of the natural adaptive capacity of farming systems, while some others have been prompted to research solutions to improve the sustainability of greenhouse production, seeing as the area covered by protected structures has been growing steadily worldwide (Vox *et al.*, 2010) and stockless or 'vegan' growers as well have accepted and integrated them into their 'farm equation' as production factors (Schmutz and Foresi, 2017).

Indoor-grown plants are protected from external agents, their quality potentially improved and yields increased, not to mention the all-year round provision of products which lengthens their market availability (Pardossi *et al.*, 2004; Simson and Straus, 2010). Within the European context, an analysis by Baeza *et al.* (2013) identified two basic types of 'greenhouse agrosystems', according to climate area and level of technological implementation: one type ('Northern') would group systems at higher latitudes, with colder climates and a higher degree of environmental control; the other type ('Mediterranean') would instead comprise systems located at lower latitudes, with warmer climates and a limited degree of environmental control, thus representing the less expensive option. Tittarelli *et al.* (2017) carried out a similar analysis for organic protected structures in Europe, as part of a working package on soil fertility management of the COST Action FA1105 called '*Biogreenhouse*' (2012-2016) (www.biogreenhouse.org), employing the same criteria used by Baeza *et al.* (2013) for classification and identifying two more categories within the main ones, differentiating protected systems according to their level of cropping intensiveness (high or low) and climatic area (Mediterranean or Northern-Central European systems). These distinctions also relate to factors such as cultivated crops and the main season in which they are grown, their rotation schemes and requirements in terms of nutrients and water, the degree of investments in structures and materials. It shows that there is a range of approaches to organic methods of cultivation within the same productive sector, not necessarily linked to certification standards, wider than the basic distinctions between 'conventional' and 'alternative' production systems have not wholly captured, making room for further analyses of the existing heterogeneity amongst organic practices and the impacts of these differences on the quality of production (Ceglie *et al.*, 2016).

So far, sectorial research seems to have been concentrating on modifying cultivation techniques and devising adequate equipment management and innovative materials to reduce use of agrochemicals, water and energy and generation of waste, as to work towards less resource-depleting greenhouse productions. However, the present study focuses less on technical aspects of organic greenhouse horticulture, and more on a detailed exploration of how organic producers see the resilience and sustainability of this production system. The main intent of the research is indeed to gather a better understanding of how organic growers regard such broad concepts as sustainability and resilience can be, both in theory and in practice, while identifying practices and issues that affect their management the most and those factors that affect their decisions about improving and/or implementing a certain practice, also mentioning any potential benefits of and constraints to these decisions.

The study also acts as a preliminary comparative analysis between two perceivably different countries, Italy and the United Kingdom. The expression 'perceivably different' is used in the wide sense, for these two countries are believed to potentially differ from multiple viewpoints: historical, climatic and geographical, but also environmental, economic, social and political. Therefore, this comparative analysis will ultimately shed light on factors that make the two groups of growers distinguish themselves, and at the same time it will help uncover issues that these two groups might have in common, for devising a more resilient and sustainable way of producing food, especially in the case of protected cropping, in which production can be intensified and pushed to the limit, can be considered a universally shared purpose. The direct interaction with growers to be employed to gather this volume of information might give this research a cutting edge in discovering what they view as 'sustainable' and 'resilient' in relation to their practical management, what they think they might implement to improve the overall performance of their farms, what are the factors and motivations that affect their decision-making the most.

Aside from the current Introduction, the present thesis will be organized in 4 other chapters, whose contents are briefly narrated in the following paragraphs. Chapter 2 gives an overview of the available literature regarding the main topics on which this research focuses on (i.e. situation of the organic greenhouse sector in Europe and regulations in force within the European Union community, practical issues of concern for organic management systems and protected productions, explanation of how the concepts of 'sustainability' and 'resilience' relate in theory to agricultural research, the fundamental role that producers play in agroecosystems, justification for the choice of the two case-study countries object of the research and overview of the state-of-the-art of organic greenhouse horticulture in the two countries), highlighting different views and understandings from different authors, eventual gaps in the theory and possible further developments. Mention is made on the importance of growers' (as in producers devoted to horticulture) knowledge in gathering primary data on their views on sustainability and resilience, the current management practices and their possible implementation, benefits and constraints related to practices' implementation, and factors that majorly affect such decisions, both in the short- and long-term. The literature review is divided into seven sections. Section 2.1 and its subsections 2.1.1 to 2.1.3 introduce organic protected horticulture within the European Union context, highlighting current issues and practices and introducing regulations and standards supporting the organic sector at Community level, and listing and explaining the main concerns detected in the body of knowledge so far, mostly of environmental nature, that are believed to have major impacts on the sustainability and resilience of the cropping system. Sections 2.2 and 2.3 introduce the concepts of sustainability and resilience, giving an overview of the available definitions currently circulating in literature related to the agricultural dimension, the reasons why such concepts are of concern in modern agricultural research, the current challenges and features that make a farming system sustainable and resilient, and the potential changes and improvements for producers. Section 2.4 focuses on growers' knowledge as the core of the study, its importance and role in modern agricultural research as the main drive for decision-making, the main issues involved and the potential changes that sharing this kind of knowledge could bring in the future. Sections 2.5 and 2.6 delve into details with an overview of the organic sector in Italy and the United Kingdom, the two countries chosen as the objects of the present research, with specific reference to both sectorial regulatory systems and their contents pertaining greenhouse productions, with Section 2.7 bringing up the rear to build up the case for choosing these two countries, listing features they have in common and make them differ, thus building the foundations for the basic comparative analysis.

Chapter 3 focuses on the methodological steps to be taken in this research and the following stages for data collection, which are presented in five main Sections. Section 3.1 gives an overview of the background for the study to be undertaken, while Section 3.2 identifies the aim and objectives of the research, which focuses on analysing organic growers' understanding of sustainability and resilience in relation to protected cropping, both in theory and practice, in two different countries, while highlighting and addressing those practices, issues and factors (relevant in their opinion) that make their farms as sustainable and resilient as they are and what growers can do to enhance these characteristics. Section 3.3 explains the research approach and Section 3.4 shows the research design and method, with its multiple Subsections describing the type of required data, the proposed and later employed sources of data, the sampling methods and the rationale behind their choice, the effective samples in both surveys' and interviews' case and for both countries, the tools used to gather information for the survey and the logistic steps behind the interviews' setting up. Moreover, Appendixes I and II, which can be found at the end of the manuscript, are connected to the current Chapter, and they show the questions used for data collection, respectively the final version of the questionnaire used for the initial sample selection through the survey and the list of questions to be used as a guiding draft for the on-farm follow-up interviews.

Chapter 4 is the core of the research and it is divided in 2 main Sections. The first part, or Section 4.1, focuses on analysing the results of the quantitative part of the study, which shows salient information collected through the questionnaires summarized through graphs and tables to integrate the discussion. Following the structure of the questionnaire, the section has been divided into multiple parts, according to the corresponding topic: Subsection 4.1.1 presents general information and basic demographics on the surveys' respondents for both countries and in Italy's case, given the difference in number with the British sample, a further subdivision of the sample into small-scale and large-scale growers; Subsection 4.1.2 focuses on the role of protected structures for the responding producers; Subsection 4.1.3 gives a taste of how respondents understand the concepts of sustainability and resilience, and how relevant they rate them in relation to their management practices; Subsection 4.1.4 shows how important respondents consider certain sustainability- and resilience-related practices and issues; Subsections 4.1.5 and 4.1.6 delve into which factors influence growers' management-related decisions the most, and what sorts of benefits or constraints they might expect from making those decisions. The second part, or Section 4.2, is dedicated to the analysis of the qualitative information gathered through the interviews, with findings from both Italy and the United Kingdom narrated together to help highlight common points and differences between the two countries in examination, and results were integrated with the discussions to follow in the discursive nature of the interviews' analysis. For this part of the discussion, a body of 7 themes were chosen based on their relevance given by the interviewees during the visits, supported by growers' direct quotes, integrated with the text. Qualitative findings are examined in context with what has been said on the subject in the literature review, and to critically evaluate what has been learnt through the research. In accordance with the anonymity of data treatment agreed on with the interviewees at the beginning of the data collection stage, all participants have been assigned a code that identifies them throughout the discussion (01 to 20, in chronological order). Further information on the interviewed growers can be found in Appendixes III (Italy) and IV (United Kingdom), showing basic data on their businesses, along with their identifying codes, at the end of the manuscript.

Chapter 5 is the conclusive part of the study, in which a brief recap of the thesis shows what has transpired in the previous chapters, key findings are discussed in detail, any issues that arose during the research are presented, an overview is supplied on the present study’s outcomes, ideas on future research possibilities are provided, and final thoughts regarding the current situation of the sector of protected productions and the future developments that may interest it in an ever-changing world are given.

## LITERATURE REVIEW

### ORGANIC GREENHOUSE HORTICULTURE

At European Union level, greenhouses have been defined by EGTOP (2013), in accordance with the EU regulation currently in force, as “permanent structures, with or without heating, covered by glass, plastic or any material that lets light through”. Although the same group of experts used the expression ‘protected cropping’ to apply to a wider selection of protective structures for crop growth, such as temporary netting and fleecing, low tunnels and mushroom culture (EGTOP, 2013), for practical reasons both ‘greenhouse’ and ‘protected cropping’ expressions are chosen to be alternately used throughout the research, to generally refer to “protective structures staying in the same place for several years” (IFOAM, 2013), also “sufficiently large and high for people to comfortably stand upright and work within” (Wittwer and Castilla, 1995).

Protected structures offer multiple advantages to horticultural productions, especially for fruit, vegetables and ornamental plants. They give protection from wind and rain, maintaining temperatures above ambient, allowing for all-weather working, enabling the grower to avoid climatic extremes and even introduce novel crops from different climates. They extend the crops’ growing period by a few weeks at the beginning and end of every season, potentially going all-year-round and therefore producing out of season, allowing producers to access the market for a longer period and permitting an output increase per unit area. They also provide benefits in terms of water conservation, nutrient loss, weed control and reduction of disease incidence (Lamont, 2005; Lamont, 2009). On the other hand, greenhouse cropping is among the most labour-intensive production systems, requiring intensive management and extensive resources, including human and financial capital as in e.g. periodic replacement for plastic inputs or technical training required of those involved for plant growing (Wittwer, 1993).

The sector received a large push forward after World War II with the advent of plastic polymers (e.g. polyethylene), in the form of covering sheets, irrigation pipes and mulching materials and gave way to a new form of vegetable crop production known as ‘*plasticulture*’ (Lamont, 2005), which became especially appealing in countries where population densities were high, land and water resources were seriously constrained, and climatic situations were particularly favourable for its development, such as North-Western Europe, Mediterranean countries, and the Near East (Wittwer, 1993; Castilla *et al.*, 2002). In this sense, a further generalised distinction can be made in term of structures used: it is believed that in the North, in countries like the Netherlands, the United Kingdom or the Scandinavian ones, optimal conditions for year-round production are provided by glasshouses while in the South, in the Mediterranean area, the same conditions for plant growth are provided by unheated plastic houses (Castilla *et al*., 2002; Baeza *et al*., 2013), suggesting that the choice of a structure type is also related to the location, other than grown crops and available financial and technical resources. Because of this, the Mediterranean region has become one of the most important areas both Europe- and world-wide in terms of protected cultivation, thanks to its mild climatic conditions in wintertime and the possibility to adopt simple and low-cost protective shelters (Castilla *et al.*, 2002). Since the 1960s-1970s, along with Middle Eastern countries, the Mediterranean area became prominent in the construction of plastic greenhouses (**Errore. L'origine riferimento non è stata trovata.**) and the production and marketing of high-value protected crops, such as vegetables, flowers, fruit, potted and bedding plants, nursery stock and ornamentals (Wittwer, 1993; Lamont, 2009). Nowadays, vegetable production under protected cultivation is a major agricultural sector in most Mediterranean countries and both cultivated area and production have increased consistently in recent decades (Tuzel, 2013).

Box 1. A brief history of protected cropping.

According to Wittwer and Castilla (1995), the first attempts to adapt crops to the environment with protective devices can be traced back to early Roman times, when they used movable beds for a limited series of crops, and covered them with translucent sheets of mica or alabaster; an example was Emperor Tiberius' *'specularium'*, specifically designed to grow his cucumbers out of season. The first precursors of modern greenhouses appeared in the late 15th to 18th century, in England, the Netherlands and France, first with glass on only one side and then, later in the 18th century, on all sides (Baeza *et al.*, 2013), and starting to get heated with stoves in the 17th century; examples were *conservatories* and *orangeries*, symbols of lavish and wealth, which were built across Europe, and overseas too, to host exotic trees (Katemopoulos, 2017).

By the end of the 19th century, greenhouse crop production has become commercially well-established, for grapes, melons, peaches, strawberries, and later tomatoes, and with it, the development of greenhouses soon spread beyond Europe. Along with North America, North-Western Europe also saw an incredible rise in the sector, with the Netherlands coming to possess the world's highest concentration of protected crops by the 1960s, followed by England. At the same time, other areas like the Mediterranean basin witnessed a phenomenal increase in high-value protected vegetable crops inside non-heated structures, letting production gradually shift south while ornamentals, flowers and potted plants started shifting north. This transition of vegetable production towards southern Europe, accompanied by a remarkable development in drip irrigation, had (and still has) Spain and Italy as leaders. Meanwhile in the North, experimentation started with technological improvements such as $CO_2$ enrichment, artificial growing media, temperature and heating control, and structures were employing them throughout the year.

According to the latest available Eurostat data, in 2016 organic vegetables covered approximately 179,000 ha in the European Union and even though they represent only 1.5% of the EU organic land share, which counted nearly 12 million ha in 2016, they have recently been gathering increasing importance, with an area that almost quadrupled in the span of 12 years, accounting for 53,000 ha back in 2004 (FiBL and IFOAM, 2016). In general, horticultural products make up for a relevant percentage of the entire food production, therefore they are considered a fundamental variable, especially with regards to issues like food safety and quality, since horticulture offers a wide range of high-value crops such as fruits, vegetables, nuts, mushrooms, spices and medicinal plants, which are all integral parts of a healthy human diet (Lutaladio *et al.*, 2010). However, statistics on protected areas have proven to be difficult to find for the specificity of information required, so it is not easy to quantify the effective area covered by organically managed greenhouses and if statistics include only specialized farms, as in businesses using exclusively greenhouses to grow their crops, or they also consider less specialized businesses, as in more diversified farms: regardless, Tittarelli *et al.* (2017) estimated 5,000 ha of organic greenhouses to be present in the EU territory, with roughly 70% of them split between Southern Italy (Sicily and Campania) and Southern Spain (Andalusía and Murcia).

As of today, the crops that are most extensively grown under cover belong to three main botanical families: *Solanaceae* (tomatoes, peppers and aubergines), *Cucurbitaceae* (watermelons, melons, courgettes and cucumbers) and *Asteraceae* (lettuce); other crops belonging to other botanical families and worth mentioning are strawberries (*Rosaceae*) and some varieties of beans (*Leguminosae*) (Tittarelli *et al.*, 2017). These crops are widely employed in these production systems either for the positive response they have shown to being grown in glasshouses or tunnels (watermelons and cucumbers), the fact that they are considered high-value crops on certain markets (tomatoes and peppers) or their supposedly acquired high sensitivity to outdoor environmental conditions (lettuce).

As a production area of organic agriculture, horticulture is regulated at EU level by the Council Regulation (EC) no. 834/2007 on ‘organic production and labelling of organic products’, which repealed the EEC Regulation no. 2092/1991, the first regulation ever issued by the former European Community on the matter, and was later implemented by the following EC 889/2008 regarding ‘organic production, labelling and control’, and EC 1235/2008 concerning ‘the arrangements for imports of organic products from third countries’. Since the regulation in force disciplines organic productions in general, these rules apply to all areas, therefore including protected cropping, since there is no specific reference to this production system.

Articles 3 and 4 of EC 834/2007 introduce the main objectives of organic production, which focus on creating a management system that is sustainable and gives high quality and widely diversified products. This is achieved using resources internal to the system such as land-based methods of cultivation and livestock production, and reducing the employment of external and synthetic inputs, not to mention the avoidance of GMOs. In terms of plant production, Article 5 sets out specific principles applicable to farming and Article 12 lists specific rules concerning soil fertility and health management, choice of species and varieties, employment of multiannual crop rotations and cultivation techniques (also for plant protection), and recycling of organic materials.

Even though one of the fundaments for the creation of this ‘sustainable agricultural system’ is that it respects natural system and cycles (Article 3), thus in line with organic agriculture’s principle of ’ecology’ (IFOAM, 2005b; Luttikholt, 2007), and protected structures defy such imperative by default, greenhouses and polytunnels are widely employed in agriculture, especially for horticultural production. However, it has been argued that there is a need for specific standards regarding such a peculiar field of production. The lack of standards is felt even more when it comes to protected cropping, for practitioners believe it involves a higher level of knowledge and skills, especially in terms of water, energy and soil management. The aim would be to include this set of specific standards in the eventual review of the EU regulation and a step in that direction was made in 2013, when the European Commission appointed a panel of experts (EGTOP, acronym for Expert Group for Technical Advice on Organic Protected Cropping) to discuss the possibility of achieving such goal, through confronting specific requirements with existing rules and advising on what to include for organic protected production. The expert group produced a final report with technical advice on soil fertility and health, crop protection, water resources, energy use and environmental control, employment of $CO_2$, growing media and mulching, and greenhouse conversion periods.

Literature is strongly concentrated on a series of issues related to protected cropping that are considered of high importance, especially from an environmental standpoint, given the fact that such production system can be highly resource-intensive and managing these resources in a conscious way might be a turning point towards the creation of more sustainable and resilient farming systems. Therefore, in the following paragraphs, attention is given to matters like soil fertility and water management, energy and climate control, and biodiversity.

### SOIL AND WATER MANAGEMENT

Although agroecosystems are complex and variable in nature, some features are essential to them to remain functional in the short and long term. One of these features is soil fertility and its maintenance is one of the basic foundations of organic production systems, which rely on the management of natural cycles, instead of external inputs, to increase soil organic matter (Borron, 2006).

Loss of soil organic matter is a serious threat to the sustainability of crop production on a global scale, especially in the wake of extreme climatic events (Gomiero *et al.*, 2011). Practices like intensive and continuous tillage, monoculture and excessive inputs of nutrients have a negative impact on soil organic matter (Raviv, 2010). The level of organic matter in any soil is not limitless but reaches a certain balance, based on soil and climatic conditions, and management practices (Scialabba and Müller-Lindenlauf, 2010), so preserving it is imperative in organically managed systems. High levels of organic matter also have positive effects on other physical-chemical characteristics such as soil structure and moisture retaining (Borron, 2006), but also microbial activity and biodiversity (Willekens *et al*., 2014). Moreover, improving soil fertility positively affects water retention potential and aggregate stability (Gomiero *et al.*, 2011). Improving soil quality leads to higher long-term productivity and better responses to extreme conditions, hence a higher stability of the system. In organic systems, soil fertility is maintained mainly through crop rotations, which also include cover crops, which help keep the soil protected by vegetation all-year-long (e.g. brassicas/mustards, rye, forage radish, oats) (Sullivan, 2003; Robačer *et al.*, 2016), and green manures, usually inserted between productive crops for at least one cycle and mainly belonging to the legumes family for their N fixation potential (e.g. alfalfa, vetch, red clover, oats, white mustard) (Baggs *et al.*, 2000; Brozyna *et al.*, 2013), given that N is the macro-element that needs constant replacement, either used by crops for growth, eventually removed through crop residues, or lost due to volatilisation or leaching.

Although crop rotations that include cover crops play an important role in organic and agroecological farming systems (Sportelli, 2014), they are not common in organic greenhouse horticulture, particularly those crops with long cycles, due to high investment costs of the infrastructure and potential crop specialisation of these systems (Mihreteab *et al*., 2013). Mihreteab *et al*. (2013) see market forces as the main drivers in choosing crops, often pushing growers towards repeated monoculture to maximise returns on investment, potentially at the cost of sustainability principles, especially in protected horticultural systems. Also, managing soil fertility and health becomes a delicate and complex matter for greenhouse cropping since given the system's intensiveness, it tends to require a larger amount of inputs, therefore there is a higher chance for nutrient accumulation in the soil, which can consequently lead to increased leaching and salinity (Shi *et al*., 2009).

It is also worth underlining the importance of using compost and manures, organic-derived and desirably locally produced (Meier *et al*., 2015) and slow releasing (EGTOP, 2013), not just for nutrient availability but also as a good practice for the implementation of soil structure. Moreover, practices such as tillage minimisation, use of different types of organic matter, crop rotation and use of cover crops and green manures, can also help in protecting the soil from compaction and loss, and reducing leaching and volatilisation of nutrients while increasing nutrient-use efficiency (Raviv, 2010). Similar effects also derive from the inclusion of trees in the management, through practices such as agroforestry and features like buffer strips around fields or along water bodies (Tilman *et al*., 2002). Although integrating woody species inside protected structures is an unfamiliar practice since structure dimensions do not always allow for such operation, the general inclusion of trees in the agroecosystem as significant capturers of $CO_2$, the employment of improved crop varieties, extended crop rotations, especially with grass–clover or forage legume leys, the application of organic fertilisers like compost or livestock waste products, and the maintenance of a constant soil cover represent powerful aids in carbon sequestration (Gattinger *et al*., 2012).

Preserving fertility through good practices that implement organic matter content, keep nutrients available, increase the carbon stock in the soil are an imperative in every situation, and are especially recommended for the restoration of degraded or marginal soils (Scialabba and Müller-Lindenlauf, 2010). Especially in Mediterranean countries, this tends to be a common occurrence since soils are usually characterised by low organic matter contents (Tittarelli *et al*., 2017). In these cases, there is a positive effect also on socio-economic aspects because not only fertility and yields can be increased, soil carbon sequestration is enhanced along with the mitigation potential, but more income opportunities can be offered, especially for rural populations, and food security can improve for market-marginal areas.

Soil health is also strictly related to water quality and availability, and practices like mulching, minimum tillage and use of efficient crop varieties have been shown to reduce crop evaporation and general water requirements (Gomiero *et al*., 2011). Water resources have become increasingly scarce, thanks to reduced rainfalls in certain production regions in the world, especially arid ones like Southern Europe, a growing demand for agriculture and higher competition from urban and industrial areas (Casas *et al*., 2014; Stefanelli *et al*., 2010), recreational restoration of streams, freshwater fisheries, and protection of natural ecosystems (Tilman *et al*., 2002). In such situations, long-term crop yield stability through climatic adversity is pivotal for agriculture to support both present and future societal demands and so far organic farming has demonstrated to be more productive than conventional agriculture under strenuous and extreme climatic conditions: in fact, due to the application of practices oriented towards a more efficient and stable soil health and the employment of drought-resistant crop varieties, organically managed crops grow in higher water-holding capacity soils, providing higher yields with a lower long-term variability and a higher system stability (Borron, 2006; Gomiero *et al.*, 2011; Tilman *et al.*, 2002).

Specifically, protected cropping gives growers multiple advantages in terms of water management, shielding crops from drought, reducing irrigation requirements and lessening the impact of hot arid climates, for there is a decrease in moisture evaporation from soil in a covered environment (Orgaz *et al.*, 2005). Greenhouse horticulture allows for ‘smart irrigation’, as in applying water-saving techniques, more easily than open field vegetable production, and it is believed to have the best scope for improving water use efficiency across all agricultural sectors, through a mix of good practices, investments in infrastructures and education (Stanghellini, 2014). Indeed, irrigation in greenhouses requires attention, for many problems with crops are likely to derive from an excess or lack of water, and depending on the type of structure they employ, growers switch preferences between overhead sprinklers and drip irrigation, and sometimes using them together for mutual support. These systems can be partly or fully automated: in the former case, the irrigation system is simply controlled by taps while in the latter, growers employ timers to control quantities and periods, even remotely. Protected structures also lend themselves to rainwater harvesting, and growers can channel the water falling on the roof of the structure from the gutters to a reservoir, to be later used inside on crops.

In the case of an automated system and an intensive production, an additional approach would integrate irrigation with fertilisation through the so-called ‘fertigation’, or liquid fertilization, which is generally considered another resource-saving technique, as it dilutes the fertiliser and distributes it locally through drip irrigation, nonetheless it is relatively expensive and may require water filtration (Simson and Straus, 2010). Greenhouse systems could also employ closed cycles to enable the treatment and recirculation of nutrient-rich waters, to employ them on other crops and reduce discharges to the soil and loss of fertilisers (Kleiber, 2012). However, closed systems represent important volumes of investments and except for the Netherlands, where closed systems are mandatory, they are mostly used for research purposes, thus not always commercially viable therefore most greenhouse systems, especially with low-cost structures, use open cycles with no recirculation and free drainage, easily manageable but involving huge volumes of wasted water and fertilisers if not rationally managed (Vox *et al*., 2010). Moreover, according to the position paper circulated by IFOAM (2013) on organic greenhouse productions, a maximum of 25% of nutrients can be supplied in liquid form through fertigation, for the main source of fertilisation would be the soil ecosystem.

Taking one step further and adding another link between plant nutrition management and protected cropping systems, hydroponic culture is worth a mention. Hydroponic or 'soilless' culture is thought to be the last frontier of 'sustainable', as in resource-saving, greenhouse cropping, representing a branch of crop-growing techniques that involves growing media other than soil (substrates) or nutrient solutions (water). It is believed to be a perfect example of sustainability if coupled with a closed system, thus with implementation of water recirculation, which brings multiple advantages such as no need for soil disinfection, reduced crop susceptibility to diseases, better growing conditions and increased production, easier reduction of N concentrations. However, the imposing investment costs, which make it especially disadvantageous in situations where subsidies are not involved and cheaper solutions are more easily applicable, as with e.g. small-scale businesses with low intensive protected systems in the Mediterranean area, are not the only downside to the implementation of hydroponic systems: the highly controlled environment requires significant skills and training in fertilization and climate control, and there appears to be no 'visual' difference between soilless-derived products and soil-grown produce, so prices often tend to not differ much (Vox *et al.*, 2010). Moreover, hydroponic culture is technically and philosophically incompatible with organic principles, therefore not allowed according to the EU regulation on organic productions, since it does not employ soil or soil-based substrates for plant growth (EGTOP, 2013), so such technique has been increasingly employed in conventional production systems.

Regarding loss of nutrients derived from fertilisation and non-optimal water use, organically managed systems have a potentially large positive impact, due to the reduced employment of synthetic inputs in favour of the application of nutrient-saving agronomic practices such as crop rotations, cover crops, green manures and alternative slow-releasing sources of plant nutrition like manure and compost. Analogically, the application of water-saving techniques, such as drip irrigation or mulching, coupled with a rational timing of water distribution and the use of treated wastewater, seawater or collected rainwater, could be strategically advisable to improve crop water use efficiency and especially in dry and arid areas in Southern Europe, decrease salinisation as well, without sacrificing yields (Pardossi *et al.*, 2004).

### AGROBIODIVERSITY

One of the fundaments of organic management, a staple on which it strongly relies, is the preservation and increase of biodiversity in the agroecosystem, and the inherent limitation to the use of synthetic inputs for pest control and fertilisation puts emphasis on sustainable crop managing techniques. In agriculture, biodiversity has many forms and includes a wide variety of resources, from genetic material of crops and livestock, to species that support production and wild ones, soil microorganisms, pollinators and pest predators (Borron, 2006). Moreover, diversification can occur over different scales, at field, farm or landscape level, and this gives producers, the stewards of the agroecosystem, multiple options and combinations to implement this feature (Altieri *et al.*, 2015).

Polycultures, agroforestry, crop rotations and intercropping are some of the pillars of organically managed systems, enhancing diversification through the presence of multiple crops simultaneously to minimise risks and give a more varied production than simple monoculture, while also benefitting water regulation and soil quality (Altieri *et al.*, 2015). The simplification of agroecosystems, usually associated with conventional or 'conventionalized' farming systems, reduces biodiversity, through monoculture or reduced marginal vegetation, with species forced to change suitable habitats (both crops and weeds), so different dynamics with pests and diseases tend to develop (Borron, 2006). Biologically diverse systems are more complex than fields of genetically identical crops, suffering from fewer great losses, going through natural successions, adapting more easily and providing important ecoservices. Especially in horticulture, where crops follow each other at a rhythm faster than any other field in agriculture, crop rotations become particularly important for their huge potential in helping break pest and disease cycles, not to mention the possibility to increase productivity, using nutrients more efficiently because of different crops with different requirements (Altieri and Nicholls, 2000; Nicholls *et al.*, 2017).

Local adaptation is essential in organically managed systems, for it makes species more resistant to adversities and enhance their resilience to eventual shocks (Scialabba and Müller-Lindenlauf, 2010), also offering more stability and consistency in yields, due to genetically acquired traits adapted to specific conditions (Borron, 2006). Other practices like integrating and maintaining features such as hedges, beetle banks, buffer strips, field margins, woodlands or grasslands have positive impacts on improving landscapes and enhancing biodiversity within the agroecosystem, through provision of natural habitats for multiple wildlife species (Gomiero *et al.*, 2011). These elements also bring benefits to carbon sequestration and restoration of organic matter in the soil, which in turn increases fertility, enhances water holding capacity and reduces drought risk (Scialabba and Müller-Lindenlauf, 2010). Said benefits are also implemented through cover crops, minimum tillage and employment of organic matter, to favour diversity both above and underground (Raviv, 2010).

Among all agricultural sectors, horticulture surely offers one of the highest varieties of crops, which have adapted to different climates and ecologies and land uses all over the world, and fostering this diversity is pivotal for human survival and long-term well-being (Lutaladio *et al.*, 2010). Moreover, this ample diversity also affects dietary quality and variety of communities, offering a wide array of crops throughout all seasons (Borron, 2006), thus reducing the vulnerability to unexpected socio-economic and environmental changes at field, farm and community levels alike (Altieri *et al.*, 2015). In such context, greenhouse horticulture might have a hard time fitting in, for it is generally identified as a production system characterised by short crop cycles and rotations, high pest and disease pressure, intense use of external inputs for fertilization and plant protection, and a reduced connection to the outside environment, which have dramatic effects on species abundance: that is why diversification of production through space and time becomes a focal factor for protected cropping systems (Gomiero *et al.*, 2011). At the same time, especially in a closed environment like a greenhouse, it is argued that reducing the use of pesticides, as directed by organic principles, might increase pest damage therefore some growers integrate agronomic techniques with biological control agents and organically certified pesticides that could still affect biodiversity in a negative way (Raviv, 2010).

Such 'extreme' situations would be linked either to the scale of production, or the intensiveness of the cropping system itself: in the former case, with a large-scale business, the capacity to invest in external inputs for plant protection, within the limits set by the regulation, tends to be higher; in the latter case, if rotation schemes are narrow or monoculture is employed, pest pressure tends to be higher and the impact of a pathogen outbreak in a greenhouse in which a limited range of crops are grown might be highly relevant. Given the nature of greenhouse cropping, when it comes to preserving diversity while reducing vulnerability to pathogens, integrated pest management (IPM) could help contribute to combine different types of pest and disease control, from agronomic to biological to chemical, while limiting the employment of external inputs for plant protection (Greer and Diver, 2000; Castilla *et al.*, 2002). Also, the fact that the environmental parameters can be controlled and modifiable could be exploited to create less ideal conditions for pathogens (Vox *et al.*, 2010). This combination of techniques is often suggested for organically managed systems, for they are considered less resistant to pathogen attacks because of the 'indirect' approach (read: non-chemical) to pest and disease control they take, although the level of an agroecosystem's vulnerability is ultimately related to the rationality of the management in terms of employed resources and applied practices. Indeed, attention is also focused on proper irrigation schedules, adequate ventilation and structure cladding, optimisation of plant density (Castilla *et al.*, 2002). Moreover, the use of healthy planting and sowing materials, such as resistant varieties, is especially important in organic farming (Simson and Straus, 2010). Vox *et al*. (2010) suggest that using compost as a growing media could give the opportunity to exploit its suppressive capacity against some pathogens, as well as taking advantage of specific plants that have biocide properties and act as soil fumigants, like some species belonging to the *Brassicaceae* family that possess these 'biofumigating' properties. Only in extreme cases of pest outbreaks, it is also advised to employ physical methods such as steam sterilisation and 'solarisation' for soil disinfection (EGTOP, 2013), however they tend to be left as a last resource because their sterilization capacity might extend beyond pathogens and affect a significant portion of soil life as well.

### ENERGY EFFICIENCY AND CLIMATE CONTROL

Organically managed systems have often been linked to a better general use of energy, compared to conventional ones, for reasons mostly related to the reduced employment of synthetic inputs, both for fertilization and plant protection, whose energy account is majorly due to their production and transportation; however, it has been argued that in terms of unit of land, organic management showed higher energy consumption ratios than conventional systems, due to greater requirements in cultivation (Raviv, 2010), with yield drops ranging from 20% for arable crops to 50% for some horticultural products (Gomiero *et al.*, 2011). Nonetheless, organic systems relying on traditional and locally-based agronomic techniques have the capacity to perform much better than industrially-scaled conventional systems, thanks to a constant adaptation of practices and a gradually building experience from the growers (Raviv, 2010), with comparable -if not higher- yields, especially under undesired conditions such as drought (Gomiero *et al.*, 2011).

Energy consumption also relate to the use of machinery: a common belief is that any energy amount that is reduced due to the limit to synthetic inputs used in organic agriculture is increased again due to the emissions derived from the mechanical power used for farming operations. However, in this case a relevant impact on the degree of machinery employment is related to soil conditions, climatic features and cultivated crops, giving room to a range of possible performances wider than previously thought (Gomiero *et al.*, 2011).

When studying greenhouse production, energy efficiency is related to many other factors that have an impact on energy consumption and saving (i.e. control of climatic parameters, structures and covering materials, employment of renewable sources, specific technologies for certain operations) and since it involves significantly higher yields than in open fields, it becomes especially important. Protected vegetable cropping needs to be resource-conserving and environmentally sound, relying on more sustainable growing techniques, equipment and materials focused on reducing energy and water consumption and waste generation (Vox *et al*., 2010). While obviously linked to the inherent limited operating space and intensiveness of cultivation, greenhouse horticulture is strongly dependent on microclimate and the level of control over it greatly varies, first and foremost in relation to the type of structure, so important differences obviously arise whether producers are employing a simple shelter-type polytunnel or a full-fledged mechanised glasshouse (Vox *et al.*, 2010).

Controlling climatic parameters such as temperature, humidity and $CO_2$ concentration, have a great impact on plant growth and can be advantageously exploited to pursuit a more sustainable way of using energy in greenhouses, through a dynamic and efficient management that employs systems to keep temperatures at optimal level (i.e. heating, cooling, ventilation), alternative sources of energy (i.e. organic waste, geothermal water, renewable energy sources such as solar or wind) and innovative covering materials, and favours a better insulation to decrease heat losses (Vox *et al*., 2010). However, the use of certain structures still tends to be relegated to specific contexts like scientific purposes, climatic conditions, types of production like high-value potting plants (Pardossi *et al.*, 2004), and most importantly, to evident volumes of investments, whereas most growers do not have access to this kind of resources. In such cases, controlling climatic parameters is still relevant but it relies on less technology and more technical ability: rationalising water and nutrient distribution to reduce consumption and optimise drainage and soil preservation, employing mulching systems to maintain a constant degree of humidity close to the soil, devising an integrated pest and disease management plan (Vox *et al.*, 2010).

## SUSTAINABILITY

Ever since it was first mentioned internationally in the Brundtland Report in 1987, when it was coupled with the word ‘development’, the term ‘sustainability’ has started assuming multiple meanings depending on who was using it and in which context. In fact, today the term is difficult to define, for there seems to be an unclear understanding of it among experts and there are no generally accepted criteria and methods to evaluate it. The result is that the concept is now more open to single political or philosophical interpretation than to scientific definition, becoming an overused term and a simple reductive synonym for *“all things positive”*. However, different people with different scientific backgrounds tried to adapt the term to their field of expertise, giving such concept more developed meanings and contexts when coupled with indicative words like ‘ecological’ or ‘agricultural’ or ‘economic’. In environmental terms, a recent basic definition was given by Raviv (2010), which describes sustainability as *“a way of using natural resources without depleting or permanently damaging them, also referring to the natural ecosystems’ endurance”*. Simply put, a system is sustainable if the use of its resources in the present does not compromise their availability in the future, which is the cardinal idea of ‘sustainable development’ as it was officially introduced to the world 30 years ago.

The need for sustainable development started to arise halfway through the 20$^{th}$ century, when human activities were having increasingly negative effects on the integrity of the environment, modifying natural ecosystems and global cycles (Morelli, 2011). Population growth and the improvement of living standards put the focus of human actions on increasing, instead of stabilising, the productivity of agricultural systems, trying to reach the maximum yield or benefit, but as the world has witnessed in the last decades of economic growth, such strive for the top came with a price, and it brought along problematic aftereffects (Walker and Salt, 2006). Since human activities can have such heavy impacts on the integrity of the environment, which in turn affect both economic and social structures at both local and global level, there exists a debate between those who view sustainability as a interwoven relationship between human society and Nature, thus forming *social-ecological systems* (Milestad, 2003; Walker and Salt, 2006), and those who believe in the three-pillar or five-pillar approaches, simultaneously benefitting the environment, economy and society in the former case (Morelli, 2011) and adding cultural and security aspects to sustainable development in the latter (Bervar and Bertoncelj, 2016).

Regardless of this, it is at least agreeable that providing clean natural resources is the fundament for a functioning socio-economic system, therefore without a sustainably productive environment to provide these resources, it would be impossible to have and maintain a sustainable society or a sustainable economy: the environment is the only 'leg' of the three to be able to stand on its own, to be independent from the existence of either society or economy (Morelli, 2011). Since agriculture is a primary sector, providing economy and society directly with food and indirectly with multifaceted services, it needs to be a model of sustainable development. Going one step further, a definition of environmental sustainability was supplied by Morelli (2011), who describes it as *"a condition of balance, resilience and interconnectedness that allows human society to satisfy its needs while neither exceeding the capacity of its supporting ecosystems to continue regenerating the services necessary to meet those needs nor by our actions diminishing biological diversity"*.

Even if it is a more complex definition than the one provided by Raviv (2010), it still relies on the concept that maintaining the capacity of the environment to supply resources and services is a pivotal feature for the survival of socio-economic systems, so sustainability is equated to environmental soundness first and foremost. Sustainability is also about social well-being, economic resilience, good governance and equity among and between generations (Scialabba, 2013). However, these definitions still lack a practical approach to sustainable development. For this reason, and for the present research too, one step further is taken to delve deeper into what it means for agricultural systems to be sustainable and develop sustainably. So far, production systems that have been deemed more sustainable than those considered conventional and industrialized, have included organic, biodynamic, natural, permaculture and many others, since there are certain principles they have in common (Pretty, 2008).

In the previous sections of this chapter, all management practices that have been described as in line with organic principles indeed fit with all the considerations done on sustainability as an all-encompassing concept so far, matching the given definitions. These same practices are also in line with a definition of **agricultural sustainability** devised by Pretty (2008), describing it as *"an approach that seeks to use nature's goods and services in the best way, thus adapting technologies and practices to local situations".* In this definition, emphasis is also put on the fact that *"there are likely to be multiple pathways toward sustainability and as well as many configurations of technologies, inputs and ecological management'*, suggesting that there are as many states of sustainability as there are agricultural systems, whose sustainability build up on the improvement of a few key components which are tightly interconnected: natural (environmental goods and services), social (people's connection and cooperation), physical (human-made resources), financial (monetary goods and services) and human (people's knowledge and skills). As an extension of the previous one, Reganold *et al.* (2001) considered the core feature of all agricultural systems, defining a farm as sustainable if it can *"provide adequate yields of high quality, be profitable, protect the environment, conserve resources and be socially responsible in the long term"*, once again encompassing all dimensions of sustainability.

Since these definitions were forged over a span of more than a decade (2001-2014), the Author of the manuscript made a summarisation of all them to create a basic definition of sustainability that would work for organic greenhouse horticulture and be valid and contextual for the present research. Therefore, an organic protected cropping system that builds on its sustainability is one that *"makes the best use of natural, human and technological capitals to minimise environmental impacts, while maximising its productivity and contribution to ecosystem services"*.

**RESILIENCE**

Along with sustainability, resilience has become an increasingly ubiquitous term in scientific and policy debate, emphasising the need to enable long-term adaptability and transformability of systems, rather than looking for short-term solutions (Darnhofer, 2014a). Gunderson (2000) gives a short overview of the existing concepts of resilience, a term that has assumed multiple meanings throughout the years, citing Holling as the first scholar who introduced it in 1973 regarding systems ecology. In ecological terms, resilience directly relates to stability: if stability is the *"persistence of a system in an equilibrium state"*, by contrast resilience is defined as the *"amount of disturbance that a system can absorb without changing state"* (Gunderson, 2000). Generally, resilience is understood as the capacity of a system to recover quickly and continue to achieve operational goals in the presence of disruptions (Wong *et al.*, 2013), relying on the system's own resources and maintaining the ability to experiment with practices and learn from the process (Borron, 2006; Milestad and Darnhofer, 2003).

It greatly differs from the engineering version of the term, which defines resilience as *"the time it takes for a system to return to its previous state of equilibrium"*. However, one of the assumption of engineering resilience is that there is only one state of equilibrium or stability. On the contrary, the ecological standpoint suggests instead that, like for sustainability, multiple states of stability are possible, and in this case resilience of a system is defined by the amount of disturbance that can be absorbed before the system redefines its structure (Gunderson, 2000). It is argued that multiple states of stability are possible in ecosystems and agroecosystems, since they are heavily influenced by human activities, thus potentially subjected to disturbances on a constant basis. Therefore, it is suggested that human activities have a significant role in modifying the resilience of a system, especially if they are an integral part of it like in agroecosystems.

Humans live and operate in social systems that are inextricably linked with the ecological systems in which they are embedded, so they exist within social-ecological systems; these systems are complex, dynamic and intrinsically unpredictable in their changes. In these systems, resilience relates to their capacity to organize themselves over time and lead to new developments, in the wake of modifications to their state (Gunderson, 2000). In other words, resilience is recognised as the property that *"allows to learn from and adapt to new conditions"* (Darnhofer *et al*., 2010), thus reflecting certain properties: a) buffer capacity, the amount of change the system can take and keep the same control over function and structure; b) reorganisation, the ability of the system to self-organise; and c) adaptive capacity, the ability of the system to build the capacity to learn and adapt (Milestad, 2003). These characteristics are indeed the fundaments of **socio-ecological resilience**.

A resilient social-ecological system has a greater capacity to absorb shocks and shift from one regime to the next, while continuing to provide goods and services, letting many experts believe that resilience is the cornerstone of sustainability (Walter and Salt, 2006). This concept is believed to be especially applicable to agroecosystems and farming systems, thus finding a context for the present research, and it links up to multiple elements that contribute to build up these systems' resilience. Nowadays, with climatic changes strongly affecting the environment and any human dimension depending on it, resilience becomes a requirement for modern agricultural systems. Both the foreseen and unforeseen drastic alterations of agroecosystems brought by climate change in the upcoming decades, especially related to temperature and precipitations variability, which will challenge farming systems and human livelihoods, will make adaptation of farm practices a necessity, to increase the ability to keep functioning when faced with unexpected events (Borron, 2006). With this level of uncertainty given by climate change affecting growing cycles and yields and putting pressure on production and supply chains worldwide, organic practices offer accessible and affordable chances to strengthen the resilience of farming systems (Borron, 2006).

This is especially true if these practices are based on ecological processes acquired through experimentation and adaptation to local conditions, so that the system can rely on its own resources as much as possible. This way, organic farming becomes a viable alternative to conventional agriculture, as it can link the conservation of the environment with economically profitable production, producing enough food and but also building resilience within agroecosystems (Milestad, 2003). Multiple management practices have been previously described as key actions for fostering farm resilience; however, it is agreeable that measures concerning soil management and agrobiodiversity seem to be pivotal for farming systems that strive to become less vulnerable to changes and survive in the long term. Especially for organic systems, maintaining soil health and enhancing diversification of crops and ecosystems, through practices like composting and manuring, adding plant residues to fields, employing mixed cropping, green manures, legume-based rotations, agroforestry, and minimum tillage (Borron, 2006), are fundamental strategies to reduce the vulnerability of farming systems to unforeseen disruptions and keep guaranteeing high and durable benefits from the ecosystem services they supply.

Enhancing health and favouring heterogeneity in the agroecosystem represent a robust path to increasing productivity, sustainability and resilience of agricultural production while reducing undesired socio-economic and environmental impacts due to climate change (Altieri *et al.*, 2015), and they greatly contribute to build up the different characteristics of the socio-ecological resilience of a farming system. Being a greatly varied and productive farming sector, horticulture is an example of a system that tends to rely heavily on agrobiodiversity and soil health for its perceived intensiveness of cultivation; however, it also has the potential to provide producers with a wide range of options and combinations for the implementation of these practices. The potential variety of crops and cropping strategies in horticulture can be applied at any scale of production, as it gives higher productivity and minimizes the risk of losses, thus reducing the system's vulnerability to climatic changes (Altieri *et al.*, 2015). As a specific feature of horticultural production, greenhouse cropping has also the potential to become a point of reference for resilience in the wake of undesired changes in climatic patterns. Polytunnels and glasshouses are widely employed to shield crops from unpredictable turns of events, so they can be considered one of the multiple factors that concur in building a farming system's resilience.

As for sustainability, definitions of resilience applicable to agricultural research were spread over several years (2000-2010), so once again the Author summarised the previous ones and created a basic definition of resilience that works for organic greenhouse production as well as for the present study. Therefore, an organic protected cropping system aimed at being resilient is one that *"possesses or builds on the capacity to absorb expected and unexpected changes and finds a new state of balance through the adaptation of its natural, human and technological components"*.

**Intensification and Conventionalisation**

Being environmentally sound and using natural resources in the best way does not imply that sustainable and resilient agricultural systems are necessarily all extensive: in a time of increasing demand for food, growing population and request for more resource-intensive diets, with agriculture competing for land, water and energy and climate change posing an ever-growing challenge on food production, the contested *debate* on **agricultural intensification** deserves a special mention, despite the discordant opinions it has raised among scholars, mainly because of the trade-offs between increased productivity and negative effects on natural resources and nutrient cycles (Foley *et al.*, 2011). Moreover, literature has provided several contexts for the process of agricultural intensification, from *sustainable* (Garnett *et al.*, 2013; Loos *et al.*, 2014) to *ecological* (Bommarco *et al.*, 2013; Mao *et al.*, 2015) to *agroecological* (Wezel *et al.*, 2015), without setting clear definitions or clearing out the effective differences between their underlying principles, and related practical applications (Wezel *et al.*, 2015).

Nonetheless, intensification is believed to have a great potential to maintain (and increase) current production rates while reducing unsustainable use of natural resources (e.g. water, soil, nutrients), and since it was introduced in literature as a general concept to rely on, comprehensive of ecological and agroecological intensification as well, **sustainable intensification** is a process coined to *"produce more with less impact"* (Tittonell, 2014) or *"use natural, human and social assets, combined with employing the best existing technologies and inputs that minimise impacts on the environment"* (Pretty, 2008), while building resilience and put a break on agricultural expansion (e.g. land sparing). It was born as a concept that would link increasing food production and scarcity of resources, first concerning developing countries and then relating to global agricultural policies (Gunton *et al.*, 2016); however, scholars have argued that there are radical implications in policies and resource management, therefore in efficiency and resilience of agroecosystems as whole entities, not to be underestimated (Garnett *et al.*, 2013). Moreover, the intensification process is highly context-specific in nature, so there is no predefined or generalisable model to follow, and there could be situations in which such transformation could be challenging and potentially threatening to local ecosystems' equilibrium, like in e.g. vulnerable and less 'high potential' areas such as drylands (Robinson *et al.*, 2015).

Although organic agriculture was first developed to represent a less intensive alternative to conventional farming methods, it has shown to be prone to intensification processes and according to the approach taken by the producers and the eventual influence of agri-businesses market-wise, it might be split between two different outcomes: as Buck *et al.* (1997) and Guthman (2004) proposed, on one hand it could involve practices that apply sustainable practices (e.g. agroecology-driven) and still provide environmental services, while supporting rural economies and safeguarding local resources, making up for that section of the sector that still relies on core principles and values (e.g. '100% organic'). On the other hand, it could backfire if taken to the other extreme, potentially veering towards the industrialisation of the sector or, as described by Buck *et al.* (1997) regarding Californian small- and medium-scale farming businesses, the **conventionalisation** of organic systems, focused on substituting inputs allowed by organic standards rather than implementing agronomic practices, in order to keep up with the market requirements established by conventional agriculture and agri-business firms, not just conventional but organic as well.

Delving into greenhouse cropping, since it could be already considered as a form of intensification of horticultural production, considerations on the effectiveness of sustainable intensification might split opinions again: either it could represent a great example of a system that can go through an intensification process in a rational and sustainable way, therefore supposed to *"produce more per unit of area while working on reducing environmental impacts and still contributing to ecosystem services"* (Tittonell, 2014), given its inherent intensive use of resources and their employment in small spaces (De Silva and Forbes, 2016); or the potential limitations in terms of applicable practices and employable inputs could be detrimental and generate, as with organic production in general, a 'conventionalised' system, regardless of the scale of production. Indeed, especially for farms producing high value crops, whether small- or large-scale, the intensification of production might bring a certain level of 'industrialisation' in their system by reproducing the most salient features of conventional production systems (Jordan, 2010), including among others e.g. increased mechanisation, hired labour, contract production, mass marketing, regional specialisation and lately, globalisation (Dinis *et al.*, 2015), and that could have repercussions on that part of the organic sector, still holding on to core values and principles, that would not adhere to this process as well (e.g. producers with diversified cropping systems, relying on internal inputs, selling their produce through direct channels to local customers), in terms of rule setting, inter-sectoral dynamics and agronomic practices (Buck *et al.*, 1997; Guthman, 2004).

Although the environmental dimension is the most preponderant and extensively emphasised, a production system's intensification does not revolve around it only so a space in the discussion must be reserved for the social and economic dimensions as well, however less renowned they might be. In this sense, every agroecosystem is a unique example, especially if small-scaled, and it would be up to research to study what kind of repercussions any change in a specific production system, according to its local conditions, would have on employed labour force, work ethics and efficiency, on traditional knowledge and its measuring up with new information, on the eventual scaling up of operations and new markets to tap into, on further technological and technical changes, and ultimately on the system's vulnerability and resilience.

## GROWERS' ROLE IN AGRICULTURAL SYSTEMS

Farms are complex and dynamic systems and in the face of climatic and socio-economic changes, the ability to maintain their integrity strongly depends on their capability to adapt to these disruptions, especially in current times when changes start to occur at an increasingly rapid pace. Farming itself is transforming and given this uncertainty, farms cannot focus solely on being productive and efficient anymore, instead they must try to balance efficiency with resilience and flexibility, thus shifting the emphasis on learning and adaptability (Darnhofer, 2014a). As the central figures of farm management, producers always need to find solutions to face unexpected events, whether temporary or long-lasting, such as extreme weather, diseases, market uncertainties or changes in labour availability (Darnhofer, 2014b). Climate change has been especially 'encouraging' producers to accelerate their need to observe, learn and respond more quickly than before (Borron, 2006). Accounting for this uncertainty and based on their perceptions and preferences, producers implement different strategies to ensure their farms' survival in the long-term and keep following the path of development and innovation, for the way to change and innovation is primarily a people-centred learning process (Kummer *et al.*, 2012).

This is one core concept of **adaptive management**, which builds on trialling practices and learning from the responses of the system, then redesigning said practices according to the knowledge acquired. In other words, farming systems adapt to changes through a trial-and-error type of approach, and this learning capacity seems to be deeply rooted in farmers' and growers' experience and traditional knowledge, especially at local level where communities have learnt to 'coexist with gradual and rapid change', therefore forming a knowledge base that allows to 'respond to environmental feedback while letting disturbances enter at small scales, without accumulating at larger ones' (Bardsley and Bardsley, 2014). Even though one general trend seems to be going towards larger farms and fewer producers (Kummer *et al.*, 2012), family-based and traditional farming systems, linked to small scale-based schemes such as Community Supported Agriculture, still represent a dominant model, based on traditional knowledge that incorporates locally adapted varieties, breeds and practices, making up for a reservoir of adaptive approaches (Borron, 2006). These farming systems are repositories of a wealth of principles and measures that can help modern agricultural systems become more resilient to climatic extremes, and they include crop diversification, maintenance of local genetic diversity, animal integration, soil organic management, water conservation and harvesting (Altieri *et al*., 2015).

It is also argued that ancestral or traditional knowledge constitutes the foundation for the present and future innovations and technologies in agriculture, for traditional small-scale farming is recognized as a long-established, successful and adaptive form of management (Altieri *et al*., 2015). In this case, both organic farming and horticulture might stand as examples of an effective mix of traditional knowledge and so called 'modern' agricultural research, with great potential to be sustainable and resilient, and functioning as laboratories for innovations that can be applied at every scale of production. It is thanks to the farmers', or growers' in this research's specific context[1] will to try and fail, learn and try again, through this producer-driven process of knowledge and technology generation, that many innovations are possible and organic farming, in its multifaceted nature, has been striving to cover that divide with conventional agriculture (Tittonell, 2014).

[1] The English language offers a difference between a 'farmer' and a 'grower', with the former representing, by common definition, a "person engaged in agricultural activities", hence taking care of plants and animals alike, and the latter being exclusively involved in raising vegetable crops. This is also reflected in real life, since growers see themselves different to farmers, as in more specialised, and would not use the word farmer to define themselves. The Italian language does not distinguish farmers and growers in the strict sense: an 'agricoltore' (Latin-derived word, rooting from 'agricoltura', literally the 'cultivation of the field') is defined as a person that works the land, regardless of WHAT they grow, given that agriculture represents a series of techniques and practices used to grow crops. Therefore, there is a corresponding term for 'farmer'. On the other hand, there might be an Italian word for 'grower', which is 'orticoltore' (same Latin derivation as before, rooting from 'orticoltura', the 'cultivation of vegetables'), but it is a term used to define technicians specifically trained in horticulture, and most of the producers are usually involved in differentiated agricultural businesses, meaning that vegetable growing is just one of many compartments to be normally found on a farm so farmers and growers, as professional figures, tend to overlap in the wide sense.

Both organic farming in general, and horticulture more specifically, have been suggested as being more sustainable and resilient alternatives to their conventional counterparts, for this is the ultimate reason for the existence of non-conventional agricultural systems and the main driver behind organic farmers' and growers' decisions to engage in sustainability- and resilience-building practices and organic farming's ambition to strive towards 'true' sustainability, characterised by Arbenz *et al.* (2016) as the 'willingness to create a more diverse, healthy and long-lasting environment'. To be able to adapt to changing conditions and take new trajectories for a more sustainable development, farming systems need to possess resilience, diversity and flexibility, which are key characteristics of adaptive management, according to Darnhofer (2014a): a) resilience, to reduce farms' vulnerability and ensure they remain functional, b) diversity, to buffer the systems from management failures and allow producers to learn from their mistakes, and c) flexibility, to maintain the integrity of all products and processes both in the short- and long-term. Therefore, the crucial role of farmers and growers in the development of a farm over time needs to be recognised, for the survival and growth of farms depends on how successfully knowledge is generated and then absorbed in the management system.

As Bardsley and Bardsley (2014) asserted, it is especially important that policies target those agroecosystems that, even if marginal in geographical and economic terms, yet sustain large parts of resident populations through important cultural relationships with local environments and can support unique forms of long-term resilience. To achieve this, research and policies need to focus on producers and understand how they cope with uncertainties, what drives them to make long-term plans to adapt and take new trajectories for development to stay in business (Kummer *et al.*, 2012). Producers potentially differ on a multitude of levels, according to what they consider important and uncovering several trade-offs that they need to incorporate in their decision-making: specialisation vs diversification, large-scale vs small-scale, innovation vs tradition, risks vs experience, or investments vs no debts. This type of 'informal' knowledge, derived from experience, helps shape multiple forms of sustainable and resilient agroecosystems and the related practices involved, relating to specific local conditions, and the producers' predispositions and relationships (Šūmane et al., 2017).

Fundamental for the adaptive nature of producers' management is also work organization, which has a significant impact on workload and its distribution through time, along with workforce availability. The balance between work time and free time, the producers' motivation to do what they do, the relationships linking them to their families and to the other people constituting the community in which they operate are other factors that affect the way growers organise their work and their life (Kummer *et al.*, 2012). This becomes especially true with intensive production systems, such as protected horticulture, which require a larger workload than other more extensive systems: in these cases, work constraints might act as a brake on innovations. There is also the issue about work quality and its effects on the grower's life and relationships with other people: it is not only about having decent working conditions in terms of hours and labour, but also about self-esteem, which affect producers' motivation and willingness to improve their work organisation (Kummer *et al.*, 2012). However, being a farmer in general is still considered a peculiar way of living, shaped by the biological nature and rhythms of farming activities, with a specific relationship with the land and the environment, and a tradition of collective work and actions (Dedieu *et al.*, 2009). In farming systems, changes happen every day and have effects on the landscape and the quality of food they produce, and modern agricultural research is affected too, thus transforming the way they visualize the figure of the farmer in the management of farms.

The main goal of research is to contribute to sustainable and resilient development, and this depends on a shared vision between producers and other stakeholders that might affect which path of development they are going to follow together. To do this, research needs to approach the issue in a participative way, as to support dialogue and knowledge exchange between producers and other stakeholders, for thinking about innovative ways of farming that increase sustainability and resilience requires communication and collaboration (Dedieu *et al.*, 2009). Moreover, farming is also connected to the market chain, in which measure depending on the scale of operation of a farm: these systems have their own dynamics and pressures to change, and interact with farming practices, culture and regional specificities. It all serves as a reminder that farms are not inert receptacles for new practices and technologies and producers static receivers of information, but they represent a dynamic system that has farmers and growers and their close peers at the centre, that requires a participatory approach to understanding the multifaceted nature of farming, thus including a wide range of disciplines, that focuses on the complex interactions between its multiple components (Darnhofer *et al.*, 2016; Kummer *et al.*, 2012).

**CASE-STUDY COUNTRY 1: ITALY**

Italy occupies a leading position in the global organic realm and is one of the key countries for organic production in Europe. With almost 1.8 million ha of organically managed land registered in 2016 (+20.3% than 2015), Italy hosts the second largest organically managed area after Spain and has one of the highest shares of certified organic land in the European Union (14.5%). It is also among the ten countries with the largest organic area at the global level, having seen one of the highest increases of organic land witnessed so far in the 2015-2016 period (+300,000 ha) (SINAB, 2017). At the end of 2016, it was reported that the total national area covered by organic vegetables, which include strawberries and cultivated mushrooms but not consider potatoes, was 43,914 ha, having registered a noticeable increase of 48.9% from 2015, the largest increase of land among all agricultural sectors, with the most commonly grown crops being tomatoes, peas, cauliflowers and broccolis, asparaguses and artichokes; other crops like cucumbers, onions and spinach have seen 80-90% increases in terms of land between 2015 and 2016 (SINAB, 2017). Operators in general have increased in number, but in different measures: according to the latest available statistics at national level, offered by SINAB (2017), in 2016 Italy accounted for 72,154 certified operators in the organic sector, with a 20% increase from 2015, and out of all operators, 55,567 were exclusive or 'pure' producers (+22.9%), 7,581 were processors (+7%), 8,643 were producers-processors and 363 were importers (+17% in both cases).

In 2014, the total market share accounted for 2.2 billion €, representing roughly 2% of the global and 8% of the EU shares, thus placing Italy at the fourth position among the biggest world organic markets, after the US, Germany and the United Kingdom (INEA, 2014; ISMEA and SINAB, 2014) and at the same fourth position in the EU, behind Germany, France and the United Kingdom (FiBL and IFOAM, 2016). Even though the national organic market keeps expanding with a continuous positive trend, the yearly consumption of organic food equals to 35€/person, much lower than the EU average consumption (47€/person) (FiBL and IFOAM, 2016). Nonetheless, the retail network is notably diversified, encompassing educational farms, *Solidarity Purchase Groups*, school canteens, direct on-farm sale, restaurants, *agritourisms*, online shopping, specialised shops, organic markets, and large distribution (Saccardo, 2015), with the latter registering the largest retail volume of organic products (i.e. 48% for supermarkets and 35% for *hypermarkets*). However, national production and demand for organic products do not match: in the 2012-2013 period imports increased by 21%, even with a support of 1.4 billion € from the 2007-2013 Rural Development Plan, suggesting that most of the production is destined for exports (INEA, 2014). Italy is indeed one of the ten largest exporters of organic products in the world (ISMEA and SINAB, 2014), mainly distributing in Germany, United Kingdom, United States, Japan and China, with fruits and vegetables usually representing between 30 and 50% of the total export volumes (Callieris *et al.*, 2010), while Italy's main suppliers of organic food are in North Africa, North America, Non-EU Europe and Asia.

Even though the current scenario is encouraging, showing the organic sector in constant expansion (areas, operators and enterprises), it still represents a small percentage on the national food market (approx. 1%), and it needs improvements, presented by sectorial associations in the form of investments in technology innovations and training, stronger collaboration between research and production, information and publicity for organic productions, integration of current knowledge with traditions, incentives for short supply chains, and simplification of the certification process (Saccardo, 2015), not to mention in-depth data collection at different scales of production (ISMEA and SINAB, 2014).

**National Regulations**

As a Member State of the European Union, Italy has received the EC 834/2007 and the following implementations through the Ministerial Decree no. 18354/2009, which disciplines organic production and labelling of organic products. In line with Article 12 of EC 834/2007 regarding plant production, Article 3 of the Decree emphasises the fact that soil fertility and plant protection are maintained through the *'temporal succession of different crop species in the same space'*. In the same Article mention is made for protected cropping, stating that in case of both specialised and non-specialised horticultural crops, grown in open fields and greenhouses alike, *'the same crop can be cultivated on the same plot only after at least two cycles of two different species, one of which destined to a legume and the other one to green manure'*, where green manure crops have a minimum cycle of 70 days in every case. Exceptions are made for:

- Tomatoes under protection, which can *'succeed themselves for a maximum of two cycles, followed by at least two cycles of two different species, one of which destined to a legume and the other one to green manure'*, and;
- Short-cycle leafy vegetables (i.e. salads, rocket, spinach), which can *'succeed themselves for a maximum of three consecutive cycles, followed by at least a root/tuber crop or green manure'*.

## Protected Cropping Systems

In terms of types of protected cultivation, Italian greenhouse cropping can either use low-intensity or high-intensity systems, both widely employed in the Mediterranean area, depending on the pedoclimatic zone, the crops grown under protection and their main growing season, the volume of investments for structures and materials, and the type of market that production is destined to. On one hand, low-intensity protected cropping systems potentially represent the majority among Mediterranean horticultural realities, where plastic materials are used for cover much more often than glass and there is a general absence, or minimal presence, of any technological implementation inside these structures (i.e. heating, $CO_2$ enrichment or artificial lighting) (Baeza *et al.*, 2013). In these low-intensity systems, crop rotations are shorter than in open fields, with a limited presence of green manures, although such systems tend to not specialize on single crops. On the other hand, in highly intensive protected cropping, plastics and glass are both used as cover materials, depending on the case, and there might be a basic level of technological implementation inside the structures (i.e. mainly for heating); these cropping systems tend to be more specialized than the previous ones and crop rotations are described as stricter and more limited than in low-intensity systems (Tittarelli *et al.*, 2017).

## CASE-STUDY COUNTRY 2: THE UNITED KINGDOM

In the United Kingdom, the latest national statistics showed that in 2016, 507,900 ha of land were organically managed, 58% of which in England (mostly concentrated in the South West and South East), and they cover approximately 3% of the national agricultural land share and coming down from 521,400 ha registered the previous year (DEFRA, 2017a). Organic vegetables covered 10,200 ha nationwide (2% of the total organic land share), slightly coming down from 10,400 ha cultivated in 2015 and following a gradual but steady decline since 2008, when they accounted for 19,800 ha, the largest share of organic vegetable land registered in the last 15 years, thus mirroring the fall in organically managed land that characterised the UK since the financial crack (DEFRA, 2015). Data from DEFRA (2017b) also showed that in 2016, there were 6,363 certified operators across the United Kingdom, showing a 5.1% increase from 2015, mostly due to a larger number of registered processors, compared to 2015 (from 2,454 to 2,804 in 2016, 86% of which in England); 53% of the operators were certified producers (3,398), which went down from 3,429 fin 2015, and similarly to processors, producers too were mostly concentrated in England (2,302 in total, 1,104 of which in the South West), followed by Wales (595), Scotland (349) and Northern Ireland (152).

Data from 2014 showed that the UK possessed a 4% share of the global organic market, conferring the country the third largest organic market share in the world after the US and Germany, with a total volume of sales of 2.3 billion € (Soil Association, 2015); within the European Union, the United Kingdom similarly possessed one of the largest organic markets in the Community, with a share of 9%, placing the UK behind Germany and France (FiBL and IFOAM, 2016). Regardless of the decline in covered areas, on the market, fresh fruit and vegetables still represent the largest sector within organic foods and drinks, amounting to 23% of the total retail volume, with fruit faring better than vegetables (respectively +6.4% and -2%) (Soil Association, 2015). However, even as demand for organic food remains high, producers are dropping out and converting back to conventional to confront with lack of absorption of high expenses and avoid excessive rise of prices, for different reasons: milk prices, soil deterioration, bureaucracy and costs associated with certification, lack of local demand for organic produce and long distances to reach the markets (Rustin, 2015), even though growing evidence has been showing that switching to greener farming methods can strongly cut costs down, especially for small-scale farmers (Harvey, 2011). Nonetheless, government figures show that while organic food sales have bounced back from the low that followed the financial crash in 2008-2009, the number of producers of organic food has kept falling and the amount of land organically managed in Britain has continued to shrink, having lost a fourth of the area since 2008, 4% only in 2013, even though the decline has slowed down since 2010 (Soil Association, 2015). In 2014, the amount British people would spend per capita on organic produce remained one of the lowest in the continent (36€/person), compared to countries like Switzerland (221€) or Denmark (162€) or even the European Union average (47€/capita) (FiBL and IFOAM, 2016).

It appears that British organic farming is stalling: the percentage of organically managed land has shown no change since the year 2000 (EEA, 2015), and the number of UK farmers and certified processors has been gradually declining since 2008-2009. The question is why, when home production is stalling, overall UK organic showed a rise in sales of 4% in 2014 (Soil Association, 2015) for the second year in a row, it seems producers are giving up, and whether more generous subsidies from the Common Agricultural Policy, starting in 2016, could tempt them back (Rustin, 2015; Soil Association, 2015). Today, as the organic market grows again but the area of certified land continues to decrease, smaller producers start to feel more confident. However, growers supplying multiple retailers are increasingly concerned about supply shortages and in the short term, there will be increasing reliance on imports. On the other hand, there has been an explosion of online buying platforms, demonstrating the potential to change local food distribution (Soil Association, 2015). As for horticultural productions, impacts of recession, extreme weather conditions and issues with pest and disease control have had an impact especially on vegetables, these last few years, resulting in a variability of returns, mostly associated with yields, prices, labour use and marketing costs (Lampkin *et al*., 2014).

**National Regulations**

As a Member State of the European Union, the United Kingdom has received the EC 834/2004 and the following implementations through the Organic Products Regulation 2009 (Statutory Instrument 2009 no. 842), which provides for the administration and enforcement of said regulations, along with a guidance document drafted by DEFRA in 2010, where standards are set to “assist those who produce, prepare, store and import organic products and the inspection bodies who license them”. No mention of protected cropping is made on either document; however, the Soil Association certification body, as the leading association for certification in the country, managed to produce a set of organic standards in 2014, in conformity with the EU Regulation and with additional rules for multiple areas of production. Section 5.2 lists extra standards for protected cropping and in this specific case, references to the rational use of water resources, energy and the possibility to employ $CO_2$ are present: a fertility management plan to be produced, a record for the energy usage to be kept and an energy plan to be drafted if consumption passes a threshold of 100 kWh/m$^2$/year, the use of $CO_2$ allowed only if it is a by-product, the collection of rainwater run-off a desired practice. However, an exception is made for crop rotations: the standards give the possibility to ‘bypass’ them, thus enabling the employment of monoculture, if growers prove that their cropping system can:

- Maintain soil and crop health, through optimising the use of legumes, green manures and composted materials, and;
- Limit their reliance on brought-in inputs for plant protection.

**Protected Cropping Systems**

In terms of protected cultivation systems, greenhouse cropping in the United Kingdom can also employ low-intensity or high-intensity systems, similarly to the rest of Northern and Central Europe. The choice between one or another depends on the crops grown under protection and their main growing season, the volume of investments for structures and materials, and the type of market that production is destined to. In case of low-intensity protected cropping, which can be found on farms that also grow field vegetables and where greenhouses cover a limited area, plastics and glass are both equally used for cover and structures employ a relatively basic degree of technological implementation (i.e. heating mostly, $CO_2$ enrichment or artificial lighting possibly). In these systems, crop rotations can be quite diversified, especially during the summer, and green manures widely employed (Tittarelli *et al.*, 2017). On the other hand, highly intensive protected systems are employed where greenhouses are the only means of production, and they mainly use glass as cover material; these structures tend to be usually equipped with a relevant level of technological implementation (i.e. heating and climatic control mainly, seldom $CO_2$ enrichment and additional artificial lighting). These cropping systems are considered the embodiment of specialized productions, therefore crop rotations are very narrow or sometimes non-existent (Baeza *et al.*, 2013).

## BUILDING THE CASE

The introductory chapter anticipated one of the roles the present study would play, which means acting as a preliminary comparative analysis between two countries, within the European Union context, that can generally be perceived as different: Italy and the United Kingdom. The expression ‘perceivably different’ is used in the wide sense, for these two countries are believed to potentially be opposite from multiple viewpoints: historical, climatic, geographical, but also environmental, economic, social and political; therefore, the proposed analysis would ultimately be shedding light on factors that make the two groups of growers distinguish themselves, and at the same time helping uncover issues that these two groups have in common, for devising a more resilient and sustainable way of producing food can be considered a universally shared purpose.

Focusing on the EU and then zeroing in on these two ‘case studies’ has been a choice initially guided by convenience and logistic reasons: first and foremost, the European Union has been regulated by common rules for more than 25 years, and it represents a unique worldwide example of a single body of directives encompassing a large community of countries, with both case-study countries as Member States. Secondly, in terms of choosing ‘case-study’ nations for the research, Italy has been on the radar since the study has started taking form, not just because of the lack of language barriers and the higher familiarity with travelling across the country for the researcher, but also because of the relevant position it occupies in the organic world within the European community (i.e. land share, market share, annual growth, number of holdings and operators, greenhouse horticulture share), and Italy’s general contribution to food culture, e.g. with reference to movements such as Slow Food (www.slowfood.it/) or Happy De-growth (www.decrescitafelice.it/). The United Kingdom was chosen for comparison mainly because the PhD project itself has been funded by a British University and the researcher has been based on British soil from the beginning of the project, but also because of the aforementioned perceived differences between countries belonging to Northern and Southern Europe; moreover, a short historical search has shown that in Europe, modern greenhouse production as the community of stakeholders involved know it today was born and given shape hundreds of years ago in England and the Netherlands, thus building the foundations of an enduring tradition. However, the same historical search showed that in recent decades, protected productions (vegetables, especially) gradually moved towards Southern Europe for the milder climate and the chance given by the rising use of plastics to employ cheaper materials to cover crops and build structures.

Nowadays, it can be said that Italy and the United Kingdom find themselves at opposite sides of the organic spectrum, especially in terms of organically managed land and number of operators where Italy shows yearly growths of land and certified producers with double digits while the UK, though following the same growth pattern in the early 2000s, has been going through a shrinking spell since the financial crash in 2008 and only recently started growing again. Land share over total agricultural area has also been growing steadily in Italy, reaching a record in 2016 with almost 15% of the national cultivated land voted to organic farming, whereas organic land share in the United Kingdom has been declining for almost 10 years now, registering a value below 3% last year. Similarly, the share of horticultural land showed an impressive 49% increase between 2015 and 2016 in Italy, while it followed a declining path, like the pattern followed by the organic land share, in the UK. Nonetheless, the United Kingdom still possesses one of the richest organic markets, with significant shares both Europe- and world-wide, accounting for over 2 billion €, with Italy trailing right behind in both cases, and yet people’s consumption of organic products in both countries still registers values below the EU average (47€/capita versus respectively 35€ and 36€/capita for Italy and UK in 2014), which is worth noting as a similarity and especially important for greenhouse growers orientated to the home market. A relevant difference between the two countries is also shown by the average size of organic holdings, which was provided by national statistics but also calculated for comparison, thus dividing the total organic land by the number of producers. On one hand, Italy shows a calculated average of 32 ha per holding, close to the data supplied by the latest available statistics (SINAB, 2017), which set the average for organic holdings at 28 ha, in both cases 3-4 times larger than general farms, whose average size was set at 8.5 ha. On the other hand, the United Kingdom shows a calculated average of 149 ha per farm, for the whole country, which is much higher than the info supplied by the latest statistics (DEFRA, 2017a), which gives a national average of 80 ha per organic holding.

Lack of updated data on organic greenhouse productions has been mentioned earlier in this Chapter, therefore a direct confrontation between protected areas, specialised or not, from the two case countries would not be possible; however, estimated values have been produced for both by literature, with Italy accounting for 2,000 ha of organic greenhouses (Tittarelli *et al.*, 2017) and 30 ha of organic heated structures registered for the United Kingdom (Schmutz *et al.*, 2011). As one of the purposes of the present study is to increase knowledge in terms of organic protected areas in both countries, an estimation has been calculated to show greenhouse areas declared by the interviewed growers, collated from Table 12 and Table 13 (Appendixes III and IV). A brief overview of the presented data is shown below in **Errore. L'origine riferimento non è stata trovata.**.

Table 1. Confrontation between data from the two case-study countries. All values are coupled with the year corresponding to the latest available update (Sources: FiBL and IFOAM, 2016; DEFRA, 2017a; SINAB, 2017). Values concerning greenhouse areas are both estimated and calculated from data provided by growers in the surveys and during the interviews.

| Features | Italy | United Kingdom |
|---|---|---|
| Organic agricultural land (ha) | 1,795,650 $^{2016}$ | 507,900 $^{2016}$ |
| National organic land share (%) | 14.5 $^{2016}$ | 2.9 $^{2016}$ |
| Organic market (billion €) | 2,145 $^{2014}$ | 2,307 $^{2014}$ |
| Global organic market share (%) | 2.2 $^{2014}$ | 4.0 $^{2014}$ |
| EU organic market share (%) | 8.0 $^{2014}$ | 9.0 $^{2014}$ |
| Organic consumption (€/capita) | 35 $^{2014}$ | 36 $^{2014}$ |
| Number of producers | 55,567 $^{2016}$ | 3,398 $^{2016}$ |
| Average size of farms (ha) (stat.) | 28 $^{2016}$ | 80 $^{2016}$ |
| Average size of farms (ha) (calc.) | 32 $^{2016}$ | 149 $^{2016}$ |
| Organic vegetable area (ha) | 43,914 $^{2016}$ | 10,200 $^{2016}$ |

| | | |
|---|---|---|
| Organic vegetable area share (%) | 2.45 [2016] | 2.0 [2016] |
| *Greenhouse area (ha) (est.)* | *2,000 [2016]* | *30 [2011]* |
| *Greenhouse area (ha) (calc.)* | *12.445 [2017]* | *7.805 [2017]* |

## METHODOLOGY AND DATA COLLECTION

### BACKGROUND

Producing food while maintaining biodiversity and ecosystems services is one of the biggest global challenges that mankind has ever been confronted with. With almost half of the planet's land surface used for agriculture, farmers are the real managers of the land and all the natural resources it hosts, shaping ecosystems and landscapes, thus farms are vital to the survival of mankind. However, not every farming practice positively affects ecosystems and landscapes, so part of the present and future challenge for farming management and research is to identify more environmentally friendly practices. Research on sustainability in agriculture has been mostly focused on reducing environmental impacts of production systems, but this should not exclude the study of farming systems or farms as whole entities, while including social and economic domains. The challenge is to start incorporating resilience in the study of farms' sustainability and resilience's way of thinking about farms as complex and adaptive systems, where management is a dynamic process, all components co-evolve at multiple scales and change is an unpredictable constant. Factors like climate change and agricultural policies have a significant influence on farmers' decisions regarding crops and methods of production, especially at local level, thus impacting the profitability of their choices and the agroecosystem (Darnhofer *et al.*, 2016).

It has been asserted that organic agriculture and horticulture have a greater potential to be both sustainable and resilient compared to their conventional counterparts, by applying a set of practices that tend to focus on preserving diversity at every level within the system and maintaining the health of the soil to ultimately guarantee food quality and security. Moreover, employing protected structures on the farm has increasingly become a popular choice among growers, especially for polytunnels' and glasshouses' main function to shield high-value crops from unexpected weather events, thus ensuring a basic provision of income for producers and food for the community and adding up to the properties a farm can possess to build on its sustainability and resilience.

### AIMS, OBJECTIVES AND RESEARCH QUESTIONS

So far, the study of sustainability in protected cropping has produced a relevant volume of literature, especially regarding greenhouse-related issues that have an impact on environmental integrity, like nutrient cycling, use of water resources or energy efficiency, followed by studies on the economic profitability of certain crops widely grown under protection, such as tomatoes, strawberries, peppers. However, little is known about the social domain of growing crops inside greenhouses, especially if organic, since horticulture is already a specific sector of organic farming and greenhouse cropping is a niche system within horticultural productions: by playing the most crucial role in farming management, growers' choices, perceptions and preferences are strongly influenced and shaped by market requirements, regulations, social norms, local agroecosystems and the structure of their farm (Darnhofer *et al.*, 2010), so they became the primary source of information for research, even though they have always been believed to be not knowledgeable and their voice has been generally underrepresented in agricultural studies (Santiago-Brown *et al.*, 2014).

Therefore, the intent of this study is not to create new indicators for another instrument to evaluate the sustainability, or a model to measure the resilience of organic greenhouse horticulture either, since farming systems are generally complex and changing in time and space so providing specific or predictive guidance would be ambitious and out of the scope of this research. The core purpose of the present work is to serve as an exploratory study of how organic growers understand and regard the sustainability and resilience of protected productions, both in theory and practice, what makes their farms as sustainable and resilient as they are and what growers can do to enhance these characteristics. The practical stage of the study will take place in Italy and the United Kingdom, to give a basic comparative analysis of two supposedly diverging countries, with different historical, environmental, social, economic and political background. In this case, part of the research will help highlight common issues and differences, thus explaining how organic growers in each country relate to the different facets of the systems they operate in. As already mentioned in the literature, two definitions were supplied to give broad concepts like sustainability and resilience a context this study could work with, thus adopting them as 'references' and working definitions for this research – see Box 2 and Box 3.

Box 2. Reference definition for 'sustainability'.

> A sustainable organic protected cropping system *"makes the best use of natural, human and technological capitals to minimise environmental impacts, while maximising its productivity and contribution to ecosystem services"*.

Box 3. Reference definition for ‘resilience’.

A resilient organic protected cropping system *“possesses or builds on the capacity to absorb expected and unexpected changes and finds a new state of balance through the adaptation of its natural, human and technological components”*.

To fulfil the purpose of the research, a set of four objectives has been drafted as follows:

- Explore how organic growers understand and regard the concepts of ‘sustainability’ and ‘resilience’;
- Identify management practices that affect farm sustainability and resilience most in their opinion;
- Critically evaluate the (environmental, social, economic, political) factors that would affect growers’ decisions about improving and/or implementing practices, according to their knowledge;
- Identify the eventual benefits growers expect from the improvement and/or implementation of these practices.

Direct interaction with growers will give this study a cutting edge in uncovering the process of transformation from theory to practice, straight from the producers’ point of view, since little is yet known and especially in times of transition and change like the current ones, getting a better understanding of organic growers’ perspectives on what they deem sustainable and resilient, in relation to their practical management, is as important as quantitively assessing how sustainable and/or resilient their business is (Foresi *et al.*, 2017). It will help discover what practices or issues they would be keener on implementing or improving to increase the overall performance of their production systems, what are the factors and motivations that affect their decision-making the most, and what issues they think would encourage or discourage them from improving or implementing certain practices. Therefore, in line with the objectives of the study, four questions were formulated to cover the main points on which the study will focus, and they are as follows:

- How do farmers understand or regard the concepts of ‘sustainability’ and ‘resilience’?

- What are the management practices that, in growers' opinion, have the largest influence on the sustainable and resilient development of a farm?
- What are the (environmental, social, economic, political) factors that affect farmers' decisions about implementing or improving practices, according to their knowledge?
- What are the potential benefits growers expect from the eventual improvement or implementation of their practices?

## RESEARCH APPROACH

The complex and dynamic nature of organic farming requires an in-depth and integrated approach to evaluate and understand the social and economic aspects of management that have a significant influence on building up sustainability and resilience of a farm, along with environmental integrity. For this reason and for the nature of the information needed to respond to the previously posed research questions, the present study employs a mixed method approach, involving the collection of both empirical (quantitative) and observational (qualitative) data. The assumption behind this choice of inquiry is that a combination of qualitative and quantitative approaches provides a deeper understanding of the problem than either on its own (Creswell, 2014). Indeed, adopting one methodological approach might be limiting in a context such as agricultural research, for it is believed that the potential complementary use of multiple methodologies would ensure that 'the bigger picture is not lost' (Munyua and Stilwell, 2009) and 'the complexity of investigations is captured' (Santiago-Brown *et al.*, 2014). These approaches have only been established in the late 1980s and in the mid-1990s, Chambers (1994) introduced the Participatory Rural Appraisal as a "family of methods to enable local people to share, enhance and analyse their knowledge of life and conditions, to plan and to act, sourcing from participatory research, agroecosystem analysis, and field research on farming systems", which could be equalled to applying mixed methods to agricultural development according to Santiago-Brown *et al.* (2014); however, it seems that agricultural sciences and mixed methods are still in the 'acquaintance' stage.

## RESEARCH DESIGN AND METHODS

Selecting a research approach is the first step; next is defining the research design, which represents a type of inquiry within the approach that provides specific direction for procedures (Creswell, 2014). Involving both qualitative and quantitative approaches, mixed methods integrate multiple forms of data deriving from different methods of collection: in these cases, all methods are believed to support each other, functioning as reciprocal validation systems, neutralising one another's bias and weaknesses. Within mixed methods designs, there are multiple combinations of qualitative and quantitative methods; for the present study, a 'convergent parallel' strategy is used so the two stages of the study will likely overlap as they are to be conducted almost simultaneously, therefore while the quantitative results are collected and analysed, the qualitative study is undertaken to have a more detailed explanation and integration of the quantitative results, and also to see if the two sets of data actually match or disprove each other (Creswell, 2014).

The key assumption of this design is that each method supplies a different type of information (in the present case, detailed observations and views on a specific issue from qualitative analysis, and scores for the importance of a certain practice from quantitative analysis), but that they ultimately give combined results. However, it is argued that for this design, even though it is thought to be popular in fields with a strong quantitative imprint like agricultural research, the challenge is to identify the quantitative information to further analyse and to be aware of the unequal sample sizes between stages (Creswell, 2014). Since greenhouse cropping is a specific production system within an already specific farming sector such as horticulture, there is a general limited availability of data on single farm businesses, specialized or not, hence the employment of multiple methods to collect information. For this study, an integration between surveys and interviews have been chosen: data collected through surveys will be analysed and interpreted, and they will be followed by face-to-face interviews to add to and integrate the volume of quantitative information, enabling the researcher to reach across both databases.

Even though it has been argued that mixed methods research is not a popular approach in agricultural sciences (Santiago-Brown *et al.*, 2014), the combination of surveys and interviews seems to be common for data collection with farmers and growers, according to De Silva and Forbes (2016). Therefore, since it is a methodology approach that enhances the understanding of problems being investigated (Munyua and Stilwell, 2009), the collection phase is split in two stages to gather information: the first 'quantitative' stage focuses on a set of closed-ended questions to be sent to an initial sample of growers, while the second 'qualitative' stage concerns a range of open-ended questions for an in-depth semi-structured interview that will concern a much smaller sample of producers that employ protected structures on their farms, among those who completed the survey. The formulated questions of the survey were tested first, to strengthen their validity and quality. Possible ‘targets’ for the testing would have been not only growers (not to be included in the survey), but also academics involved in organic horticulture, staff from potential data sources such as certification bodies or national sectorial associations, all groups of stakeholders thought to be able to provide feedback on what might need improvement in terms of length, flow and structure.

### TYPE OF DATA

Since the survey was to target growers, a pre-test of the survey has been done with a grower in Italy in early May 2016, with a format consisting of a total of 36 questions, split into two main sections, 2 questions in the beginning as an introduction and a conclusive 5-question set linking to the follow-up interview. The first section contained 17 closed questions concerning business operations and general information on the farm, such as size and percentage of protected area, total turnover and percentage of turnover from protected crops, number of workers, channels of product distribution. The second section listed 12 questions, both closed and open-ended, concerning the interviewee’s views on a series of issues and practices linked to sustainability and resilience, the importance given to these issues and practices regarding the respondents’ farm management, the factors that might have a major influence on their managerial decisions to implement or improve said practices, the expected benefits or constraints related to their improvement or implementation.

The structure of the survey was based on a study done on the sustainability of New Zealand’s horticultural sector by De Silva and Forbes (2016), which has been used as an example and the questions expanded to consider resilience as well. This study has been chosen as a literature reference for the operational stage because at the fieldwork preparation stage (Spring 2016), it was the only available peer-reviewed paper that touched the topic of sustainability in the horticultural sector encompassing questions on all three dimensions of sustainability, and that used a mixed methods approach to gather data on horticultural operations in New Zealand. Taking from the previously mentioned reference and widening the research to enrich the range of issues touched by the survey, a list of management practices has been ultimately put together through the available literature (De Silva and Forbes, 2016; Dennis *et al*., 2010 and Hall *et al*., 2009, the latter two regarding sustainable practices in floriculture and greenhouse nursery production).

The complete list of issues and practices was split into an environmental and a socio-economic group, as shown in Table 2 and Table 3 below.

Table 2. Sustainability practices (environmental) suggested by literature.

| |
|---|
| Integrated pest management programme/biological pest control |
| Management of herbicide usage and application/weed management |
| Disposal of chemical containers/chemical runoff protection |
| Soil protection |
| Soil testing and fertiliser/nutrient management |
| Organic waste management/composting |
| Water conservation/recycling |
| Recycling and reusing non-organic waste/landfill management |
| Habitat and wildlife protection |
| Energy efficiency |
| Product disposal/end of life processes/biodegradable pots |
| Packaging management/reduction |
| Fuel efficiency |
| Effluent and/or waste water management |
| Paper conservation |
| Environmentally-focused supplier programme |
| Use of sustainably produced raw materials/alternative media |
| Written environmental policy |
| Environmental auditing |
| Pollution and emission/carbon footprint monitoring |
| Environmental manager or employee with similar responsibilities |
| Use of energy generated from renewable sources |
| Environmental life cycle analysis |
| Biogas/odour management |

Table 3. Sustainability practices (socio-economic) suggested by literature.

| |
|---|
| Food safety/quality programmes |
| Documented safe working conditions for employees |
| Documented product traceability systems |
| Documented product safety policy |
| Preference purchasing from local suppliers |
| Job training, education and development |
| GrowSafe certification for employees |
| Flexible employment practices |
| Written employee policy |
| Sustainable procurement practices |
| Equitable employment opportunities/consider diversity in staffing decisions |
| Monitoring job satisfaction |
| Human resources manager or employee with similar responsibilities |
| Event sponsorship |
| Establishing a charitable foundation or making donations |
| Wellness benefits |
| Engagement in charitable activities |
| Formal resource allocation in budget for implementation of sustainability practices |
| Financial benefits |
| Community liaison manager or employee with similar responsibilities |
| Written community policy |

These lists targeted producers, processors and distributors alike, therefore they have been adapted to group the most significant issues and practices connected to farm management, and to fit with producers of any scale of business as the sole target group. Multiple issues were grouped together as they were seen to belong to the same topic, whereas others were taken out as specific for the New Zealand context, so not fit for a survey targeting producers from different countries. The list was ultimately updated also with the help and advice of the test farmer, who completed the newly drafted questionnaire in approximately 20 minutes, which could be considered a suitable time for a survey of such length to be completed. The updated list of issues, environmental and socio-economic, as it appeared in the official version of the questionnaire that was sent out for surveying, is shown in Table 4 below.

Table 4. Updated version of sustainable practices (environmental and socio-economic).

| |
|---|
| Weed management |
| Soil fertility management |
| Waste recycling / reusing |
| Wildlife protection |
| Energy efficiency |
| Use of renewable energy |
| Water conservation |
| Carbon emissions |
| Environmental auditing (LCA, footprinting) |
| Profits |
| Financial survival |
| Financial benefits |
| Events sponsorship |
| Short food supply chain |
| Local community engagement |
| Landscape and heritage protection |
| Public access to farm |
| Products traceability |
| Job training, education and development |
| Work safety |
| Traditional knowledge |

There were no available studies to draw resilience-related issues and practices from at the time, so the list that was later used in the survey was drafted condensing information and taking cues from literature, the best help coming from works by Darnhofer and Milestad (Darnhofer, 2014a; Darnhofer, 2014b; Darnhofer *et al.*, 2010; Darnhofer and Milestad, 2003; Kummer *et al.*, 2012). A similar process was followed to draft the list of factors that influence the improvement or implementation of practices, finding and summarizing suitable information from the literature review. All topics, first introduced in the survey and then explored in-depth through the interviews, were drafted in accordance with the research questions:

- Views on sustainability and resilience, with growers supplying their own level of understanding of the concepts and confronting them with the definitions chosen as references from the literature;
- Current practices, their potential implementation and major influencing factors;
- Eventual benefits of practices' implementation or improvement.

The interview was semi-structured and comprised 11 open-ended questions, subdivided into four different categories based on the format of the survey, which acted as a guide for the discussion, with an indicative completion target time of 60 minutes. Semi-structured interviews are extremely useful when the researcher has developed enough of an understanding of their topic of interest to have a clear idea for the discussion with the informant but remains open to having their understanding of the topic open to development through the responses of the interviewees (RWJF, 2008). Interviews were done face-to-face, directly on site, and a farm visit were to follow or to be integrated with the questioning to observe the farmers act and behave in their own setting, and potentially gather more information on certain topics that the interview might miss (i.e. historical and cultural facts). Ethical approval was received for the project in early December 2015 and according to the proposed plan, all the interviews were recorded and transcribed, and all data treated anonymously. Participant Information and Consent Form were in place and have both been translated in Italian.

**SOURCES OF DATA**

In Italy, the Ministry of Agricultural Policies, Environment and Forestry (MiPAAF, www.politicheagricole.it) approved and recognises 14 organic certification bodies. For this research, the volume of contacts was provided by ICEA (www.icea.bio), currently counting the highest number of names among all certification bodies, whose website supplied a database of all its certified farms at national level. The database included all types of enterprise (i.e. milk and cheese, wine, olive oil, meat, cereals, vegetables), and comprises producers, processors and distributors, which accounted for a total of 9439 names, as on 16/06/2016, all the listed businesses certified accordingly to the EC 834/2007 Directive. The list of names has undergone an initial screening to target all organic vegetable producers, since growing horticultural products inside greenhouses is not an information that farmers often supply, although they might if it is a specialized production. The screening came up with a first selection of 905 names of organic growers, all listed on a spreadsheet (on 27/06/2016).

In the United Kingdom, the Department for Environment, Food and Rural Affairs (DEFRA, www.gov.uk/defra) approved and recognises a list of 9 organic control bodies. Even though Soil Association is the body that assembles the largest group of certified organic farms across the whole nation, its database is not accessible without permission and asking for such access seemed out of scope for the research. Therefore, in this case the screening part included sieving every single control bodies' website for names mainly (not necessarily whole contacts) and checking linked websites whenever possible. A final list of 54 names of organic growers was put together on a spreadsheet (on 18/10/2016).

The two lists of growers, securely stored in multiple private electronic storage devices, were to constitute the official samples for the survey.

### SURVEYS' SAMPLING AND DATA COLLECTION

Given that producers do not have to state the eventual presence of protected cropping on their farms, since in most cases the targeted farms potentially enclose a variety of different enterprises, the initial survey has used organic producers as a reference population, to be gathered through the ICEA database for Italy and the Soil Association for the UK. The survey has been created through the Bristol Online Survey software and then sent to both samples of producers through e-mail. Even though there is no exact agreement on the required response percentage for qualitative studies, the available literature suggests aiming for an average rate of approximately 10% for online surveys (Pullman *et al*., 2009).

The official survey contains a total of 36 questions, the very first question (Q1) reiterating the anonymity of the data collection and the voluntary nature of participating to the survey, and the following one (Q2) acting as an additional tool for selection asking respondents if they have greenhouses on their farm or not. A positive answer to this question lets respondents access the rest of the questionnaire; in case of a negative response, producers get automatically screened out. The final 5 questions (Q32-Q36) basically link up to the qualitative stage of the research, asking respondents if they wish to have this follow-up interview directly on their farm and if not, would they agree to supply a contact of their own that they think would be interested in taking part in the study. The remaining 29 questions form the core of the survey and are split in two sections. The first section encloses 17 closed questions (Q3-Q19) concerning business operations and general information on the farm, such as geographical location, farm size, area covered by protected structures, type of structures employed, main crops cultivated indoor, number of workers, total turnover and percentage represented by protected crops, and channels of distribution. In this section, special mention is made of the reasons supplied for the employment of protected structures on farm, which links up to the growers' capacity to confront with and adapt to extreme events and their possible solutions to do so. The second section comprehends the remaining 12 questions (Q20-Q31), both five-point Likert-scaled and open-ended, regarding the interviewee's views on sustainability and resilience and the importance given to them in relation to their management, their current practices, their eventual implementation or improvement of others, the factors that might have a positive or negative influence on their improvement or eventual implementation of practices, the perceived benefits and constraint in relation to the implementation or improvement of these practices.

The survey for the Italian producers was opened on 18/07/2016 and sent out the next day via e-mail to all 905 contacts; the survey for the British producers was opened on 27/10/2016 and again sent out the next day via e-mail to all 54 contacts. In both cases, the official close date of the survey was set on 30/06/2017 so growers would have between 9 and 12 months to send their responses in: this date also marked the official closing day for all fieldwork. The temporal difference between the two launching dates has been planned as to avoid overlapping between fieldwork in the two countries, so scoping for potential interviewees in Italy began with a few months' advance than in the United Kingdom.

By December 2016, roughly 20% of the messages sent out to all 905 Italian producers came back negative because of non-existent e-mail addresses, thus reducing the effective sample volume to approximately 730. At that time, the Bristol Online Survey software reported that for Italy, 25 respondents were screened out and 27 questionnaires were completed, while a total of 86 participants were still progressing through the survey. Moreover, 22 farms were added to the 'screened out' group for they rejected the survey through e-mail, because either they were not equipped with protected structures or it turned out they were not growing vegetable crops, even though it was mentioned otherwise in the database. From a brief mid-fieldwork analysis of results, in Italy's case the target average responses would amount to roughly 73, according to literature (i.e. 10% of 730), so the completed questionnaires represent approximately 37% of the expected 73, which means that the general response rate is 3.7%, roughly three times lower than the percentage suggested by Pullman *et al.* (2009).

In the United Kingdom's case, by December 2016, there were no messages coming back because of wrong e-mail addresses and flat-out rejections. This could be due to more updated websites and databases, at least compared to the Italian case, but that is just an assumption due to circumstances and investigating the truthfulness of said assumption would fall out of the scope of the present research. At that time, the Bristol Online Survey software reported that for the United Kingdom, 2 respondents were screened out and 5 questionnaires were completed, while 4 more respondents were still progressing through the survey. From a brief mid-fieldwork analysis of results, in UK's case the average responses would amount to 5 (i.e. 10% of 54), so the completed questionnaires represent 100% of the expected 5, which means that the response rate already corresponded to the literature-based 10%.

The substantial difference in responses between the two countries brought to the decision to send out a second wave of questionnaires, to collect a higher number of responses especially in the United Kingdom, therefore they were sent out a second time on 09/01/2017 (UK) and 23/01/2017 (Italy). The decision to attempt to expand the group of positive responses, in both countries but especially in the United Kingdom, was especially driven by the chance to widen the list of potential names for the follow-up interviews.

At the end of the operational stage, on the survey's official close date, the number of completed questionnaires from Italian producers had reached 42, representing 57% of the expected 73, which means that the final general response rate was 5.7%. Further analysis of results also showed a total of 61 'screened out' responses and 141 still in progress, while the number of rejections through e-mail had raised up to 35. The response rate has seen an important increase since the previous time, however it is still far away from the 10% suggested by literature, suggesting for future reference that online surveys alone might not be enough to reach that threshold, thus needing other means of contact as support.

As for the United Kingdom, on the survey's official close date, the number of completed questionnaires had raised up to 10, having doubled up the response thus representing now 200% of the expected 5, which means that the final general response rate was 20%. Further analysis of results also showed a total of 5 screened out responses and 11 still in progress, while 3 rejections appeared through e-mail. In this case, the response rate has seen an incredible increase since the previous time, having surpassed the 10% suggested by literature, which could be due to a smaller sample than the Italian batch of contacts; although it is a simple assumption due to circumstances, with small samples, online surveys alone are effective in reaching the minimum threshold.

If considering the average final general response from both groups of respondents, it worked out as 12.9%, thus having surpassed the 10% threshold suggested by the literature, therefore no further questionnaires were sent out.

## INTERVIEWS' SAMPLING AND DATA COLLECTION

There is no tested or safe way to know the exact entity of the effective number of organic farms employing protected structures to grow horticultural products. Therefore, part of the intent of the research was to identify a limited group of cases, theoretically between 10 and 15 for each country in the beginning, to collect a relevant volume of information even in the face of 'numerical uncertainty'. In this case, a concept that literature introduces for research based on qualitative data is the 'saturation point', which represents a moment in the analysis when no new substantial information is acquired (Etikan *et al.*, 2016). Although the aim would be to reach this data redundancy, it is not always easy to decide on a proper number of cases to enclose in the study that would make such goal reachable and the present research is an example; in this case, however, reaching the saturation point was of secondary importance, given the potential richness of issues that would emerge from the discussion, whether with fewer or more producers, so it was agreed to start from the same number of interviews per country both for practical reasons and to gather enough information to ensure that at least the research questions would be answered. Given the much smaller number of growers in the UK sample, it could not have been increased considerably and a symmetric design of interviews was preferred. The analysis revealed rich material and at least for the UK sample, it can be assumed that further sites would not have added substantial new information and the sample size was at or at least near the saturation point.

For this, a mix of non-probability sampling methods was used, for they seem to be preferred when it comes to recruiting stakeholders in community-engaged research (Valerio *et al.*, 2016), not to mention they are quicker and cheaper to implement than probability sampling methods (Etikan *et al.*, 2016): purposeful and snowball sampling were employed, the former for an initial selection of potential cases to be included in the study, although literature is not clear on how many cases are enough for a qualitative research to avoid reaching the saturation point, and the latter as a support to purposeful sampling for the identification of other cases for the interviews through the previously selected participants. However, according to Palinkas *et al.* (2013), qualitative methods tend to determine the required number of participants relying on eventual research precedents, level of detail needed and whether they put emphasis on homogeneity or heterogeneity (smaller vs larger sample, in this case).

Purposeful sampling is usually employed in qualitative research to identify and select information-rich cases to use limited resources effectively, relying on the judgement of the researcher when it comes to selecting the subjects to be studied, which are usually knowledgeable or experienced with the phenomenon of interest, not to mention willing to participate and apt to talk about said phenomenon of interest in an articulate, expressive and reflective way (Etikan *et al.*, 2016; Palinkas *et al.*, 2013). Usually, the sample being investigated is quite limited, especially when compared with sampling techniques employed in quantitative studies, where significant sample numbers are a key factor (Lærd Dissertation, 2012a). Unlike probability sampling techniques, the goal of purposeful sampling is to focus on interesting characteristics of a population, which will best enable the researcher to answer their questions. The sample being studied is not representative of the population, but for researchers pursuing qualitative or mixed methods research designs, this is not considered to be a weakness (Lærd Dissertation, 2012a). However, as not requiring to be representative of the population they target, purposeful samples can be highly prone to bias and it can be difficult to defend the representativeness of the sample and that the judgement used to select units to study was appropriate. The idea that such sample would be created based on the judgement of the researcher is considered a negative characteristic, although this judgmental, subjective component could be a major disadvantage only when such judgements are ill-conceived or poorly considered. Such viewpoint is understandable and choosing the right tool to collect data is always an imperative, since there is no amount of analysis that can make up for improperly collected information (Etikan *et al.*, 2016), however finding a restricted group of stakeholders within an already specific population did require some case selection, even though purposeful sampling initially entailed a certain degree of randomness: in that sense, geographical position also played an important role in the process, especially for the Italian sample (i.e. higher familiarity with national geography, larger number of respondents from survey).

Snowball sampling belongs to the purposeful sampling methods group and is believed to be quite common in qualitative studies and for selecting respondents for semi-structured interviews (Hardon *et al.*, 2004). It can be used to gain access to hardly-accessible populations (in this case, growers employing protected cropping among organic vegetable producers) because it takes advantage of established social networks of people with characteristics of interest (Valerio *et al.*, 2016). It initially involves identifying an easily accessible number of respondents in the desired population (i.e. organic vegetable producers) and then using these units, called ‘seeds’, to find further respondents and so on (Sedgwick, 2013). Snowball sampling is a useful choice of sampling strategy, especially as a support to purposeful sampling, when the population of interest is hidden or hard-to-reach because there could be no obvious list of contacts to draw from, therefore making the sample difficult to access otherwise (Lærd Dissertation, 2012b), or the range of possible variation within the purposeful sample might be unknown before the study (Palinkas *et al.*, 2013), thus opening to the potential exploration of uncovered characteristics of interest. Moreover, the use of existing cohorts to recommend other potential members probably encouraged recruitment through an element of trust in the community (Sedgwick, 2013). Since snowball sampling does not select respondents for inclusion in the sample based on random selection, unlike probability sampling techniques, it is impossible to determine the possible sampling error and make statistical inferences from the sample to the population. As such, similarly to purposefully sampled ones, snowball samples are not to be representative of the population being studied (Lærd Dissertation, 2012b).

As a first step towards identifying purposeful samples, towards the end of the survey, growers encountered a question (Q33) asking them if they were interested in taking part in a follow-up interview and having the chance to talk in more details over the topics that were touched in the questionnaire. Therefore, the interview was designed to be semi-structured and comprised 11 open-ended questions, subdivided into four different categories based on the grouping of issues operated in the survey. Although, since interviews were semi-structured, the draft acted more as a guide for the discussion than a proper script, letting growers follow the topics picked up from the survey and expand the discussion with any other related issue important to them. Since literature could not give specific directives on the correct number of interviews to integrate in a mixed methods design, it was decided to reach the even number of 10 in each country, a decision that came with the reservation to eventually raise the number up to 15, given the trial-like nature of the research and the wide range of issues that would potentially arise during the discussion; such decision was also taken in case there were enough contacts available after the 10 initial interviews, there was still time to plan for 10 more transfers and the saturation point has not been reached yet. However, as it was anticipated in the previous chapter, being representative of the whole population of farmers growing vegetables in greenhouses, both in Italy and the UK, was never an objective of the present study.

Interviews' ultimate target length was set at 60 minutes, and the effort to respect that target time has been put from both interviewees and interviewer alike, rather successfully in most cases. However, every grower has a different attitude towards sharing details of their business, so the duration of the discussion varied from case to case, with the shortest interview lasting 27 minutes and the longest one lasting 148 minutes, and an average of 74 minutes for both countries. Interviews were face-to-face, directly on site, and a visit to the farm was integrated with the questioning, either after the discussion or during the interview, which helped matching what was said in theory with what was done in practice. In these cases, a farm visit can be considered an invaluable support as it enables researchers to gather more information on the growers' behaviour in their environment and it might help shed more light on certain topics that the interview, in its perceived formality, might have missed, such as historical and cultural facts, direct observations, or personal thoughts. With one exception in the UK, all the interviews have been recorded and then transcribed.

In accordance with the anonymity of data treatment concorded with the interviewees before data collection started taking place, all interviewees have been assigned a code that would identify them throughout the discussion, the following transcription and in later stages (01-10 for Italy, 11-20 for the United Kingdom, according to the chronological order in which they were interviewed). Further information on the interviewed growers' basic profiles and identifying codes can be found in Annexes III (Italy) and IV (United Kingdom). As anticipated in the previous section, travelling in the two countries began in different moments of 2016, to have time to contact all growers, give them enough notice to fit the interview in their schedule, and keep track of travelling times, distances and costs. All 20 interviews were spread over a period of 7 months, taking place between September 2016 and April 2017 (Table 5).

Table 5. Lengths, with approximation in minutes, of all interviews with corresponding dates.

| Interviews | Italy | | United Kingdom | |
|---|---|---|---|---|
| 1 | 1:37:00 (87) | 07/09/2016 | 0:58:45 (59) | 30/11/2016 |
| 2 | 1:01:17 (61) | 12/09/2016 | 2:27:41 (148) | 12/12/2016 |
| 3 | 0:40:01 (40) | 15/09/2016 | 0:26:54 (27) | 17/01/2017 |
| 4 | 1:13:46 (74) | 21/09/2016 | 1:25:37 (86) | 27/01/2017 |
| 5 | 1:08:20 (68) | 22/09/2016 | 0:49:00 (49) | 06/02/2017 |
| 6 | 1:21:46 (82) | 06/10/2016 | 1:17:49 (78) | 22/02/2017 |
| 7 | 1:42:44 (103) | 07/10/2016 | 0:47:15 (47) | 27/02/2017 |
| 8 | 1:42:44 (103) | 07/10/2016 | 1:14:50 (75) | 08/03/2017 |
| 9 | 1:42:44 (103) | 07/10/2016 | 0:38:00 (38) | 16/03/2017 |
| 10 | 1:15:31 (76) | 30/12/2016 | 2:08:22 (128) | 04/04/2017 |

Specifically, 10 interviews were granted, 10 were recorded and 7 farms were visited in Italy between September and December 2016, travelling by car: exceptions were made for GRO07, GRO08 and GRO09 who were present on the same farm at the same time, so a single combined interview for 3 growers was recorded, and for GRO10 who granted to meet in town for the interview for business-related reasons, thus bypassing the farm visit. In the United Kingdom, another 10 interviews were granted, 9 were recorded and 9 farms were visited between November 2016 to April 2017, splitting transportation between car and train: the only exception was made for GRO19 who could not have a face-to-face meeting due to a busy schedule, thus agreeing on having the interview over the phone; although this interview was not recorded, written notes were taken during the discussion.

Since there was a relevant number of Italian growers agreeing on being interviewed already in July-August 2016, it seemed sensible to group respondents based on their geographical position: at that time, results showed that the highest percentage of possible participants were in the Northern part of the country, while a much lower percentage of responses came from the Centre and South. Choosing a representing region for each macro-area was dictated mainly by the history behind their economic development, which the three zones have gone through in different measures: for a long time, the North has represented the 'richer' part of the country while the South has been economically struggling, with the Centre always (literally) standing in the middle. However, organic agriculture has grown more in the South and Centre, compared to the North: in 2016, Southern regions like Sicily, Apulia and Calabria were the top three in terms of organically cultivated areas, accounting for over 800,000 ha, 46% of the national organic area, followed by Central regions such as Latium (5$^{th}$) and Tuscany (6$^{th}$), while Emilia-Romagna, Piedmont, Lombardy and Veneto were the first Northern regions appearing in the ranking, respectively occupying the 7$^{th}$, 11$^{th}$, 14$^{th}$ and 15$^{th}$ positions (SINAB, 2017). Data on vegetable crops, which included strawberries and cultivated mushrooms, showed that at the national level, the largest area voted to organic horticulture was in Apulia (10,658 ha), followed by Sicily (6,490 ha); in the Centre, Tuscany (2,928 ha), Marche (2,741 ha) and Latium (2,473) are close contenders for the first place in terms of vegetable cropping area, while in the North, Emilia-Romagna possesses the largest horticultural land (4,395 ha), followed by Lombardy (1,803 ha), Piedmont (1,353 ha) and Veneto (991 ha) (SINAB, 2017).

According to this information and the survey responses, the choice would have fallen on Emilia-Romagna and Tuscany for Northern and Central Italy; however, these two regions are geographically close to each other and the research aimed at first expanding then eventually narrowing the range of variations, through this multistage sampling (Palinkas *et al.*, 2013). Therefore, based on the available responses from the survey and cross-checking with the information from the report, the three chosen regions that would represent the three Italian macro-zones, while geographically distant from each other thus potentially as diverse as possible, ultimately were Veneto for the North, Latium for the Centre and Apulia for the South. Out of the 10 Italian growers interviewed, 4 were chosen because of the positive response they gave while completing the survey (i.e. 01 through 03, and 07); the remaining 6 were gradually suggested by the respondents as potentially interested in the research and if their geographical position fit with the criterion (i.e. 04 through 06, 08 through 10).

The situation was different for the United Kingdom: with a significantly lower number of responses in October-November 2016, the idea of choosing specific counties or regions to find potential interviewees revealed to be difficult, thus being discarded in favour of starting with the available contacts and waiting for more questionnaires to be completed, and aid the sample randomization. In terms of areas, in 2016 England possessed 58% of the organic land in the United Kingdom (296,500 ha), followed by Scotland (121,600 ha), Wales (81,500 ha) and Northern Ireland (8,300 ha); within England, 49% of organic land fell in the South-West region (145,100 ha ha) and 15% in the South-East (43,800 ha) (DEFRA, 2017b). Vegetable crops accounted for 10,300 ha in the UK, representing approximately 2% of the national organic share, however no regional statistics were available in this case. Regarding the interviews, 7 out of the 10 British growers were chosen because of their positive response (i.e. 11 through 14, 16 through 18), while the remaining 3 were suggested by the respondents as potentially interested in the research or representing interesting cases of farming management (i.e. 15, 19 and 20).

Transcription stage started while interviews were being recorded, once audio files were passed from recorder to laptop, to have them all at hand at any given moment and to store a first copy of all files: interviews were listened to through a simple multimedia player and simultaneously transcribed on a Word processing text file, which was later stored in a designated folder along with the corresponding audio file. After transcription, selection of possible themes to be integrated in the discussion was done by employing an EBH approach (i.e. Eye-Brain-Hand)[2], identifying recurring issues that emerged during the interviews and major key words, related to said issues, that were central for

[2] The author is familiar with the value and support of a designated software such as nVivo, however a 'hands-on' approach to the analysis of themes (reading the excerpts several times to ensure thorough comprehension, highlighting recurring words and concepts, summarising relevant issues to draft the discussion, while identifying interesting quotes) would work all the same and give equally valuable results without the use of a software package. The same rigour as in the software was applied to the hands-on approach taken.

the research: final choice for themes fell on ‘greenhouse’, ‘soil management’, ‘diversification’, ‘growers’, ‘practices’, ‘sustainability’ and ‘resilience’, which were all presented as single themes and integrated in the discussion.

## DATA ANALYSIS

### QUESTIONNAIRES

As previously anticipated, the core of the survey comprised a total of 29 questions, divided in two main sections. The first section counts 17 questions (Q3-Q19), both close- and open-ended, which help give a general picture of the two samples of growers that took part in the research. They comprehended information such as geographical location, farm size, area covered by protected structures, type of structures employed and eventual employment of heating systems, main crops cultivated inside protected environments, number and types of workers, total turnover and percentage represented by protected crops, and channels of distribution. Given their relevance for the present study, data like farm size, area covered by protected structures and relative percentage on farm size, total farm turnover and percentage represented by protected crops, and channels of distribution are reported and explained more in-depth in the following paragraphs, supported by graphs.

The second section comprises 12 questions (Q20-Q31), which describe growers' grasp of the concepts of sustainability and resilience, the level of importance they give to a multitude of issues related to these concepts, the kind of benefits they might expect from improving or implementing some of the issues they deem important, and the factors that have an influence in their decision-making process. In the survey, these questions were presented as five-point Likert-scaled so growers were asked to attribute a weight to issues and practices in relation to how important these would be to the sustainability and resilience of their farms' management, and this weight was given through a score between 1 (=the lowest degree of relevance) and 5 (=the highest degree of relevance). Results from Italian and British organic growers have been compared to fulfil one of the research objectives and discern basic commonalities and differences between the two countries, given the importance these sustainable and resilient practices and issues have for farming management systems. For the questions pertaining to the relative survey sections, original data has been turned into percentages, to overcome the numerical difference between the Italian and British samples of respondents and have easily comparable information and presented through tables.

In the survey, special mention is made of the reasons supplied for the employment of protected structures on their farm (Q19), which links up to the growers' capacity to confront with and pull through extreme events and their possible solutions to do so.

**GENERAL INFORMATION**

For Italy, there were 42 respondents that completed the questionnaire and were geographically distributed as follows: 33 in the North, with Emilia-Romagna (11), Piedmont (8) and Veneto (7) as the leading regions, 6 in the Centre (2 in Latium and 4 in Tuscany), 2 in the South (respectively in Campania and Apulia) and one from the Islands (Sicily). Aside from a few exceptions covering sizeable areas (i.e. a farm in Tuscany spread over 300 ha, one outside Rome with 167 ha, and another in Apulia counting 110 ha), most of the respondents (26) have a farm whose size is under 10 hectares, with 19 of them under 5 ha (**Errore. L'origine riferimento non è stata trovata.**). However, the calculated farm size average for all Italian respondents was 27.36 hectares, which would be very close to the average size of organic farms given by the latest available data from SINAB (2017), which was reported to be 28 hectares.

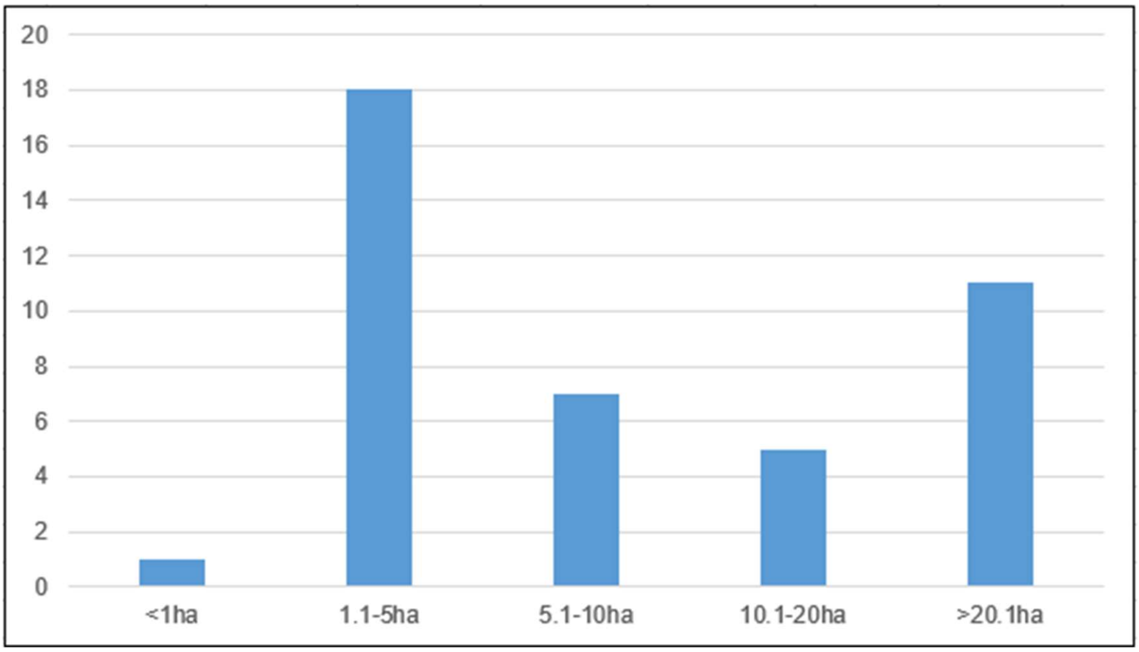


Figure 1. Distribution of farm sizes among the 42 Italian respondents.

For the United Kingdom, the 10 respondents that completed the questionnaire were geographically distributed as follows: one in Scotland (Aberdeenshire) and 9 in England (2 in Gloucestershire, 1 in Devon, 1 in Lancashire, 1 in Wiltshire, 1 in Oxfordshire, 1 in East Sussex, 1 in West Midlands and 1 in Cornwall). Aside from two exceptions, which are part of much larger farms covering hundreds of hectares (respectively 625 and 800 ha), 6 respondents' businesses have less than 10 hectares and 5 of them less than 5 ha (**Errore. L'origine riferimento non è stata trovata.**). In this case, the calculated farm size average for all British respondents was 146.52 hectares, registering a higher value than the one showed by the latest available statistics, which is 80 hectares for a holding's average size at country level, and spanning across 85 ha for England, 109 ha for Scotland and less than 50 ha for Wales and Northern Ireland (DEFRA, 2017a).

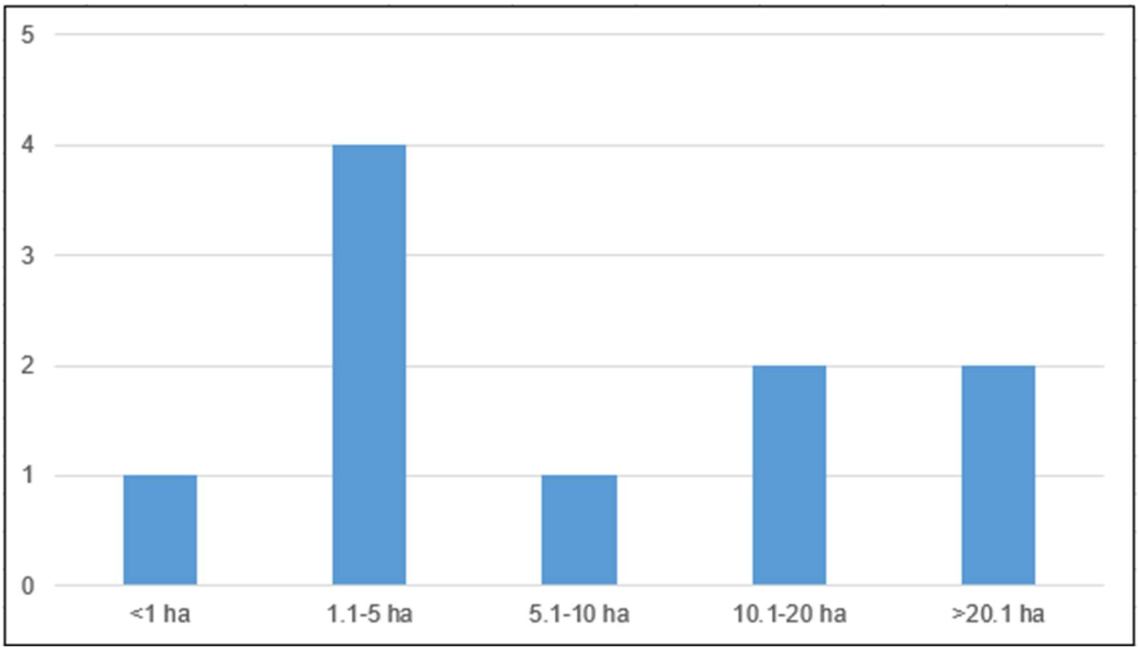


Figure 2. Distribution of farm sizes among the 10 British respondents.

Results have shown a relevant difference between the two samples, so for the first section of survey results a further division was operated within the Italian group of respondents, according to farm size. For this, the threshold was set at 10 ha to make the two new subgroups as equal in numbers as possible and reduce the existing difference with the British group as well. Therefore, the 24 Italian growers with a farm size below 10 ha are identified as small-scale producers and the remaining 18 with a farm size above 10 ha are identified as large-scale producers[3]. Given the subdivision, the average size of Italian small holdings goes down to 3.96 hectares, while large-scale farms rise to an average of 58.56 hectares.

[3] Survey results for Italy showed two farms with a size of 10 ha, therefore they were included in the large-scale group of producers to further balance the subdivision so final subsampling resulted in 24 vs 18, instead of 26 vs 16.

Generally, the percentage of protected areas on a farm varies according to different interconnected factors such as the type of structures involved, the available volume of investments and the crop or crops cultivated. Results from Italy show that the incidence of protected areas over total farm size varies only slightly between small- and large-scale producers. Most farms in general have a percentage of covered crops below 10% of the total farm area (37 cases across both groups). However, there is a major incidence of farms with a protected area ranging from 1% to 5%, especially among small-scale farms (9 against 4 large-scale businesses). There is also a higher number of farms with less than 1% incidence of protected area over farm size within the large-scale group (8 against 5 small-scale businesses) (**Errore. L'origine riferimento non è stata trovata.**). However, the calculated average of the incidence of protected areas over total farm areas only showed a slight difference between the two subgroups, registering 5.68% for small-scale producers and 5.37% for large-scale growers.

Especially with great land extensions, covering even a small percentage of said land with greenhouses is an important investment indeed, an opportunity but a relevant cost at the same time. It is also a question of simple math: for example, covering 5% of a 3-ha farm means building a 150 $m^2$ structure, which is a plausible area to turn to protected cropping on such a small farm; on the other hand, occupying the same 5% on a 300-ha farm would mean building 15 ha worth of glasshouses and/or multi-tunnels, which would represent a major and visually impacting investment, even for a large firm. However, the incidence of protected area does not seem to be strictly related to farm size: among Italian respondents, the highest percentages of land occupied by greenhouses registered were 22% and 43%, respectively on a 3-ha and a 70-ha farm, showing once again that farm size is not the only factor involved in such choice. In the United Kingdom, 9 cases out of 10 had 10% or less of the total farm area covered by protected crops, 5 had less than 5% and 2 had less than 1%. The remaining case, a farm of 2 ha, reported 50% of their land occupied by greenhouses, reconfirming that size does have an influence on the matter, but it is also a question of structures, investments and crops as well (**Errore. L'origine riferimento non è stata trovata.**). For British farms, the calculated average of the incidence of greenhouse areas over total farm areas was slightly higher than in both Italian cases, setting at 7.85%.

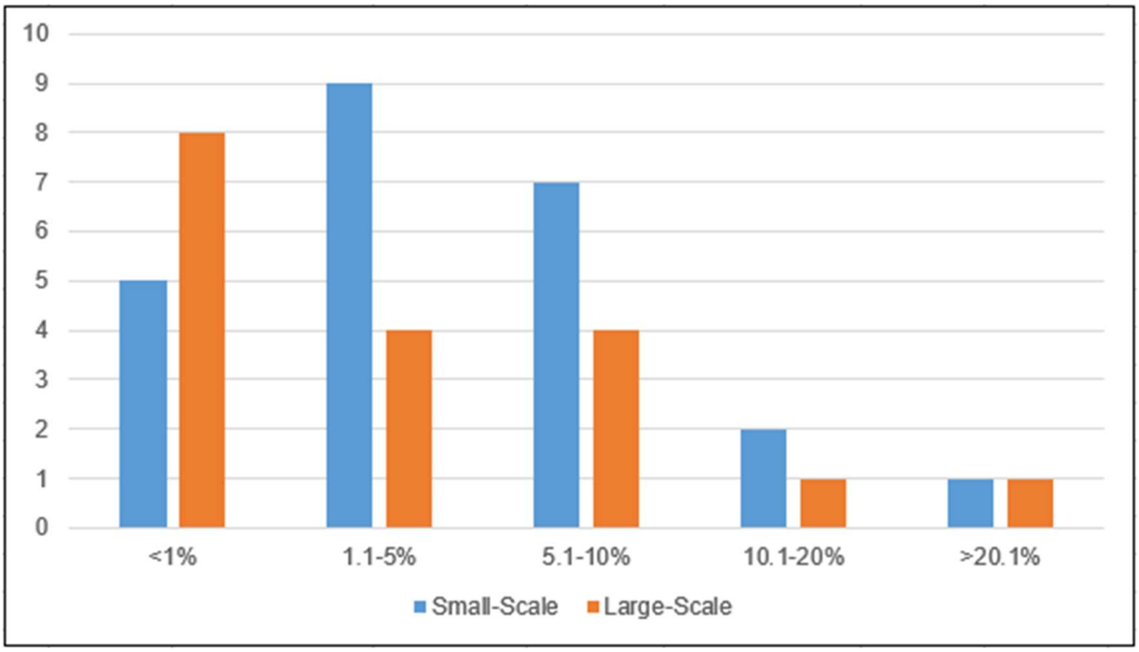


Figure 3. Distribution of the incidence of protected area over farm size among Italian small-scale and large-scale respondents.

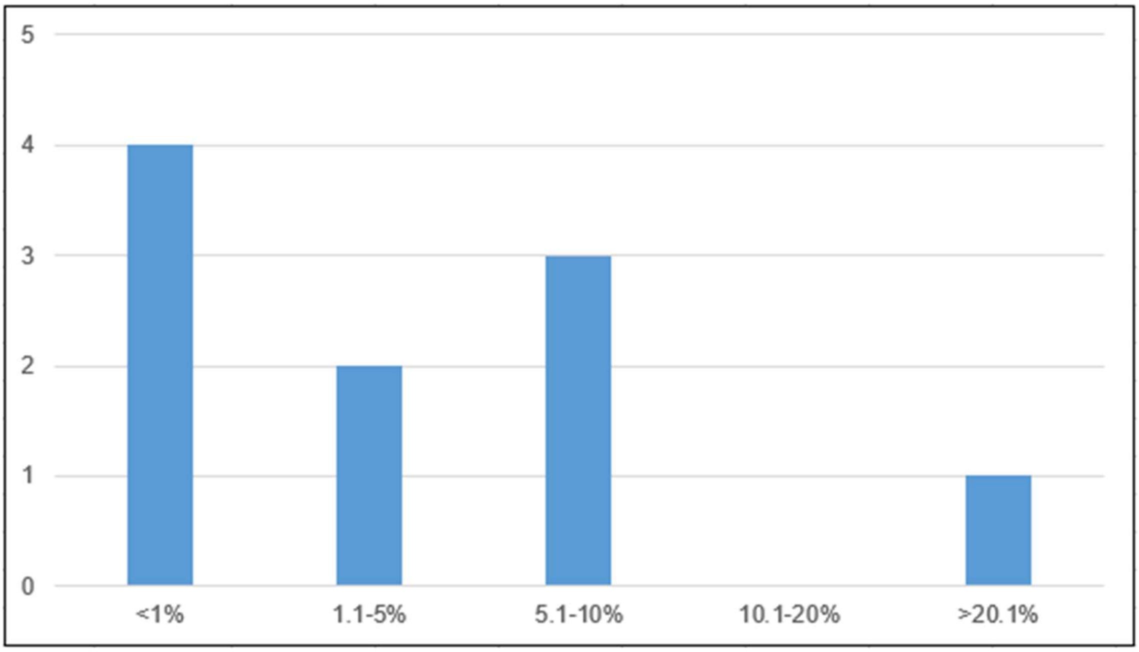


Figure 4. Distribution of the incidence of protected area over farm size among the 10 British respondents.

In Italy, choice between structures is split almost evenly between small- and large-scale producers, with a total of 16 respondents employing polytunnels (8 and 8) and 14 using multi-tunnels on their farms (7 and 7). The remaining 12 respondents have listed seasonal and mobile single tunnels as their chosen structures.

Nine producers in total have said to employ a heating system inside their tunnels, 6 of them being large-scale, using boilers fuelled by locally-sourced materials (i.e. woodchip, vegetable waste) to keep their crops warm during the winter months or to propagate their seedlings on heated beds. However, most respondents possess unheated structures, the larger group among small-scale growers (21 out of 24, and 12 out of 18 for large holdings), which remains a more common solution among Italian growers, regardless of the scale of business, for it comes at lower costs, given the warm climate that characterises the country.

Results for total turnovers showed slight differences between the two subgroups of Italian producers. Although it appears that the total turnover of a farm is not related only to its size, there seems to be a sort of correlation between them in this case: in fact, two thirds of large-scale producers earn more than €75k per year, while only one fourth of small-scale growers made it in the same class of values. Especially for small farms, turnovers are more spread out across the lower ranges of values, potentially meaning that total turnover might also be related to factors like how diversified the production is in terms of both crops and enterprises, showing the highest percentage of respondents from the small-scale group residing in the average class (6 in the €30k-45k range) (**Errore. L'origine riferimento non è stata trovata.**).

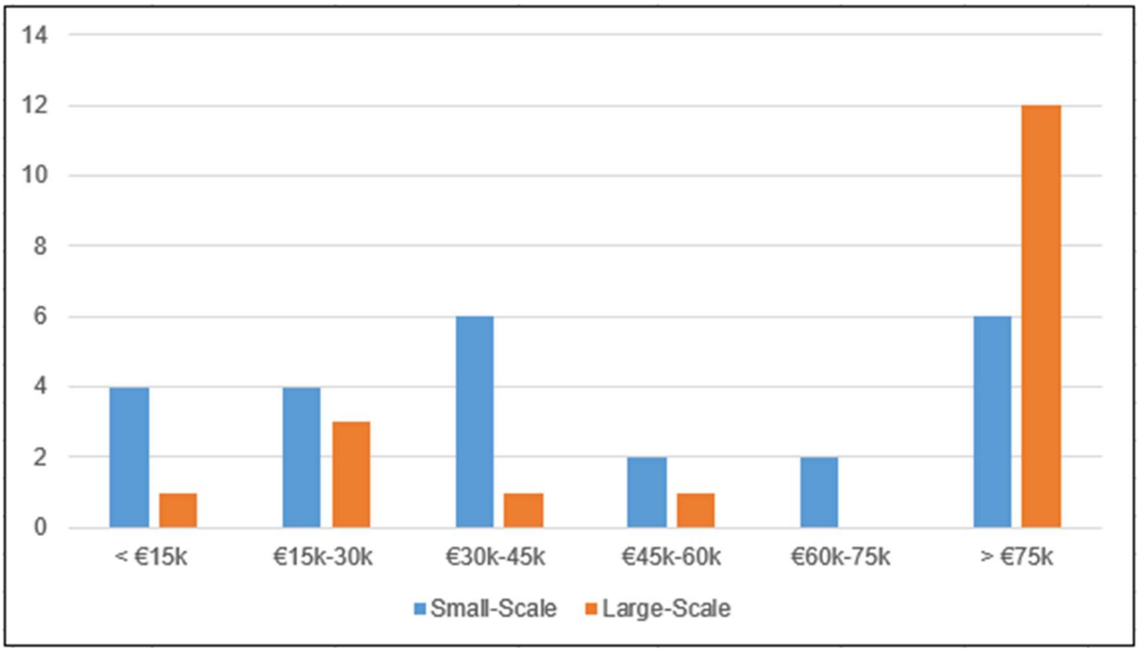


Figure 5. Distribution of the total farm turnover among Italian small-scale and large-scale respondents.

In the United Kingdom, the respondents have revealed a major presence of small-scale farms, with six farms sized under 10 ha if using the same criterion used to group Italian producers. In this case, the choice between structures is leaning more towards polytunnels, which are usually cheaper and growers can assemble them themselves, having gained 70% of all responses, while the other 30% use multi-tunnels on their farms.

The most notable and obvious difference between the two countries would be in the climate, which becomes even more relevant during the growing season (i.e. hot, long and dry in Italy; milder, shorter and subjected to higher rates of precipitation in the UK); however, wintertime can turn much harsher and colder in Northern Europe, if compared to the Mediterranean area so an element of surprise would be that none of the British respondents has said to employ a heating system inside their tunnels, partly contravening to what both Baeza *et al.* (2013) and Tittarelli *et al.* (2017) sustained regarding Northern greenhouse systems. That could suggest that using a heating system inside greenhouses is not exclusively related to climatic conditions, but it might also be linked to possibilities to invest in such systems, their adaptability to the structures, and businesses' choices in terms of scale, production and period of distribution of their produce.

It was anticipated that according to farm size, most of the British respondents might be considered small-scale businesses, so the same rule used for Italian producers could be applied in terms of total turnovers, meaning that farm size is important but there are also other factors farmers' yearly earnings can be related to, like diversification of production and enterprises within the business. Results for the UK showed that 40% of them earn more than £75k per year, while the rest is concentrated on lower ranges (4 of the remaining 6 with turnovers between £30k and £45k per year, the other two between £45k and £75k), with none of them making it to the lowest categories of values (**Errore. L'origine riferimento non è stata trovata.**).

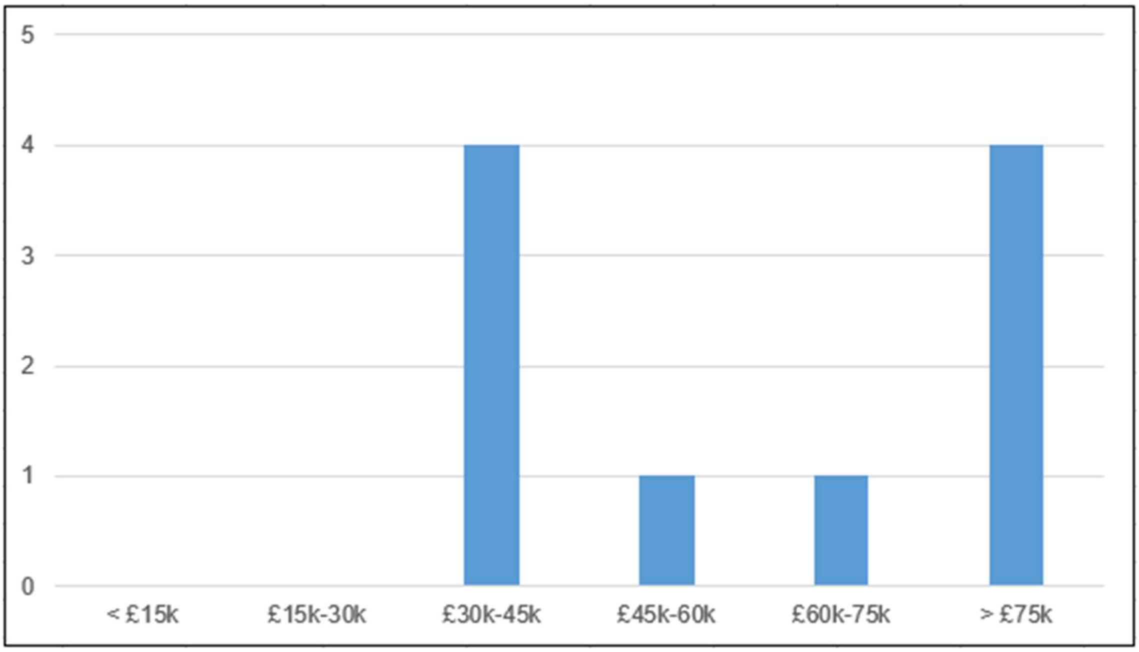


Figure 6. Distribution of the total farm turnover of the 10 British respondents.

Although many respondents in both countries confirmed that on a general rule, most of their turnover comes from open field cropping, results showed that products grown in protected structures can still represent an important percentage of their yearly earnings, regardless of farm size and extension of protected area.

For Italian small producers, in 9 cases these products account for a share between 20% and 80% of the whole production, while another 5 stay between 10% and 20% and for the remaining cases (10 in total), percentages stay below 10%, with a calculated average contribution of 23% to the total farm turnover. Responses from large producers followed a similar trend: the highest class of values registered the largest number of responses, with roughly 45% of the farms (8) referring an incidence between 20% and

80% of greenhouse products on their total turnovers, and the remaining 10 cases spread out almost evenly across the lower classes (**Errore. L'origine riferimento non è stata trovata.**), with a calculated average contribution of 35% to the total farm turnover.

For the UK, in 90% of the cases, products supplied by protected structures account for a share below 20% of the whole production; of these 9 cases, 5 stay between 10 and 20% and for the remaining 4, percentages stay below 10% (**Errore. L'origine riferimento non è stata trovata.**), while in the last case, protected structures supply a share of 35% of the total production; the average for all British producers showed a calculated contribution of 12.5% to the total farm turnover. The fact that on average, protected products make up for roughly a tenth of the total turnover of British farms, whereas this percentage can reach up to a fourth or a third of total turnovers for Italian producers, might be relatively linked to issues like different lengths and temperatures in the growing season, once again longer and warmer in the Mediterranean area, and a higher percentage of large-scale production in the Italian sample.

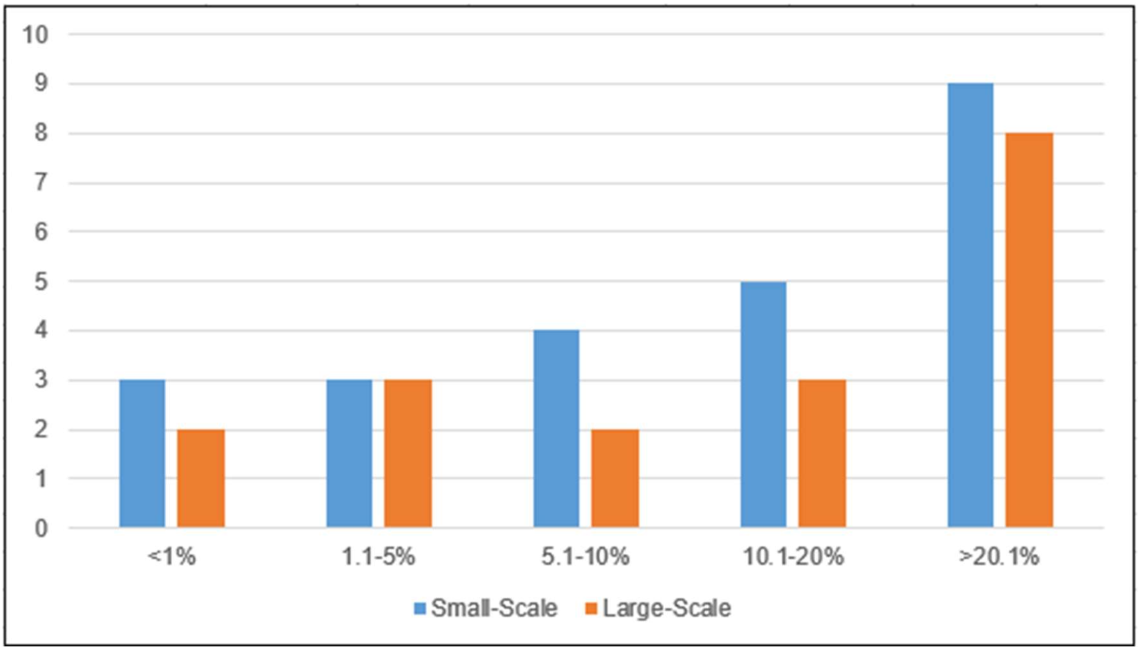


Figure 7. Distribution of the incidence of greenhouse products over total farm turnover among Italian small-scale and large-scale respondents.

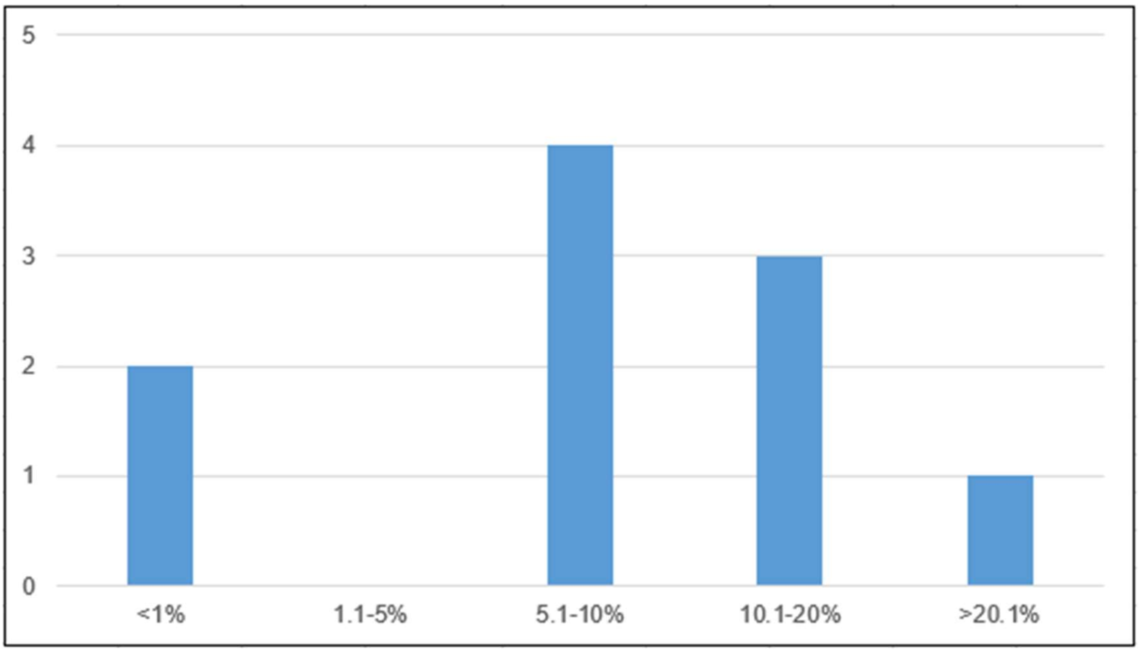


Figure 8. Distribution of the incidence of greenhouse products over total farm turnover of the 10 British respondents.

Results from both countries showed that distribution of produce is greatly varied. In Italy, direct on-farm sales are the preferred and most used channel for small-scale and large-scale producers alike, respectively with 21 and 13 preferences, followed by box schemes (9 and 7) and large distribution (7 and 4), while online sales earned the lowest number of preferences in both groups (**Errore. L'origine riferimento non è stata trovata.**). Similarly, in the UK direct on-farm sales earned 5 preferences, followed by box schemes (4), large distribution and online sales (both earning 2 responses).

In Italy, 18 respondents also chose the ‘other’ option, which they split between *Solidarity Purchase Groups*, self-consumption, restaurants and shops. In the UK, 7 respondents’ choice for ‘other’ channels of distribution fell on market stalls, restaurants, wholesale, Community Supported Agriculture and processing (**Errore. L'origine riferimento non è stata trovata.**).

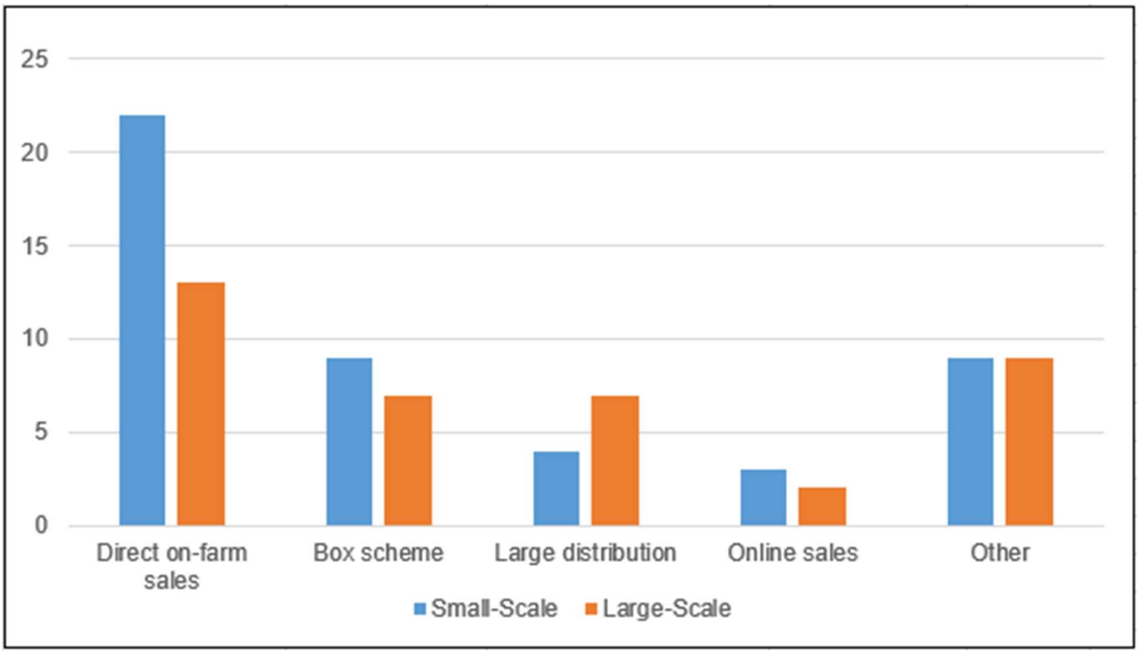


Figure 9. Distribution of the preferences for different market channels among Italian small-scale and large-scale respondents.

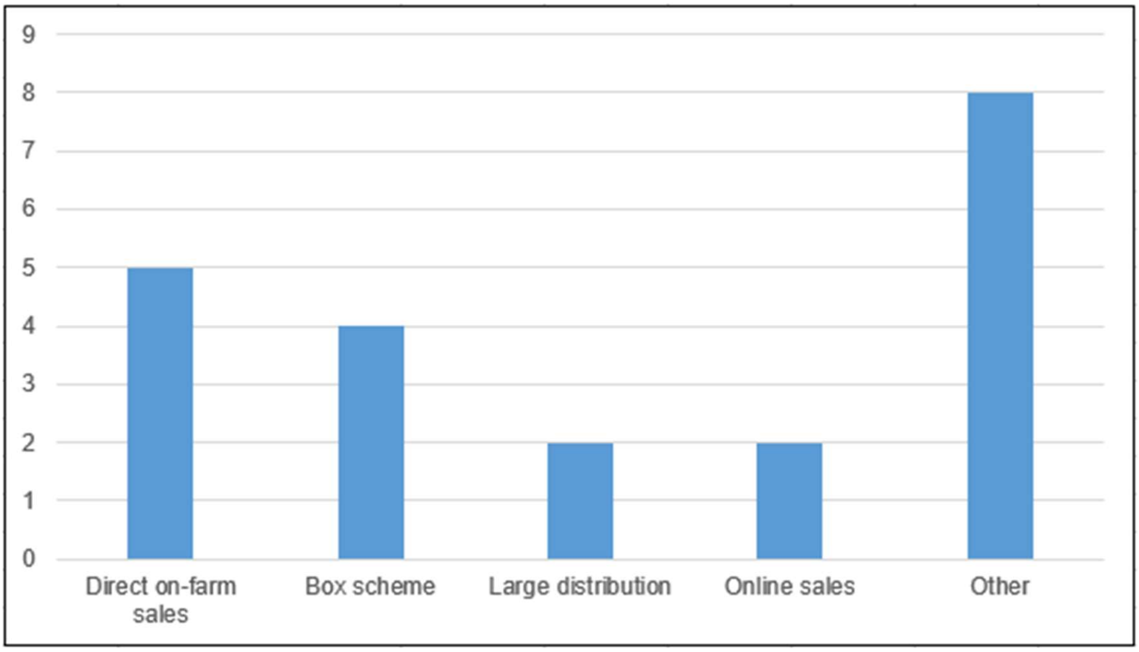


Figure 10. Distribution of the preferences for different market channels among the 10 British respondents.

A question that appeared in the survey but needs further analysis given its perceived weight in the three-pillared sustainability equation is related to workforce. Literature often asserted that protected cropping tends to be more intensive than open field production, and that is fundamentally true because it is a system that has been designed to make the best use of reduced spaces. However, many different factors concur in making this system as intensive as it is pictured, and it is not just a matter of size, thus suggesting that the larger the business, the more resources it needs for management, especially people. When it comes to protected cropping, the variety of structures and applicable techniques and technologies makes it difficult to identify the exact workforce requirements, at any scale of business. In fact, results from the survey showed that the number of farm workers and their type vary according not necessarily to farm size only, but also to factors like grown crops and the seasons in which they grow, the level of mechanization they employ inside the structures, the agronomic practices they apply, the scale of production, the financial possibilities to invest in labour, and management choices.

Generally, small-scale farms are usually family-conducted, with a low level of mechanization, and a degree of intensiveness of cultivation that might vary with the scale of distribution, therefore full-time people tend to be a reduced number whereas there tends to be a higher reliance on part-time, seasonal or occasional workers. As an example, two Italian farms of the same size (3 ha), one relying on local customers and the other focusing on large distribution, with a wide difference in the incidence of protected areas (0.7% vs 22.7%) and (supposedly) production intensiveness, and total turnovers belonging to opposite categories (< €15k vs > €75k), have slightly different requirements in terms of workforce: the first one has one full-time employee and one part-time worker, while the second employs three people full-time. As for large-scale producers, workers' numbers may vary for the same reasons as above, however there is a higher chance for these businesses to have a slightly higher number of full-time workers, compared to small-scale farms.

### THE ROLE OF PROTECTED STRUCTURES

As anticipated earlier in the section, special mention is made of the reasons supplied by growers for the employment of protected structures on their farm (Q19), which links up to their capacity to confront with and pull through extreme events and the possible solutions they find to do so. Growers employ greenhouses for multiple reasons, the most fundamental ones being protection (in summer and winter mostly, from weather events, pathogens and diseases), all-year-round production and lengthening of seasons. Usually, protected structures manage to extend seasons by a few weeks in both 'directions', giving growers the possibility to market both anticipated and late crops, the former especially important since those precocious crops tend to occupy market stalls during the so called ‘hungry gap’. Early spring is commonly recognized as such, when winter crops are almost at the end of their cycle and growers start preparing for the following season, so there would be an actual ‘void’ in production. Therefore, closing the hungry gap would mean closing the year-round production circle, integrating growers’ income thus increasing their turnover, and guaranteeing a potentially constant harvest. This way, protected cropping is not only limited to summer production, usually reserved for high-value crops, but it reaches into colder and ‘emptier’ months as well when also workload is supposedly less demanding.

Growing crops under protection provides growers with a wide range of crops, to be integrated with those cultivated outside, and gives them the opportunity to grow peculiar varieties as well, so that they can market and supply their customers with a larger selection of products. Growing crops in a controlled environment represents an important increase in yields and an improvement in their quality. A greenhouse environment is also widely employed in the production of transplants for open field cropping. Since managing soil fertility inside protected structures is believed to require more skills than the more ‘conventional’ open field production, growers employ greenhouses also to focus on improving the quality of poor and marginal soils. Moreover, greenhouses consent a better management of water resources, through improving soil quality and rationalizing irrigation, and a better climatic and pest control.

It is commonly agreed on that protected structures are considered as a system that helps enhance farms’ resilience reducing farms’ vulnerability to unexpected events through adaptation, whether they be directly related to the environment like floods (which are linked to waterlogging, a direct consequence of poorly drained soils), drought, hail, frost, high humidity, excessive rain, unknown pathogens, wild animals, strong winds, heavy snow and weeds, or linked to the socio-economic context in which producers operate. In this sense, respondents from both countries have classified as ‘extreme events’ issues like reduction of funding and grants, inconstant clientele, lack of workforce, changes in rules and laws, and market fluctuations, the latest issue specifically referring to the 2008-2009 recession which brought a general wave of sales decrease, according to British respondents. However, greenhouses and polytunnels are just a small part of a larger series of factors that growers have said to employ to confront with and adapt to these extreme events. These factors obviously include agricultural practices, newly implemented or simply improved, such as rational irrigation management, fertility implementation and focus on soil health, varied agronomic techniques, development of alternative farming systems, restoration of local biodiversity, maintenance of drains, implementation of windbreaks and crop protective netting, selection of species and varieties suited for local conditions, and avoidance of winter cropping.

Enhancing farm resilience also means improving the socio-economic aspects of agroecosystems management, thus taking advantage of opportunities to increase their businesses' capacity to thrive and survive in the short- and long-term. In this case, in order to be 'thinking ahead', growers mentioned the desire to improve and implement their communication with consumers, business flexibility, insurance possibilities, dedication, cropping diversification, to create new selling opportunities, educational farm projects and niche local products for large distribution, to strengthen direct sales and develop new ways of diversifying their production (i.e. *agritourisms* in Italy), to work on participating to calls for bids for research and experimentation, and to organize fundraising events.

### UNDERSTANDING THE CONCEPTS

In the introduction to the Chapter, the second section of the survey was presented as a list of five-point Likert-scaled questions, to which growers would attribute a weight in the form of a score between 1 and 5. For the questions regarding growers' understanding of sustainability and resilience (Q21 and Q23), a score of 1 meant 'none' while a score of 5 meant a 'perfect' comprehension of said concepts. Results have shown that in both countries, growers generally seem to have a good grasp of what sustainability is and what it means to be sustainable, revealing the largest percentage of responses in the second highest category of relevance for both Italy (48%) and the United Kingdom (80%); in Italy's case, another significant group of respondents also gave a 'very good' score to their understanding of sustainability (45%). Even though resilience seems to be slightly less popular than sustainability among growers, the general degree of its understanding is still remarkable, with the largest percentage of Italian producers (50%) showing a 'good' degree of comprehension of what being resilient means, and 60% of responses from British growers giving resilience a 'good' degree of understanding. However, there may be differences between understanding broad concepts from a theoretical viewpoint and understanding the degree of relevance these concepts might have in relation to a farm's practical management; for these questions (Q21 and Q24), a score of 1 meant a 'very low' importance and a score of 5 meant a 'very high' relevance. Indeed, most Italian growers deemed sustainability highly important in their opinion, with 71% of responses in the second top score category; British producers were equally split between the top two score categories (50% of responses in each category), thus giving sustainability a 'high' and 'very high' degree of relevance for their business. Similar results were obtained for resilience and its importance; although it is not a concept as well understood as sustainability, it is still considered relevant by most respondents from both groups, with 48% of Italian responses giving resilience a 'high' degree of importance and 80% of British growers equally split between the top two categories (40% in the 'high' and another 40% in the 'very high' score categories) (**Errore. L'origine riferimento non è stata trovata.**).

Table 6. Summary of responses (expressed in %) from Italian and British producers regarding the level of comprehension and importance given to sustainability and resilience. Scores given by highest percentages of respondents are shown in bold.

| **Sustainability and Resilience** | **Italy** | | | | | **United Kingdom** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **1** | **2** | **3** | **4** | **5** |
| **Sustainability Comprehension** | 0 | 0 | 7.1 | **47.6** | 45.2 | 0 | 0 | 0 | **80** | 20 |
| **Sustainability Importance** | 0 | 0 | 2.4 | 26.2 | **71.4** | 0 | 0 | 0 | **50** | **50** |
| **Resilience Comprehension** | 7.1 | 11.9 | 16.7 | **50** | 14.3 | 0 | 0 | 30 | **60** | 10 |
| **Resilience Importance** | 2.4 | 4.8 | 16.7 | **47.6** | 28.6 | 0 | 0 | 20 | **40** | **40** |

In terms of sustainability and which one of its three components growers deem the most important (Q22), results supposedly confirmed what has been anticipated in the literature, when Morelli (2011) agreed on the fact that in the three-pillar approach to sustainability, *"providing clean natural resources is the fundament for a functioning socio-economic system, therefore without a sustainably productive environment to provide these resources, it would be impossible to have and maintain a sustainable society or a sustainable economy".* Therefore, out of the three pillars, maintaining environmental integrity was generally considered the most relevant, with 74% of Italian responses in the 'very high' category and British growers equally splitting all responses between the top two score categories (50% in each category). Social equity was considered significantly relevant by both groups of respondents, registering 52% of the responses in the highest category of importance in Italy, and 50% of British growers asserting that social sustainability is highly relevant for their businesses. Even though preserving economic viability is indeed a fundamental requirement for the short- and long-term survival of farm businesses, it appeared to be the 'least popular' of the three pillars, regardless of the scale of production, with the highest percentages of responses split across the top two score categories in Italy (33% in both the 'high' and 'very high' categories) and 40% of British respondents considering economic sustainability highly relevant (**Errore. L'origine riferimento non è stata trovata.**).

Table 7. Summary of responses (expressed in %) from Italian and British producers regarding the importance given to the three sustainability pillars. Scores given by highest percentages of respondents are shown in bold.

| **Sustainability Pillars** | **Italy** | | | | | **United Kingdom** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **1** | **2** | **3** | **4** | **5** |
| **Environmental Sustainability** | 0 | 0 | 4.8 | 21.4 | **73.8** | 0 | 0 | 0 | **50** | **50** |
| **Social Sustainability** | 2,4 | 0 | 9.5 | 35.7 | **52.4** | 0 | 0 | 10 | **50** | 40 |
| **Economic Sustainability** | 2,4 | 0 | 31 | **33.3** | **33.3** | 0 | 0 | 30 | **40** | 30 |

## EVALUATING PRACTICES AND ISSUES

This section discusses over the respondents' views on a series of issues and practices linked to sustainability and resilience, and the importance growers give to these issues and practices regarding their management. As anticipated in the methodology chapter, the list of issues and practices used in the survey is based on a study done on the sustainability of New Zealand's horticultural sector by De Silva and Forbes (2016), later integrated with two papers by Dennis *et al*. (2010) and Hall *et al*. (2009), regarding sustainable practices in floriculture and greenhouse nursery production. These studies had producers, processors and distributors alike as targets, therefore the lists of practices and issues have been adapted and reduced to group the most significant matters connected to farm management, and to fit with producers of any scale of business as the sole target group.

Multiple issues were grouped together as they were seen to belong to the same topic, whereas others were discarded as specific for the New Zealand context, therefore not fit for a survey targeting producers from different countries. There were no available studies to draw resilience-related issues and practices from, so the list that was later used in the survey was drafted condensing information and taking clues from the literature review, the best help coming from works by Darnhofer, Milestad and Kummer (Darnhofer, 2014a; Darnhofer, 2014b; Darnhofer *et al.*, 2010; Darnhofer and Milestad, 2003; Kummer *et al.*, 2012). A similar process was followed to draft the list of factors that influence the adoption or implementation of practices, finding and summarizing suitable information from the literature review.

### *SUSTAINABLE PRACTICES AND ISSUES*

The updated list of sustainable practices and issues, as it appeared in the official version for the survey (Q27), comprises 21 elements in total: weed management, soil fertility management, biodiversity protection, energy efficiency, use of renewable energy, water conservation, carbon emissions, and environmental auditing for environmental sustainability; profits, financial survival and benefits, events sponsorship, short food supply chain, local community engagement, landscape and heritage protection, public access to farm, products traceability, job training, education and development, work safety, and traditional knowledge for socio-economic sustainability.

Results showed that most Italian growers consider *fertility management* and *biodiversity protection* of the utmost relevance for their management systems, along with *short supply chains* and *product traceability*, with more than half of the responses scoring in the highest category of importance (67% for fertility management, 52% for biodiversity protection, 55% for short supply chains and 57% for product traceability), showing that maintaining soil fertility and preserving agrobiodiversity in farming systems are key to improving the sustainability and enhancing the resilience of said systems, same as focusing on maintaining a relationship as direct as possible between producers and consumers and increasing the awareness in consumers of where products come from. A major degree of importance was given by a relevant percentage of respondents to *water conservation* and *weed management*, intimately linked to fertility management and biodiversity protection, both getting 47.6% of responses in the highest score category; a similar level of importance was given to *education and formation*, and *landscape protection*, respectively with 43% and 45% of preferences in the highest category of score. A slightly smaller sample of responses attributed issues like *public access to farms* and *communities' involvement* a high relevance, respectively with 38% and 33% of preferences in the highest score category. *Work safety* and *waste recycling* got more than 40% of responses in the 'high' category of score (48% for work safety and 40.5% for waste recycling), while *carbon emissions* and *financial survival* both got 36% of preferences in that same category of importance. *Renewables use*, *environmental auditing* and *energy efficiency* garnered their largest percentages of responses split between different categories of importance: using renewable energy got 31% of responses on the ‘high’ and ‘very high’ score categories each, environmental auditing got a third of respondents (33%) considering it either highly or averagely important, and energy efficiency got more than 70% of responses equally split between the ‘very high’ and the ‘average’ classes of importance (36% each). *Profits*, *traditional knowledge* and *financial benefits* were attributed an average degree of relevance by respectively 43% (profits) and 38% (traditional knowledge and financial benefits) of responses, while *events sponsoring* earned 38% of preferences in the lowest category of importance, making it the least relevant issue for Italian growers in terms of management.

For British producers as well, *fertility management* and *short supply chains* were attributed the highest degree of relevance by the largest percentages of responses, with respectively 70% and 60% of preferences in the highest score category; the same degree of importance was attributed to *product traceability* and *communities' involvement* by 40% of responses. More than half respondents gave a ‘high’ degree of relevance to issues like *weed management* (60%), *public access to farms* (60%), and *education and formation* (60%), followed by *renewables use* (50%), *energy efficiency* (50%) and *traditional knowledge* (50%), while *landscape protection* earned 40% of preferences in the ‘high’ category of score. *Carbon emissions* and *work safety* earned 80% of responses equally split between the ‘high’ and ‘average’ score categories (40% each), while *biodiversity protection*, *environmental auditing*, *profits* and *financial benefits* were attributed an average degree of relevance by more than half of the respondents (50% for biodiversity protection and environmental auditing, 60% for profits and 70% for financial benefits). Less than half of British respondents gave *waste recycling* and *financial survival* an average score in terms of importance (40% both). Responses for *water conservation* were split across different categories of score, resulting in significantly differing opinions upon the matter of conserving water resources on farms, thus registering 30% of preferences in the ‘very high’, the ‘average’ and the ‘low’ classes. In the United Kingdom’s case as well, *events sponsoring* confirmed to be the least relevant issue for farm management, with 60% of responses registering in the lowest score category (**Errore. L'origine riferimento non è stata trovata.**).

Table 8. Summary of responses (expressed in %) from Italian and British producers regarding the importance given to sustainable practices and issues. Scores given by highest percentages of respondents are shown in bold.

| **Sustainability Issues** | **Italy** | | | | | **United Kingdom** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **1** | **2** | **3** | **4** | **5** |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Fertility Management** | 0 | 0 | 4.8 | 28.6 | **66.7** | 0 | 0 | 0 | 30 | **70** |
| **Biodiversity Protection** | 0 | 2.4 | 14.3 | 31 | **52.4** | 0 | 0 | **50** | 10 | 40 |
| **Water Conservation** | 0 | 4.8 | 11.9 | 35.7 | **47.6** | 0 | **30** | **30** | 10 | **30** |
| **Renewables Use** | 4.8 | 7.1 | 26.2 | **31** | **31** | 0 | 20 | 30 | **50** | 0 |
| **Carbon Emissions** | 2.4 | 4.8 | 31 | **35.7** | 26.2 | 0 | 10 | **40** | **40** | 10 |
| **Environmental Auditing** | 0 | 7.1 | **33.3** | **33.3** | 26.2 | 10 | 20 | **50** | 20 | 0 |
| **Waste Recycling** | 4.8 | 2.4 | 23.8 | **40.5** | 28.6 | 0 | 10 | **40** | 30 | 20 |
| **Energy Efficiency** | 0 | 2.4 | **35.7** | 26.2 | **35.7** | 0 | 0 | 30 | **50** | 20 |
| **Weed Management** | 2.4 | 4.8 | 16.7 | 28.6 | **47.6** | 0 | 0 | 20 | **60** | 20 |
| **Communities Involvement** | 0 | 14.3 | 23.8 | 28.6 | **33.3** | 0 | 10 | 20 | 30 | **40** |
| **Financial Survival** | 9.5 | 0 | 26.2 | **35.7** | 28.6 | 0 | 0 | **40** | 30 | 30 |
| **Public Access** | 2.4 | 9.5 | 21.4 | 28.6 | **38.1** | 0 | 10 | 20 | **60** | 10 |
| **Education and Formation** | 0 | 2.4 | 14.3 | 40.5 | **42.9** | 0 | 10 | 10 | **60** | 20 |
| **Short Supply Chain** | 2.4 | 9.5 | 7.1 | 26.2 | **54.8** | 0 | 10 | 0 | 30 | **60** |
| **Product Traceability** | 2.4 | 2.4 | 9.5 | 28.6 | **57.1** | 0 | 10 | 30 | 20 | **40** |
| **Work Safety** | 0 | 2.4 | 14.3 | **47.6** | 35.7 | 0 | 10 | **40** | **40** | 10 |
| **Landscape Protection** | 2.4 | 0 | 21.4 | 31 | **45.2** | 0 | 10 | 30 | **40** | 20 |
| **Profits** | 7.1 | 2.4 | **42.9** | 33.3 | 14.3 | 10 | 0 | **60** | 20 | 10 |
| **Financial Benefits** | 19 | 14.3 | **38.1** | 19 | 9.5 | 0 | 20 | **70** | 10 | 0 |
| **Events Sponsoring** | **38.1** | 23.8 | 14.3 | 16.7 | 7.1 | **60** | 20 | 20 | 0 | 0 |
| **Traditional Knowledge** | 0 | 2.4 | **38.1** | 31 | 28.6 | 0 | 20 | 30 | **50** | 0 |

In the survey, producers were then asked to add other aspects related to environmental sustainability they would like to improve or implement, as an integration to the preferences they already expressed (Q27a). Italian growers put their focus on issues like self-production of local seeds and animal welfare, while British producers brought attention on better equipment with low carbon impact. Like for environmental sustainability, it was suggested in the survey that producers add other aspects related to socio-economic sustainability that they would like to improve or implement, as an integration to the already expressed preferences. In Italy, focus was put on issues like land fragmentation, having adequate funds and research, and creating business networks, while British producers pointed toward skilled labour, farm housing, fairer wages, integrating the 'leisure' and the 'duty' part of working, engaging more with customers and the rest of the community (i.e. CSA members and growers), and more efficient work practices.

### *RESILIENT PRACTICES AND ISSUES*

The list of resilience issues, as it was drawn from the available literature, comprised 5 elements: crop diversification, market diversification, production diversification, knowledge exchange and capacity to face changes (Q30).

In general, resilience plays a significantly important role in farming management for growers from both countries. However, Italian producers ascribed a major relevance on *crop* and *production diversification*, and the *capacity to face changes*: cultivating a variety of crops, contrary to specializing monoculture, and being able to cope with changing conditions both earned 55% of responses in the highest score category, while marketing multiple products got 43% of respondents considering it of utmost importance. *Knowledge exchange* was considered of 'high' relevance by more than half of the respondents (55%) while *market diversification*, thus distributing through different channels, garnered the largest percentage of preferences in the 'high' score category (36%).

Similarly, British growers ascribed a major degree of importance to *crop diversification*, with half of the responses in the highest class of value (50%). *Knowledge exchange* and *capacity to face changes* both got 50% of preferences in the 'high' score category. *Market* and *product diversification* both got the largest percentages of responses considering these issues averagely relevant for farm management, with respectively 40% and 50% of responses in the middle score category (**Errore. L'origine riferimento non è stata trovata.**).

Table 9. Summary of responses (expressed in %) from Italian and British producers regarding the importance given to resilient practices and issues. Scores given by highest percentages of respondents are shown in bold.

| **Resilience Issues** | **Italy** | | | | | **United Kingdom** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **1** | **2** | **3** | **4** | **5** |
| **Crop Diversification** | 2.4 | 2.4 | 4.8 | 35.7 | **54.8** | 0 | 0 | 30 | 20 | **50** |
| **Market Diversification** | 4.8 | 2.4 | 23.8 | **35.7** | 33.3 | 10 | 0 | **40** | 30 | 20 |
| **Production Diversification** | 2.4 | 0 | 14.3 | 40.5 | **42.9** | 0 | 0 | **50** | 30 | 20 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Knowledge Exchange** | 2.4 | 2.4 | 9.5 | **59.5** | 26.2 | 0 | 0 | 30 | **50** | 20 |
| **Capacity to Face Changes** | 2.4 | 0 | 9.5 | 33.3 | **54.8** | 0 | 0 | 20 | **50** | 30 |

Like for sustainability, the same suggestion was made for resilience-related aspects, so growers were given the chance to list other issues that would potentially aid in fostering present and future resilience of their farming systems, once again as an integration to the already expressed preferences (Q30a). In this case, Italian producers added agricultural regeneration, optimization of quality and quantity of production, and increase in 'marketable gross production', while British growers mentioned experience and ability to learn, care for the 'human' side of working on a farm ('joy, happiness and health'), receiving more support from and sharing risks with customers (especially if producers are part of a CSA community), having highly skilled people working and doing on-farm research as well, and the security of having land tenure.

### IDENTIFYING INFLUENCING FACTORS AND CONSTRAINTS

This part of the section discusses the factors that have a certain degree of relevance in influencing or constraining growers' decisions regarding their management systems. As anticipated in the methodology chapter, the group of influencing factors is based on a study done on the sustainability of New Zealand's horticultural sector by De Silva and Forbes (2016). The list of influencing factors, as it was drawn from the available literature, comprehended: feasibility and bureaucracy, costs of investments, consumers' demands, farm size, regulations, subsidies, perception of risks, and perception of benefits (Q29).

For British producers, a major influence on their decisions regarding implementation and improvement of practices was ascribed to *costs of investments* and their *perception of benefits*, which both earned all responses equally split between the 'high' and 'average' score categories (50% each in both cases). For the other issues, the largest percentages of responses considered them having a general average weight on their implementation or improvement of practices, with *feasibility and bureaucracy* and *regulations* in force with 70% of responses, followed by *farm size* and growers' *perception of risks* with 60% of preferences, and *consumers' demands* with half of the responses. In this case, *subsidies* got most respondents considering them of low importance (40%) for growers' decisions over practices implementation or improvement.

In Italy's case, there were no peaks of preferences for any of the listed issues, showing that for all these growers, all factors might contribute in the same measure to their decisions to implement or improve their practices. However, results showed that a good portion of responses ascribed a high degree of importance to *feasibility and bureaucracy*, which earned more than 70% of responses split between the ‘high’ and ‘very high’ score categories (36% of preferences each), *costs of investments* and *consumers’ demands*, with 38% of responses respectively in the ‘high’ and the ‘very high’ score categories. *Subsidies* and growers’ *perception of benefits* followed with one third of responses considering them highly influencing in decision-making (33% in both cases). For the remaining issues, the largest percentages of responses considered them having an average weight on their implementation or improvement of practices, with *farm size* and growers’ *perception of risks* with 38% of preferences, and *subsidies* with 31% of the responses in the ‘average’ score category (**Errore. L'origine riferimento non è stata trovata.**).

Table 10. Summary of responses (expressed in %) from Italian and British producers regarding the importance given to major influencing factors. Scores given by highest percentages of respondents are shown in bold.

| Influencing Factors | Italy | | | | | United Kingdom | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **1** | **2** | **3** | **4** | **5** |
| **Feasibility and Bureaucracy** | 9.5 | 9.5 | 9.5 | **35.7** | **35.7** | 10 | 0 | **70** | 20 | 0 |
| **Costs of Investments** | 0 | 9.5 | 28.6 | **38.1** | 23.8 | 0 | 0 | **50** | **50** | 0 |
| **Consumers’ Demands** | 4.8 | 2.4 | 28.6 | 26.2 | **38.1** | 10 | 0 | **50** | 30 | 10 |
| **Farm Size** | 11.9 | 19 | **38.1** | 21.4 | 9.5 | 10 | 10 | **60** | 0 | 20 |
| **Regulations** | 9.5 | 21.4 | **31** | 26.2 | 11.9 | 0 | 20 | **70** | 10 | 0 |
| **Subsidies** | 9.5 | 7.1 | 31 | **33.3** | 19 | 20 | **40** | 30 | 10 | 0 |
| **Perception of Benefits** | 4.8 | 19 | 31 | **33.3** | 11.9 | 0 | 0 | **50** | **50** | 0 |
| **Perception of Risks** | 4.8 | 14.3 | **38.1** | 35.7 | 7.1 | 0 | 0 | **60** | 40 | 0 |

As for all issues related to sustainability and resilience, growers were asked to add other factors that, in their opinion, might have an influence on their management-related decisions (Q29a). Respondents from Italy mentioned better seasonal contracts and better support to small producers, while British producers added government policies for food and agriculture, distorted perception of food prices and importance of unprocessed food, different business models being confusing (i.e. it is argued that growers belonging to social cooperatives tend to implement practices at varying degrees) as factors that have a certain degree of relevance on their decision-making process.

### IDENTIFYING EXPECTED BENEFITS

This final section discusses respondents' opinions on the expected benefits related to their decisions to improve or implement a certain practice or to address a certain issue (Q28). As anticipated in the methodology chapter, the choice of these types of benefit, associated with the three dimensions of sustainability (environmental, social and economic), was based on a study done on the sustainability of New Zealand's horticultural sector by De Silva and Forbes (2016).

Parallel to the trend of responses for the three sustainability pillars and their perceived relevance for growers, most of the respondents in both countries showed to be surer to expect environmental and social benefits from implementing or improving practices than they are of economic benefits. Indeed, half of the Italian respondents gave environmental benefits the highest score in terms of importance, followed by social benefits with 40.5% of responses in the same score category; economic benefits earned the largest percentage of preferences in the 'average' category (33%), potentially meaning that most growers are aware that changes in practices are slow processes, and their perceived monetary reward might not be immediate.

Results showed a similar situation for British respondents, which are surer to expect environmental and social benefits from implementing or improving practices than they are of economic benefits. In fact, 70% of the growers gave environmental benefits a high score in terms of importance while social benefits gained 60% of preferences in the same category of relevance; as for economic benefits, all responses were equally split between the 'high' and 'average' score categories, with 50% of preferences in each (**Errore. L'origine riferimento non è stata trovata.**).

Table 11. Summary of responses (expressed in %) from Italian and British producers regarding the importance given to the types of benefits expected from implementing or improving sustainable and resilient practices and issues. Scores given by highest percentages of respondents are shown in bold.

| **Expected Benefits** | **Italy** | | | | | **United Kingdom** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **1** | **2** | **3** | **4** | **5** |
| **Environmental** | 0 | 2.4 | 14.3 | 33.3 | **50** | 0 | 0 | 20 | **70** | 10 |
| **Social** | 0 | 4.8 | 16.7 | 38.1 | **40.5** | 0 | 0 | 30 | **60** | 10 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Economic** | 0 | 7.1 | **33.3** | 31 | 28.6 | 0 | 0 | **50** | **50** | 0 |

## INTERVIEWS

The entire body of interviews took place between September 2016 and April 2017 (September to December 2016 in Italy, November 2016 to April 2017 in the United Kingdom). During this period, 16 farms were visited and 19 interviews were recorded, while the twentieth interview was done by telephone.

The following paragraphs describe the main themes that emerged during the discussions, as their role was stressed out by the interviewed growers as fundamental for the good management of their operations and the ultimate survival of their businesses. These themes are presented as a single body of results and integrated with the discussion part of the thesis, as to maintain the discursive nature of the qualitative data. Boxes are inserted within the text to focus the attention on and offer an in-depth analysis of interesting issues and specific experiences that relate to the main themes and were highlighted by growers during the interviews.

### GREENHOUSES

Horticulture is a ubiquitous agricultural sector, widely practiced at most latitudes on the planet, and compared to other agricultural enterprises (i.e. arable, pastures, industrial crops, etc.), vegetable growing is a very intensive cropping system that has the highest turnover per unit of area and time. Although horticultural products generally represent a relevant percentage of the entire food production, their organic 'portion' is still limited. Compared to open field horticulture, protected vegetable cropping is recognized as being much more intensive, especially in terms of labour, though it tends to give higher yields. Mostly in relation to weed, pest and disease pressure, it is considered a challenging sector and bound to a limited set of techniques and tools, if linked to organic management (Granatstein *et al*., 2010). Specifically, it is argued that protected horticulture requires a huge amount of energy, generates large quantities of wastes, and involves investments and costs that are much higher than in any other farming sector (Vox *et al*., 2010). However, issues like the quantity of waste generated or the amount of energy employed strongly depend on the type, opportunity and choice of investment in structures and technologies, not to mention the reliance on agronomic techniques.

Nevertheless, employing a protected structure in horticulture is common practice, whether it is a simple polytunnel (Figure 11) or a full-fledged glasshouse (Figure 12), and it brings multiple advantages to production.

Figure 11. Classic PVC polytunnel, with an area of 300 $m^2$, under a no-dig soil management, and equipped with drip pipes, integrated with overhead sprinklers, for irrigation. Diversified cropping system growing a wide variety of crops -in this polytunnel: onions, garlic, different types of salads, rocket. Farm location: Cirencester, Gloucestershire, United Kingdom (30/11/2016).


Figure 12. Glasshouse, with an area of 1 ha (10,000 $m^2$), employing a sandy substrate specific for growing these crops, ventilation and winter heating systems in place, with mechanical wings moving over the raised beds to irrigate, sow and harvest. Specialised cropping system of microgreens- in this picture: plants at different stages of growth. Farm location: Borgoricco, province of Padova, Veneto, Italy (07/09/2016).

First and foremost, such structures protect the crops against 'undesired' weather events, like hail, heavy rains or snow, extreme environmental conditions such as strong winds and high temperatures, and issues like birds or insects, to *"produce crops with the maximum value at the best moment"* (GRO13) and give the grower a guaranteed yield even in the case of unexpected situations. They manage to extend crop cycles so that growers may have longer periods to place their products on the market and fill those gaps that remain open in certain moments of the year, such as early spring, commonly known as the 'hungry gap', or late autumn, thus potentially giving an all-year-round supply (Pardossi *et al*., 2004; Simson and Straus, 2010) (Box 4).

Box 4. Protected cropping and seasonality.

Strongly related to one of the multiple purposes protected structures can be employed for, '*deseasonalisation*' has revealed to be a point where growers' opinions tend to clash. I was in Apulia (Southern Italy) for an interview in October 2016, and the grower believed that there are nutritional differences existing between open field crops and protected productions, which become more pronounced when crops are off-season because vegetables that are grown in-season receive the amounts of light and nutrients they naturally require.

Out of season, such factors come in different amounts, so crops are thought to be organoleptically different and growing certain crops in protected structures brings about a partial deseasonalisation of products, for *"crops being cultivated outside of their normal cycles assume a different set of nutritional characteristics than those they are supposed to possess"* (GRO06). My guess? It is greatly related to the possibility to choose: global market and large distribution (and protected cropping on the side) made it possible to have any food (not only fruit and vegetables) available at any moment of the year from anywhere in the world, and people got gradually used to it.

Seasonality can be however considered part of the problem but not THE real problem since *"anyone knows tomatoes taste better in the summer, so it is not really a nutritional issue"* (GRO17). What seems to be more pressing in relation to this peculiar aspect of protected cropping is the cost of producing these foods that might not be reflecting in their price that is of concern, the 'hidden' costs known as 'externalities': *"being obsessed with seasonality, localness, eating stuff that is grown in the area -potatoes are not from Scotland and yet we are the best potato growing nation in the world"* (GRO17).

Given that the last decades of agricultural research and development have focused mainly on maximising growers' income through intensification of input use and consequently productivity increase, and less concerned with food shortage and resources depletion, a more quality-focused production system would have been and is still preferred (Raviv, 2010; Stefanelli *et al.*, 2010). For this, protected structures are employed to give the more sensitive crops a chance to be grown in a controlled environment to avoid being exposed to changes in climatic conditions and still express the highest level of quality. Such option is also strongly considered when these crops are destined to markets that require a certain uniformity of products, a feature particularly sought after when produce is destined to large distribution (Box 5).

Box 5. Economies of scale: Large distribution.

In my research, I managed to come across a couple of large distributors in each country. The first encounter was in October 2016 with a biodynamic producer whose farm was located 10 km south of Verona (Veneto, North-Eastern Italy). Production was focused mostly on salads and kiwis and even though his business size could be considered small (6.5 ha), however close to average for Italian standards, he was wholly oriented towards large distribution because that is what he thought would give him an incentive in increasing the quality of his produce, not just the quantity: a small producer and a large distributor. Moreover, his farm is freshly certified biodynamic, after being organically managed since 1982, and he distributes his products on the German market, which is more receptive for such denomination than others, Italian one included, and that gives his products further added value. To achieve this, he turned his entire farm into multi-tunnels so that he could fill those yearly ‘hungry’ gaps (e.g. early spring or late autumn), and give sensitive crops the chance to thrive all the same in a protected environment.

The second example comes from the Isle of Wight (United Kingdom), from a visit that happened in April 2017 to a farm that is part of a much larger business with sites spread all over the UK. In this case, production is focused on tomatoes, grown both conventionally and organically, flooding the British supermarkets and making up for one third of the national tomato production. The site in question is a sizeable one, with 26 ha entirely covered by one-million-pound-each glasshouses (6 of which organically managed): a large producer and a large distributor.

In this climate of changes, what would be the best solution? A world of small producers or a mix of small- and large-scale farmers while gradually transforming the way food is produced? Certainly both economies of scale have an important role in the global food system, since most producers are small scale and large distribution plays an important variable in the ‘food market equation’. Simply dismissing either variable would mean taking out a sizeable slice of food products flooding the organic market all over the world. If on one hand, it is fundamental to let small businesses have the chance to flourish and thrive, on the other hand large producers keep having a key role in food distribution at the global level and *“just because a certain business is big, it does not mean it represents the devil incarnate”* (GRO20).

However, open field growing is still considered the best option for more common staple crops, mostly grown in wintertime and considered less valuable, while greenhouse cropping is usually preferred for ‘high-value’ crops. For most growers, regardless of the scale of their production, having a quote of protected structures on their farm is of great importance and represents an insurance for both the crops and the business’ survival. This quote seems to be related more to market demands than to farm size, and the choice between structures (polytunnels or glasshouses) is mostly a matter of availability of resources and possibility of investment. Moreover, the level of intensiveness of cultivation under cover is not only a matter of size or climate or cropping system, indeed showing great variation within the same scale of production or climatic area or production method. Therefore, basic distinctions between *'large industrial-scale businesses vs smaller lifestyle-oriented producers'* (Goldberger, 2011) or even *'organic conventional vs agroecology-based organic systems'* (Ceglie *et al.*, 2016) tend to clash with practice, showing that the differences between two situations in a similar context can be subtle, especially in terms of the intensiveness of cropping systems employed in protected environments. In this sense, discussions with both groups of growers have shown that such compartmentalization is too reductive for the range of possibilities that greenhouse cropping offers, with referral to inputs to be employed and techniques to be implemented.

**SOIL**

Agriculture has always been both the cause of and the solution to the issues it has raised, and soil deterioration is one of the most prominent and poignant of all. Especially since the 'Second Industrial Revolution' that hit the globe mid-20$^{th}$ century and brought huge innovations to agricultural chemistry and mechanization, soil has been one of the most intensively used natural resources in every agroecosystem worldwide and its overexploitation due to erroneous practices costs the global farming system millions of tons of soil loss every year. Deterioration of soil quality and fertility is a globally felt issue, threatening the integrity of the environment and the sustainability of farmers' livelihoods, especially smallholders (Alliaume *et al.*, 2014).

A well-managed and healthy soil maintains good physical and chemical qualities (i.e. structure, water retention, $CO_2$ absorption and storing, etc.), and looking after such resource should be perceived as *"an investment in food for the future generations, not a cost"* (GRO18). In this sense, organic productions are considered inherently sustainable and resilient because managing the soil non-conventionally would mean "*giving the soil all the tools it requires to work well, and since there is no way of knowing exactly what the soil needs yet, growers just try to create the richest and most varied environment possible and leave nature to do its job*" (GRO01), therefore it is about *"preventing, rather than curing"* (GRO05). Intense tillage, poor green cover, low organic carbon inputs and frequent cultivation all concur in severely eroding the physicochemical properties of soils, particularly in those areas when these practices are likely to combine with the extremization of weather events and the reduction of water availability for irrigation (Alliaume *et al.*, 2014).

Especially in horticulture, where land use is much more intensive and the speed at which crops follow each other throughout the seasons much higher than in any other farming systems, maintaining soil fertility is fundamental and the short- and long-term survival of the farm strongly depends on how soil is managed. In protected vegetable production, that is especially true since soil conditions and scale of operations tend to differ from open field cropping, so growers use multiple practices and techniques to keep their soil healthy and productive. This is of utmost importance for organic systems, given that the use of synthetic inputs is restricted by regulation and soil fertility is usually not managed through external sources, for *"it takes time to build the organic matter and the biology"* (GRO20).

Practices such as employment of green manures, crop rotations and composting are widely used and strenuously advocated, for their application helps maintain -and sometimes even increase- the organic matter content, and improve soil structure as well, so that *"plants can get a better grip on a more stable and structured soil"* (GRO06). An example of the effects of long-term applied good practices on soil quality comes from North-Eastern Italy, several years of green manures employed in summertime, when production is supposed to be at its apex, and constant integration of on-farm compost brought the organic matter content up to 6%, from an average of 1% in the area (Source: GRO08). Rotations are also employed to relieve the soil from eventual pathogen pressures that might build up in a heavily cropped and relatively enclosed environment such as a greenhouse.

Minimum disturbance to the soil is another practice that helps favour the development of microbial life as well, so growers can also choose to reduce their use of machinery, both inside and outside the structures, and implement practices such as no digging, direct sowing or strip planting to reduce and/or concentrate the use of resources and energy on basic operations. Care for the soil is one of the focus points of organic productions, and that is a feature that associates it with other alternative farming systems, such as biodynamic (Box 6) or natural agriculture (Box 7).

Box 6. Beyond organic: Biodynamic farming in Northern Italy.

In October 2016, I spent an afternoon on a farm 15 km south of Verona (Veneto) and while nursing coffee and some freshly squeezed apple juice, I had a long discussion with the owner and two of his friends, both producers from the area. Two of them (the owner being one) revealed to be certified biodynamic and the third was on his way to obtaining the certification since they all perceived biodynamic agriculture as a *“natural transformation from applying good organic practices”* (GRO07). Although in the beginning, they all had a bit of reservation because there was *“a bit of suspicion towards the philosophical implications of converting to biodynamic and their practical applicability, especially for producers with a scientific background”* (GRO08), the continuous employment of certain agronomic practices such as composting, ample rotations, extensive use of green manures, continuous grass cover, and maintenance of hedges, made the transition from organic to biodynamic feasible.

Two of them were working with large distribution and more specifically, they were shipping their produce to foreign countries such as Germany, Austria or Switzerland, not only because these countries were the philosophical cradle of the movement back in the early 20th century, but also because they asserted that biodynamic certification (Demeter®, in this case) gives their products an extra push on these markets. They were all agreeing that such transition represents one step further up the “sustainability ladder” and guarantees an ulterior added value to both their production and their business, since biodynamic standards are said to be stricter than organic ones and they also put great focus on ecosystem services, therefore not directly linked to production (e.g. biodiversity preservation).

Especially for farming systems that rely more on agronomic practices than external inputs, great importance is given to the integration of producing crops with non-productive areas on the farm, like hedges, beetle banks, permanent grass covers, or agroforestry, to *“compensate for any negative impacts and supply other services to the environment”* (GRO09). However, even though they said that numbers (of farms in conversion and operation) are growing every year, organic and biodynamic markets are still limited, where production keeps exceeding consumption and compared to conventional products, *“small quantities of produce still make the difference in terms of price”* (GRO07).

Box 7. Beyond organic: Natural agriculture in Central England.

In February 2017, I visited a farm in England who employs principles of natural agriculture to grow vegetables, to have more information on this alternative farming system and get an idea of the eventual differences with organic production. Natural agriculture was founded in Japan mid-20$^{th}$ century and its philosophical implications are as present and compelling as in the case of biodynamics and although producers are normally believed to *"never really rest or have it easy"* (GRO18), it has been called a 'lazy way of farming', since it requires some very basic labour and practices throughout the year and then Nature is left to do its job, hence the system's denomination. According to its principles, soil is the crucial focus and considered an entity so powerful that it can *"produce nutrients and recover from tiredness on its own, and remember a specific crop and help grow it every year, for practice makes perfect"* (GRO15). For these reasons, monoculture is widely used and recommended and inputs like compost are not employed, except for emergencies like when soil is very hard due to not enough moisture. With natural agriculture, plants are believed to have longer cycles and be generally stronger. However, in October 2016, during an interview with an organic grower in Southern Italy who trialled alternative systems on his farm throughout the years, from biodynamic to natural agriculture to permaculture, he confessed that some natural farming practices may not be suitable for every climate -hot and dry, in his case. It always takes time to experiment and find the best practices and techniques possible for every specific situation, given the common assumption that *"if you find a system that works, you tend to stick to it"* (GRO12).

**GROWERS**

As Darnhofer (2014b) stated, in the face of volatile economic, social, political and environmental conditions, since the effects of climate change are as much a reality now as they ever were, growers are constantly faced with unexpected turns of events to which they must find short- and long-term solutions, for they *"see the changes every year, even though they are not the same changes as before, and what strikes the most is the extremes of everything"* (GRO11), and every decision they take directly affects their businesses. Farms are complex systems and growers are complex individuals, so their decisions are driven by a multitude of factors spanning personal views, philosophies and interests, economic and political contexts in which they live and operate, social pressures from the community they work in and for, the specificity of the environment they are part of. A producer's life in general seems to be an eternal compromise between "*what the market requires, what is right for the economic survival of the farm and what to do to be* *the least impactful on the environment*" (GRO01) and sometimes, "*there is a bigger pressure from the financial world than from production itself*" (GRO03).

Expanding the area of protected structures on their farm is one of the multiple compromises growers encounter when making decisions, a compromise that not everyone can agree on, not only for the monetary aspect but also because some growers "*would not want to see the whole garden covered in plastic"* (GRO12, GRO13, GRO16). However, employing protected structures in horticulture is a decision that growers still commonly make though and represents an important initial investment, usually market-driven and ensuring of the partial durability of their business, if farms are not specialised. Facing all sorts of difficulties, even though they are believed to be *"resilient by nature, especially if organic"* (GRO01), most of the times growers learn to *"do whatever they can with what they have"* (GRO07, GRO08). Moreover, growers often remarked that the economic and socio-political environment they are part of is not as attentive to their needs as it should be, in a world where agriculture is still mostly voted to conventional methods.

Throughout the decades, since the movement started to take form at the dawn of last century in Europe, and more assertively on a political and economic level in the 1980s, organic growers have noted a descending lack of support from the institutions, not necessarily on a purely financial level but more regarding the 'human' side of production, for people seem to have forgotten that it is ultimately institutions, and consequently consumers, "*that detain the real power to choose and stir food production in the right direction: what is missing is the awareness of being able to do so*" (GRO07). Growers have tried to take the issue at heart and since then embarked on a 'mission' to re-educate the public to health and sustainability, showing people that good food should be accessible to all and making them understand that the price for organic food comprises differences in both practices and values, if compared to conventional agriculture, because *"people need to understand how important food is for climate change, biodiversity and social justice"* (GRO17). However, the real costs of raw materials and work hours to put any product on the market are often lost among the eventual post-harvesting stages (i.e. distribution) and yet, the price for organic products tends to be generally higher than what is required by the market (Box 8).

Box 8. The subtle importance of work ethics.

In several occasions, growers have remarked the importance of a productive and healthy work-life balance, which can be linked to the 'social' sustainability or the resilience of their businesses. For some, achieving this balance would mean to *"fulfil the potential of the land and enjoy life: the plan is to have a manageable business which generates enough income to pay all who are working so they could all earn a living"* (GRO13); for others, it is intended as *"thinking in terms of efficiency on the job, as in rationally managing time and resources, so that there are fewer 'dead' moments"* (GRO16).

With greenhouse cropping, in most cases growers make a continuous and intensive use of their growing system to maximise yields and keep their business running, so sometimes they find themselves working up to 70-80 hours per week and in such cases, labour is a defining factor, even a limiting one for some. An example of this would be a producer I interviewed in March 2017, growing vegetables on roughly 3 ha and working on his own. He used to have a business partner up to 5-6 years ago, the farm 3-4 times bigger with a more diversified system (including other arable crops and animals), and a larger work force; however, when his partner died he was forced to massively reduce the scale of the business, since he could not follow up on everything by himself. Now that he is his own boss, he does everything in his power to avoid overworking himself, refusing to slot 16 hours a day, setting his maximum to 12 if he cannot help it, and mostly in the summer, for he believes in the unsustainability of working too much and the necessity of working enough.

He felt that growing crops in polytunnels is not as easily viable as it seems, with particular reference to the UK since "*in places like Spain or Italy, it can be made much cheaper, with better climate, cheaper labour, and efficient production at such costs that other countries might never match."* (GRO18). Also, competing against Mediterranean protected productions is seen as unfair, technically and economically, because *"their way of cropping is not sustainable though, plus all the transport involved, but here in the UK we can produce at a higher cost only for people who know where it comes from and how it is produced, all the times trying not to overproduce, but instead producing the right amount for the customers that will surely pay for it"* (GRO18).

Even though organic production keeps on expanding, agriculture seems to be still partly leaning towards industrialisation, with large firms focused on quantity rather than quality, thus hindering smaller producers. Italian producers have also argued that products are bought at low prices at the origin (or very close to conventional ones) and competition is unforgiving, especially from foreign countries where workforce and land have ridiculously low costs, if compared to local resources. Many have confessed that nowadays, they feel people have somehow lost their connection to the food they consume, hence the growers' willingness to help raise awareness among their consumers for they believe paying more for food of a higher quality, and indirectly for people's health and wellbeing (Box 9), should not be considered a hurdle: *"if people stop caring about the quality of their food, then the whole point of producing it is somehow lost. It is a simple reasoning, yet it seems such a difficult concept to understand"* (GRO02, GRO09).

Box 9. The 'third' pillar: social justice in Scotland.

An example of accounting for the social and ethical aspects of food production comes from Scotland, where an interview with a farmer near Edinburgh in February 2017 brought up this issue that had not been mentioned before. The problem is compelling from an economic point of view as well, since many Scottish people live with a low income or work with zero contracts, are overweight or have diabetes and they struggle to afford fresh food at a reasonable price week after week. To fight this situation, unacceptable for a supposedly developed country, local associations for social justice are working towards an implementation of the national legislation with the 'right to food', to help developing *"schemes for people with low income to enable them to afford decent food"* (GRO17).

The grower also wanted to have people understand that there is more behind food production that what meets the eye, especially if we are talking about food produced in a controlled environment and distributed at a global level. Since other growers expressed the concern that *"choice is potentially the biggest driver of unethical productions"* (GRO11), he felt strongly for including those factors of production that often pass under the radar when it comes to food prices, which are known as 'externalities', and instead need to be taken into consideration, such as *"impacts on climate and biodiversity or the excessive use of water resources in countries like Spain or having people from North Africa being enslaved to work inside the polytunnels, so that people can have tomatoes on their table in winter simply as an eye-candy"* (GRO17).

For growers to continue staying on this virtuous path, sharing knowledge and having the chance (and resources) to experiment and innovate are issues they consider fundamental and draw strength from, coupled with the support and involvement of their community. Given the multitude of farms and growers, knowledge and innovations are strongly context-specific and for each one of them, it is *"a matter of balancing potential and possibilities with practices"* (GRO13), since producers tend to adapt practices and techniques to their local conditions, so that they can show *"the potentialities linked to the* *land they are stewarding"* (GRO03) and simultaneously keep educating the present and future generations on how to produce good food in a sustainable way (Box 10).

Box 10. Generational gap and knowledge transfer.

In November 2016, the first grower I interviewed in the United Kingdom expressed a keen interest in the transfer process of knowledge among generations of producers, since an apparent problem in the UK seems to be the generational gap, which is common among Italian growers as well: according to him, the average age of farmers is 60-70, the people from the following generation basically have no skills, and very few universities offer practical training programmes. In such cases, 20-year-old sons of farmers go to study and learn the latest techniques while their fathers live up to 80-90 years of age, never retire, and sons do not get to take over the farm until they are in their 40s and their knowledge is already expired in a way, so there is a gap of 20-30 years gone that way.

In this sense, British growers revealed to be very passionate about and expressed the importance of educational programmes such as apprenticeships, which have been defined as a cardinal element in building resilience because thanks to them, *"every year people leave with a set of skills to use and pass onto the knowledge"* (GRO11). According to the interviewee, however the real interest lies not in the practices and techniques, but in the knowledge linked to a specific land: if a family has worked on a farm for decades, they have very specific expert knowledge on that area, on its soil and environment, and the fact is that *"some things cannot be learnt at university, but only through the continuous passing of knowledge onto generation after generation"* (GRO11).

Italian growers also pointed out that in their cases, the generational gap issue could be related to land fragmentation, which is a common occurrence in the country for its great variety of landscapes and resulting agroecosystems, so often properties tend to be highly fragmented and their management can become logistically nightmarish. Moreover, general population is aging and working the land still is a hard job, land properties are mostly rented out because proprietors still find it difficult to let go of such a physical capital, and properties are often small, so farmers find themselves with bits and pieces of land all over the place. Growers also feel a distinct lack of will or chance or time to keep working the land in the country, and rural areas are the ones who especially take the fall for this, what with being less populated and geographically remote, so they are being progressively abandoned.

In this sense, agriculture has always managed to take giant steps forward thanks to growers' 'trial-and-error' way of working with novelties, so having the possibility to experiment and research new crops or varieties or techniques has always been a winning ticket for the short- and long-term survival of farms, and especially in the face of unexpected events and transformations, growers *"have to guard against problems but also take advantage of changes"* (GRO11). In such context, protected production is and will be extremely helpful to growers, given the uncertainty of the future, however open field vegetable cropping will never wholly disappear because growing crops in their natural environment and building up their resistance to changes remains an important key to present and future resilience.

**DIVERSIFICATION**

In agriculture, every new investment comes with a potential risk and when running a business, profitability of any change in the system must be accounted for. Generally considered a huge contributor in reducing risk of losses in produce, diversification has become a core issue of organic production and can be linked up to multiple factors, such as scale of distribution and operation, market demands and resource availability. If production operates on a large scale, in most cases it tends to specialise on a very limited range of products which are then destined to large retailers (i.e. supermarkets), or even exported to foreign countries, if the market permits it; in such cases, diversifying is usually logistically unadvisable, especially when huge volumes of investments are involved and key operations such as transplanting, irrigating and harvesting, tend to become mechanised.

Some growers expressed their preference in this sense for they believe large distribution and foreign countries offer them *"a more florid market and more rigid standards of production, which make farms stay competitive and farmers always updated"* (GRO01, GRO08, GRO09). However, it is also believed that a risk that large productions could incur into is '*conventionalisation*' (Darnhofer, 2014a; Goldberger, 2011; Tittarelli *et al.*, 2014), where crop management tends to be focused less on agronomic practices and more on input employment, with production and post-production starting to get 'industrialised'. Specifically, a farming system such as organic, born with the main objective of distinguishing itself from the more traditional ones, might gradually resemble conventional farming while operating a simple substitution of inputs for production or in Buck *et al.* (1997)'s words, a *"proliferation of mechanised post-harvest processing"*. On the other hand, when the scale of operations gets smaller, growers generally tend to keep their produce distributed at a local level and farms go through a 'de-specialisation' process, where production is more varied and risk of losses is reduced, and it does not only encompass the differentiation of crops but of market outputs as well (Box 11).

Box 11. Beyond production: Processing.

De-specialising does not have to end with production and as few growers showed me, it reaches post-harvesting stages. In this case, an interesting focus was given to processing, which is taken into strong consideration and widely accepted as a phase that gives added value to products. While talking to an Italian grower in September 2016, he strongly advocated for it and considered it a winning step for an easier placement of products on the market.

His 30-year experience in greenhouse cropping gave him the chance to extensively experiment with different structures and substrates, and although he is not formally certified organic he considers himself a conscious producer. His main products comprise strawberries and cucurbits, but he is convinced fresh produce is not as remunerative as it seems, given the fact that *“organic transplants are bought at the same original price as their conventional counterparts, so the real difference in price comes out at a later stage along the supply chain”* (GRO06).

He strongly believes in processed products, like preserves, jams and condiments, being one step ahead of fresh produce because they have a longer shelf-life so they become non-perishable, and given the chance, producers can form cooperatives to present a wider choice of products to customers. For this, he advised and felt wholly in favour of the use of local products and traditional processes, or as he preferred to call them, *“simple solutions for a selected multitude of by-products, almost like Grandma’s recipes*” without producing enormous quantities “*to keep customers interested, to have them come back for more, and still let the single identities of businesses stay intact”* (GRO04).

If distribution is local, the network of connections they establish with consumers is especially important for their businesses’ success because they *“build a direct relationship with customers, who come to know the work and the worker behind the entire production”* (GRO07). A short food supply chain is also believed to be a virtuous path to follow *“if there is intention and desire to salvage local economies and keep them steady to continue giving support to small producers”* (GRO06).

Protected structures are long-term investments and employed on both large- and small-scale businesses alike; even though the dimension and cost of the structure do not seem to be strictly related to the size of the holding, there is a common occurrence that huge glass (or plastic) structures tend to be used more often on large farms, whereas cheaper polytunnels are preferred by growers on smaller enterprises. Indoor, the degree of diversification of production receives a strong influence from the demands of the market, in the form of trends in customers' choice, and the growers' possibilities in terms of available resources, as in crop varieties, machinery availability and degree of use, or eventual financial support.

Especially for small scale businesses, the eventual integration of main crops with non-productive species (i.e. wild plants, green manures, flowers, even woody species) is a choice that growers make to increase the level of biodiversity, thus veering more towards an agroecology-based approach to production (Box 12). Such implementation becomes especially relevant with crops growing under protection where there tends to be a milder exchange with the outside environment, therefore higher risk of pressure coming from a uniform system, because growers believe it gives an added value to their farm and production, since *"diversification and biodiversity are key to the evolution of the agroecosystem, through de-specialisation of soil and production, and reduction of the risk of losses"* (GRO07).

Box 12. The impact of Agroecology: A case from near Verona.

Even though the term ‘agroecology’ never came up directly during the interviews, the basic principles belonging to this discipline that have populated literature since the mid-1990s, have multiple points in common with the same principles that organic growers normally follow and apply in practice. However, in one occasion the name of the scholar who is considered the father of agroecology was mentioned, while I was visiting a group of organic and biodynamic growers near Verona (Italy) in October 2016.

One of the growers recalled the day when he received a visit from Prof. Miguel Altieri and his team of technicians, some 20 years earlier when the grower was already certified organic but pushing his farm to the limit with the intensive practices he would use to grow his crops, both inside his greenhouses and out in his fields. That is when Prof. Altieri, with his knowledge of traditional farming systems in developing countries, suggested that the grower start integrating trees with his field crops (agroforestry) and keep a constant green cover on the soil inside his tunnels, while expanding his crop rotations to enhance agrobiodiversity and restore a semi-natural environment around the farm.

Now, two decades later, thanks to a well-placed piece of advice, the grower stated that his farm is a flourishing business, rooting in a very diverse and sustainable growing system, thus giving him the appropriate tools to be resilient as well, as in being able to cope with unexpected changes (i.e. summer droughts or market fluctuations). In fact, as Altieri *et al.* (2015) mention in one of their most recent papers, the predominant idea behind these measures is to equip producers in general with the right tools to reduce their farms’ vulnerability, especially to climatic changes, which are major threats to food security worldwide. The core of agroecology effectively revolves around important concepts such as the importance of traditional farming systems, which are considered models of resilience, the enhancement of agrobiodiversity, a significant contributor to the reduction of farms’ vulnerability, and the fundamental role that soil management plays in the ‘resilience game’.

On the other hand, however, some growers are concerned that association with non-productive species inside the greenhouse, especially wild plants, while rendering every operation manual therefore incrementing labour and costs, could be detrimental for productive plants because of competition. Given their nature, wild species are more adapted to the local climate, unlike horticultural crops which have adapted to it with varying degrees and in their own time, so some crops tend to suffer from climatic changes more than others. Relating to the level of adaptation of wild species to changes, few growers are entertaining the idea of their farm working towards self-sufficiency, as in managing to ‘close the cycle’ by employing locally available resources, and be as independent from outsourced inputs as possible (Box 13).

Box 13. Self-sufficiency in agriculture.

In the face of current and future changes of climatic, environmental, economic and social conditions, Italian producers have mentioned the idea of being self-sufficient as a potential objective for the resilience of their farm. Becoming independent is believed to be a plausible process, although not likely to happen overnight, which would be greatly aided by the diversification of productions and the singularity of the property. In their opinion, the first step in this direction would be the self-production of seed, to improve sustainability as well, by *"being independent from mass-scale distributors and experimenting with local varieties, which are more resistant to local conditions"* (GRO06).

Growers consider employing their own seed resources (i.e. ancient varieties from original seeds) a fundamental tool in building self-sufficiency and resilience, not only environmentally but socially as well, because it would mean *"implementing the protection and conservation of local resources, while also encouraging cultural exchanges between growers"* (GRO05). However, it is argued that farms are still businesses and their main purpose is to earn a profit from their production, so self-sufficiency might be *"not always reachable, mainly because the purpose of a business strongly clashes with the idea of a farm being an independent entity"* (GRO06).

**PRACTICES**

Having been born as an alternative to 'traditional' methods of farming, organic agriculture has been contrasting conventional for over 30 years now, with organic production almost always on the losing side because of required areas and market-related reasons: large farms do have great extensions of land but they can easily fall into the 'conventionalisation' trap, and small holdings do not have such large productions so they often rely on local distribution, making up for a very small percentage of the whole food market. Nonetheless, an increasing number of growers have been taking on organic farming because they do think that the conventional system is not a viable option anymore and organic production is backed up by a sound scientific body of literature, making them hope that in the future it might become as mainstream as its conventional counterpart still is. Growers firmly believe that organic agriculture is "*a cutting-edge system, requiring a wide range of significant skills, trying to modify current ways or finding new ways of doing things, and stimulating those involved to always stay on top of new developments with constant research, especially with the ever-changing situation*" (GRO11).

Given the variability of conditions that farms singularly and inherently possess, it is believed that there are no such things as 'best practices', since practices can be context-specific and are always evolving and although organic principles are the fundaments, "*every farm, soil, climate is different and every farmer operates in a unique way and with a specific set of tools*" (GRO05). However, growers still feel there needs to be a distinction between organic practices and 'good practices', or 'true to principles' and 'conventionalised' as Darnhofer (2014a) described it, like two sides of the same coin: one side shows a system that favours uniformity and quantity, pointing towards the gradual industrialisation of production and post-harvest processes, whereas the other represents a system that manages production in a more conscientious and quality-endorsing way, since growers perceive there still is *"a clear distinction between a mindful and a wallet-ful organic system, distinguished by a different relation between philosophy and practice"* (GRO07). Although such distinction may sound reductive generally speaking, growers still consider it valid given the perceived easiness with which organic production might fall into the 'conventional' trap and the fact that not all producers started as organic, but many of them converted from conventional for different reasons, the most pressing ones related to economic advantages and health issues (Box 14).

Box 14. A story of conversion: From conventional to organic production[4].

There is a story behind every producer, and the one I was told when I was discussing with the biodynamic growers in Verona was a story of change. The central part of Veneto, one of the most productive areas in North-Eastern Italy, has been brought up as an example of the incredible development that agriculture underwent in the 1970s-80s. In that period, farming has seen an impressive growth, largely favoured by an extensive use of chemical fertilisers and pesticides. Growers stated that at that time, an increase in the incidence of tumours has been detected, which apparently showed a higher rate among people living in the countryside than people from urban areas. Due to this newfound development, suspicions started to arise that maybe all the chemical products that were being used to care for the crops had something to do with it.

Similar patterns were later observed in honeybees while researchers were studying the effects of pesticides on their populations (*see footnote below*). Growers reported that in those days, there would be new cases of acute intoxication every week, with people dying within months, and that was the reason why a multitude of producers decided that a drastic change in producing food was overdue, if only to try and salvage their health, that of their family and their consumers. They also believe that nowadays products have become ‘softer’ and show their effects over the span of decades, and that the use of plant protection products has been increasing, stating that *“agriculture has in fact grown sneakier, not cleaner”* (GRO07).

Horticulture represents a specific sector of agriculture, and it is believed to require extra-skills and knowledge by its practitioners; for such reason, growers in the EU area have been looking at drafting a separated set of standards for vegetable production to be included in the community regulation for organic productions, some of the loudest voices coming from the United Kingdom and its principal certification body, the Soil Association. Said absence of recognized tailored rules is felt even more in the case of organic protected cropping, so the general regulation is normally applied; however, exceptions exist and sectorial organizations, such as certification bodies, were allowed to draft specific suggestions for the sector over the years, advising growers on different options, but not standards per se though.

In confronting the current organic regulation (cfr. Article 3 of EU 834/2007) with the advice given by the group of experts formed by the European Commission in 2013 on

[4] Paper by Celli and Porrini (1987), from University of Bologna, about a 3-year study [1983-1986] on pesticides residues in honeybees and hives at national scale in Italy). See reference list.

organically managed protected productions, apart from the more obvious features that distinguish protected systems from open field cropping (e.g. water resources, energy use and environmental control, eventual employment of $CO_2$, possibility of using different growing media), the main differences picked up mainly concern the primary source for soil fertility and the length of crop rotations. Regarding the former, the use of slow release fertilisers has been recommended as the main source of nutrients, which links up to the crop rotations, having been advised to be shorter than outdoor cropping because of the intensiveness of the cultivation. However, practice shows that length and complexity of crop rotations are not only a matter of market demands but also related to the level of diversification of the cropping system and the degree of attention given to soil fertility management. As an example, although crop rotations are widely contemplated by the regulation and one of organic agriculture's fundaments to maintain soil fertility and reduce the risk of pathogens outbreaks, thus widely used in horticulture, monoculture is applicable to greenhouse cropping and employed in both large and small holdings alike, showing that diversification of production is not strictly related to farm size and/or scales of distribution and operations.

**SUSTAINABILITY**

What this research has clearly shown is that producers trust concepts more than plain definitions, especially in the case of a broad subject like sustainability, which has been previously defined in a variety of ways in relation to the context it was being used in. In these cases, they might not have a detailed definition for such issue, but they properly demonstrate their understanding through what they do in practice to support their business in the short- and long-term. Growers identify sustainability in a multitude of different ways, not just linked to the environmental dimension but also to the social and economic ones, showing that the reality of managing agroecosystems is a multifaceted issue.

In this sense, many growers have confessed that a field of work such as farming naturally requires compromises, meaning finding a balance between different viewpoints, not just because it is ruled by an incredible variety of factors spanning across multiple dimensions, but also because in many of these factors' cases, growers have little to no control over and rationally managing these balances is one key to a flourishing and long-lasting business. In farming systems management, a major compromise is struck between *"business' requirements and manager's philosophies"* (GRO12), which has an important influence on issues like the choice between specializing or diversifying, or the scale of produce distribution, or even the choice between favouring manual labour or employing mechanical support for farm operations.

First and foremost, putting environmental integrity at the top of their list of priorities is a commonly shared mindset among organic growers, for they seem to have a deep awareness of the fact that agriculture is indeed heavily influenced by a variety of factors that are mostly out of their complete control, therefore as producers and stewards of the land, they feel like it is in their power and possibilities to harmonize their activities with the complex functioning of the agroecosystem, thus letting natural cycles and processes work in their favour. When it comes to greenhouse horticulture, making such considerations is an intriguing matter because of this production system's nature: being able to partly control these factors could be seen as both positive and negative a feature, positive for the 'shelter effect' that environmental control creates for crops inside these structures and negative because of what growers fear will equal to accommodating crops' requirements under 'artificial' conditions, rather than letting crops get acquainted with the natural environmental.

This could be linked to the level of cultivation intensiveness, in which case low-intensity protected systems have a greater chance of building on their sustainability in a more natural way than high-intensity cropping systems, given the latter's higher level of control over climatic parameters. However, the main intent of present and future cropping systems would be to maintain themselves environmentally sound while increasing their productive capacity to feed a growing number of human beings within the next few decades, thus undergoing processes of 'sustainable intensification'. Greenhouse horticulture is perceived as one great example of a system that 'produces more with less', given its inherent intensive use of resources and their employment in small spaces, and in this case technological progress, the pressure put on organic farming and its ability to feed the whole humanity enabled this sector to take one step forward through the implementation of hydroponic systems, thus presenting soilless culture as the last frontier of sustainable greenhouse cropping (Box 15), particularly for the complete control over an operation that requires skills and attention such as fertilisation.

Box 15. Hydroponics: An experience from near Rome.

During my research, I found a single case in which hydroponics were employed, when I visited a small farm on the Tirrenian coast, some 40 km north of Rome, in September 2016. It was managed by a retired guy who had 30 years of experience with greenhouses and has been using his own knowledge to experiment with substrates and growing structures, and make a small living selling his products locally.

While looking for a suitable growing medium to host his short rotation scheme of greenhouse strawberries, beans and courgettes, he ultimately chose *lapillus*, a volcanic material that is locally sourced, very light in weight and coming in different degrees of granularity. Filling long bags with this material, he then makes top and bottom holes and deposits them on the ground; since the system was fully automated, these plants would receive the nutrients they required, made of naturally-derived ingredients, and water multiple times per day through drip fertigation. However, the porous texture of the medium gives root systems a significant amount of space to develop and with holes at the bottom of the bags, plants can further expand their root systems and reach the soil below should they incur into stressful situations.

Aware of the fact that hydroponics is not allowed by the regulation on organic productions because plants lack that basic connection they have with the soil, the farmer seemed to have found an interesting technique halfway between a soil-based system and an aeroponic one – is this production system straddling a fine line between conventional and organic farming? In the end, the issue about hydroponics keeps being relevant and controversial, especially considering that soilless culture appears to have been taking over conventional greenhouse chief crops, such as tomatoes, peppers and cucumbers, on a large scale, and the upcoming *"negotiations with the United States, which will fly in jets of so called organic products being grown hydroponically overseas, and being accepted as organic and carrying the EU organic logo"* (GRO14).

It is, however, a system that goes 'against the organic rules' and yet it appears to be a growing sector, especially in conventional settings where soilless culture has been spreading for the last 15-20 years, thus gradually losing that biological connection between plants and soil. What organic growers are concerned about is that this way, an increasing number of people might be subjected to a shift in their diet in the upcoming decades, and to avoid that a major transformation must happen in the global food system first, because *"there is not enough evidence yet saying that people can live a lifetime on a hydroponically-grown diet and not lacking major nutrients to remain healthy"* (GRO14).

In a sustainable farming system, taking care of soil fertility and consequently organic matter is universally considered the most important issue, for healthy food ultimately comes from healthy soils. In protected cropping, where soils are usually different from those in open fields because of the different environment and degree of control over their characteristics, improving organic matter contents through a variety of management practices becomes a top priority, especially if growers deal with poor quality or marginal soils.

Along with soil fertility management, enhancement and conservation of diversity in all its forms is also a necessary step towards a more sustainable agroecosystem. Small-scale growers become especially familiar with this concept because for most of them, it is also about supporting their communities therefore focusing their production on local clientele; in these cases, they prefer to favour a more varied cropping system instead of specialising their production, promoting quality over quantity and *"avoiding the oversimplification of their territories"* (GRO07). This is especially important for protected cropping, for too often it happens that specialising, thus potentially falling into the 'conventionalisation' trap, is an option always awaiting just around the corner. Therefore, it is fundamental from a management standpoint to become aware that *"the intensiveness of such cropping system has and should have a limit, and growers should strive to achieve a better production with fewer resources"* (GRO08), particularly if these resources manage to be locally-sourced.

If distribution stays local, growers tend to focus their attention on short supply chains, to avoid intermediaries, get better prices and have the chance to place all their produce on the market without incurring into rigid standards, usually related to a larger scale of distribution, that might reduce the volume of produce they ultimately sell. However, this is not to say that local markets require lower levels of quality, given that standards for large distribution usually require a certain uniformity of product: in these cases, the relationship small-scale growers build with the consumers is much different and more direct, making them understand where the food they consume comes from and the effort put into producing it, effectively giving them the opportunity to *"recognise the value of a grower's work"* (GRO14, GRO20) and especially for organic producers, *"to be seen as actually different from conventional ones"* (GRO10), thus enabling consumers to trace that product back to a known face instead of just a bar code.

Social well-being and economic viability occupy a different position in the growers' scale of relevance, although this is not to state that they are less important in pursuing sustainable development: being well-integrated in and supported by the community and striving to have more than a barely-surviving business are fundamental features, especially if growers operate locally. It is an ulterior confirmation of the fact that privileging *'an approach that seeks to use nature's goods and services in the best way'* (Pretty, 2008), regardless of the scale of operations, is the most vital step to make towards a more sustainable food production, and that *'without a functioning environment there are no functioning society or economy'* (Morelli, 2011).

### RESILIENCE

Even though resilience is less popular than sustainability, its understanding is well-ingrained in the growers' minds and translated into practice in multiple forms. It is believed to be intimately entwined with sustainability, being *'the property that allows agroecosystems to learn from and adapt to new conditions'* (Darnhofer *et al.*, 2010), and especially for organic systems it strongly relates to *'local situations'*, which is pivotal for sustainable development. It has been said that in agriculture *"there is always the chance to start over"* (GRO02) and to be able to do this, a resilient agroecosystem gets equipped with the proper tools to respond to changes, therefore possessing the ability to *"prevent, rather than cure"* (GRO05). Being resilient is also identified by growers with their own *"readiness to make sacrifices to soften the blows of traumatic events"* (GRO02), in terms of both long-term benefits to production and personal life style and well-being, as to guarantee that the agroecosystem and those who manage it continue to provide production and services.

In the case of long-term benefits to production, the concept of diversification becomes fundamental, in terms of crops, products and market, for favouring a varied environment in the farming system has positive effects on the ability of the system to reduce its vulnerability to expected and unexpected changes by creating multiple options, as in cultivated species, available products and marketing outlets, thus spreading risks of crop and monetary losses. Although it is perceived as a significant aid in enhancing the economic sustainability of the farm, specialisation still tends to reduce the system's resilience and appears to have negative effects on both environmental and social sustainability (Goldberger, 2011). Indeed, a specialised production makes it challenging to maintain a functional and integrated ecosystem, which becomes even more so inside protected structures where the environment is partly controlled and the connection with the outdoor tends to be reduced, especially in high-intensity cropping systems; in these cases, growers believe that it is important to find a balance between production and the services the environment could provide as to create the richest and most varied agroecosystem possible and maintain the integrity of its resources, for example by rotating green manures, instead of crops, in summertime to release pressure on soil, rebuild organic matter contents during the most productive season of the year and reduce the risk of pests outbreaks (e.g. infestations of nematodes are quite common on poor soils and dry climates), or by avoiding cropping during flood seasons in flood-vulnerable areas to prevent losses of crops and income, in a way by sacrificing present yields to save future ones. In this context, protected cropping seems to represent a dividing issue: on one hand, many growers have warned that relying too much on protected crops might compromise the natural capacity of agroecosystems, especially cultivated crops, to properly respond to changes, thus technically contravening to one of organic productions' basic principles, according to which ecological systems and cycles should be aided, sustained and ultimately emulated (i.e. principle of '*ecology*') (IFOAM, 2005b), for it is considered key to *"build resistance into crops through selecting better varieties and experimenting with different agronomic techniques, rather than the other way around, modifying the environment and accommodating crops"* (GRO12). On the other hand, both Italian and British growers asserted that future horticulture will partly go towards an expansion of protected areas, within limits though -they hope-, as a guarantee to have continuous yields and products for the largest part of the year, especially in the face of climatic and economic instability.

In the case of personal lifestyle and well-being of growers, being resilient assumes multiple meanings, from increasing efficiency on the job to striking new balances between work life and free time. Growers argued that job efficiency is not just about working on reducing dead moments between operations, like *"cutting down distances between field and shed to retrieve tools or machinery, or having step-by-step plans for farm core tasks written down for all to use and know"* (GRO16), to improve the overall management but also about concentrating on a number of basic operations throughout the year (e.g. sowing, transplanting, irrigating, fertilising, harvesting, whether done by hand or machine) to reduce the physical workload and the eventual amount of power and fuel employed. In this context, organic farming might raise ambivalent opinions because while it could imply a lighter load of work due to reduction or avoidance of some operations on which conventional farming relies, it could also require a greater effort from the growers in managing production and post-harvesting stages, especially if small-scaled and locally rooted, to keep their business running and guaranteeing their presence on the market, sometimes pushing themselves to their physical and mental limit and potentially evolving into self-sacrifice, or as literature identified it, 'self-exploitation' (Galt, 2013), according to which growers work much harder than what they are due in terms of labour costs. This passage is perceived to be even easier with protected cropping, for both large- and small-scaled producers alike but especially for the latter: if production is guided by organic core values, rather than market-related decisions, and diversified, therefore farm operations tend to remain manual, a certain dose of self-exploitation becomes systemic and growers' labour is often undervalued.

Farming systems are complex and dynamic entities, therefore building resilience within such systems does not limit action only to the maintenance of environmental integrity, but also to the fostering of socio-economic stability, which becomes pivotal in organic farming systems, where management should be voted to protect the health and well-being of present and future generations (i.e. principle of '*care*') (IFOAM, 2005b). In this sense, growers see resilience as a series of strategies for people to *"have a chance at survival in such unstable times"* (GRO07), for both sides of the food system spectrum: those who consume it (social justice) and those who produce it (work ethics). Growers, especially if small-scale, strongly advocate for organic productions to turn 'mainstream' and hope to *"see them as normal in the future"*, which would require a *"collective effort"* (GRO20), to start moving away from the intensiveness and overexploitation that have become typical of conventional farming systems and rebuilding the food system.

In this sense, an important role could be played by knowledge sharing and collaboration. About the former, few growers highlighted the relevance of letting acquired knowledge and skills flow through generations and groups of peers, especially for organically managed systems which strongly rely on localness, therefore on context-specific information, and require constant update and research. For the latter, it is not only about making a conjoint effort to change the face of the global food system in order to make it more favourable for organic productions, but also about sharing the burden of doing that at a local level: for this, growers from both countries have expressed the desire of grouping together to form 'cooperatives', which would represent a positive step in terms of adding value to single lines of production, offering a wider range of products and sharing the costs of maintaining their organic certification as well.

Such considerations would add a new dimension to protected productions: on one hand, it would give organic growers the chance to share an in-depth level of knowledge on a specific aspect of an already niche sector of agricultural productions; on the other hand, it would help producers to attempt giving extra-value to greenhouse products, therefore show consumers the potential differences with crops grown in open fields.

# CONCLUSIONS

## THESIS RECAP

The present study has served as an alternative viewpoint to 'evaluate' sustainability and resilience on a practical level, by giving voice to organic growers, and applying their perspectives and understandings of such broad concepts to a specific aspect of a specific production sector, such as protected horticulture can be. Chapter 2 has given an overview of the main issues regarding protected cropping that current literature has been focusing on, while presenting the two case-study countries and the state of their organic, horticultural and protected cropping sector, thus integrating economic and legislative information. Theory links up to practice through Chapter 3, in which the methodological steps taken to collect information were described, through surveys and interviews, and Chapter 4 followed right up to show and discuss in detail the results from both methods of data collection, thus creating a fertile soil to stem the discussion of issues, related to sustainable and resilient practices, that organic growers from two different countries considered relevant for their present and future management.

## KEY POINTS OF DISCUSSION

Results from surveys and follow-up interviews with growers from the two case-study countries brought up multiple topics of interest and concern alike, whether they regard environmental, socio-economic or cultural and political aspects of protected cropping systems under organic management. For the conclusive chapter, the wide range of topics touched throughout the discussion have been merged into four main issues that encompass them, and give a different perspective on what organic growers, from two countries with different backgrounds, deem relevant and influencing for the success of their businesses and the implications of what being sustainable and resilient means for them in practical terms.

### ORGANIC GREENHOUSE CROPPING: PRESENT AND FUTURE

Now, the European Union is lacking reliable and uniformly updated data on areas devoted to organic protected vegetable production, but approximately 5,000 ha of greenhouses are estimated to be managed organically throughout the EU (Tittarelli *et* *al.*, 2014). Although the reach of the study was limited as discussed earlier, the 20 interviews made it possible to account for a protected area of 12.5 ha for Italy and 7.8 ha for the UK, theoretically representing highly different percentages of the literature-based greenhouse area (respectively 0.6% and 26%; see Table 1). However, in both cases comparisons should be made carefully for two main reasons: 1) in Italy's case, it is not clear whether the estimated 2,000 ha (Tittarelli *et al.*, 2017) refer to specialised greenhouse farms or they consider more diversified systems as well, where protected crops represent a fraction of the total turnover; 2) in the UK's case, the estimated 30 ha (Schmutz *et al.*, 2011) only referred to heated structures, while the collected data have shown an almost distinct prevalence of unheated systems. The general gap in comparable data that emerged from the present research would require a more in-depth study of protected cropping systems in both countries, starting with a collection of data on greenhouse areas, specialised and not, at national level, given the fact that in the wake of unpredictable climatic and financial changes, with a rising population and an increasing number of people in need of improved diets, there is likely going to be an increase of both extent and dispersion of protected structures within the next decades.

Organic production systems have shown to go in two possible main directions: one way is the 'conventionalised' path, with growers relying more on the employment of inputs permitted by the regulations rather than agronomic practices, thus operating a simple input substitution and further driving a wedge between two already existing currents or, as Goldberger (2011) put it, between *'large industrial-scale businesses and smaller lifestyle-oriented producers'.* However, in this instance fieldwork cases showed that in practice things are not as definitive and set in stone as they might look, and that distinction is simply one way of assessing the issue, directly connected to the intensiveness of cultivation in protected environments. In this sense, the discussion with both Italian and British growers from different areas have revealed that simple compartmentalisations are too reductive for the range of possibilities that greenhouse cropping ultimately offers. Indeed, there is a wide range of situations to be confronted with when it comes to the level of intensiveness of protected cropping, especially in organically managed systems, which cannot be reduced to either high- or low-intensive systems and fitting into the Mediterranean area or Northern-Central Europe classification. This distinction also relates to the cultivated crops and related growing season, their rotation schemes, nutrients and water requirements, and the volume of investments in structures and materials. Practice showed that there is a range of approaches to organic methods of cultivation, not necessarily linked to certification standards, which is wider than what basic distinctions between ‘conventional’ and ‘alternative’ production systems have not been able to capture, making room for further analyses of the existing heterogeneity amongst organic practices and the impacts of these differences on the quality of production (Ceglie *et al.*, 2016).

Interesting examples have come from both countries, indeed showing differences in the level of intensiveness employed inside greenhouses even within the same scale of operations. In Italy, results showed a 6.5-ha farm near Verona, North-Eastern Italy, which turned 100% of its cultivated area into protected structures and has them working with a highly intensive system, since produce -salads, mostly- is destined to large distribution in foreign countries, and a 14-ha farm, located roughly 40 km away, with a small share of 1,800 $m^2$ of greenhouse cropping (less than 2%) and a more diversified less intensive cropping system, which shows that local situations might drastically change within the same area. Similarly, data from the UK revealed a 1-ha farm in Devon, South-Eastern England, with 10% of its cultivated area covered by polytunnels and a highly-intensive cropping system in place, yet with a wide rotation of leafy greens, and a 3-ha horticultural holding in Gloucestershire, Central England, part of a much larger farm, with a percentage of covered area of roughly 2.5% under a low-intensity cropping management, although close to monoculture because of a very short rotation scheme. Important differences are also shown among large-scale producers: interviews in Italy showed a 50-ha farm close to Padova, North-Eastern Italy, with 2 ha of specialised glasshouses producing micro-salads destined to be packed and shipped to foreign markets, employing a medium level of technology inside the protected structures, mostly for winter heating, irrigation and harvesting operations, and yet using a wide rotation scheme integrated with green manures. Interviews in the United Kingdom showed a 26-ha horticultural company on the Isle of Wight with 6 ha of organically grown tomatoes distributed to supermarkets in the whole country, employing a high level of technology inside the greenhouses and a highly intensive monocultural cropping system.

Every fieldwork case showed that employing protected structures is considered a necessary step for production, regardless of the size of the business, for multiple reasons, the most important ones being the possibility to shelter crops from those extreme events that growers see exacerbate year after year, and the chance to have their products on the market in those moments of the year when stalls get literally hungry, simultaneously guaranteeing a certain yield and income even in uncertain times. Many of the interviewed growers in both countries sustained that it has become a common belief among them that the future will likely bring a gradual expansion of the area under protective structures. However, production will need to focus on higher quality and a more effective resources management, thus shifting the emphasis from *'efficiency to adaptability'* (Darnhofer *et al.*, 2010); in this sense, processes of intensification will play an important role in building up sustainable and resilient management systems in protected cropping, and their effectiveness will need to be 'evaluated' case by case, since every agroecosystem is unique and some are more prone to go through such transformations and leave their functionality not compromised. As an increasingly relevant part of agricultural productions, protected cropping systems should be striving towards the so called 'true' sustainability, which would show the validity of organic practices through evidence-based findings and help integrate their adoption into agricultural systems (Arbenz *et al.*, 2016), especially in the case of organic protected cropping. However, aiming at being resilient should not answer to the 'climate change and future development' question with an indiscriminate expansion of protected areas, otherwise organic protected cropping systems might incur in what psychological sciences have recognised as the 'dark' side of resilience, which could translate into productions potentially becoming 'overly tolerant of adversity' or 'too resilient' (Chamorro-Premuciz and Lusk, 2017).

## EVOLUTION AND IMPACT OF MANAGEMENT PRACTICES

It goes without saying that alternative farming systems are born for a basic reason, which is the need to diverge, both theoretically and practically, from conventional (or conventionalised) productions. In such cases, it appears that they all seem to follow a set of basic principles, which enclose the use of locally adapted varieties, naturally derived and easily retrievable growing media and mulching resources, the on-farm production of fertility sources, and the employment of crop rotations and intercropping to reduce pathogen and weed pressure and increase diversification. These guiding lines are mostly dictated by common sense and the awareness of the impacts of agriculture on the health of the environment and all its inhabitants, regardless of the denomination these farming systems are given.

These principles are also renowned to the academic world as the fundaments of **agroecology**, a discipline deeply embedded in policy that was first brought to life in developing countries, to give small-scale farmers the chance to employ a set of practices that would keep their farms productive and equip them with the right tools to be less vulnerable to unforeseen changes. In this sense, organic productions can be considered the 'first of many' in terms of applied alternatives to conventional farming, although growers from both countries strongly agreed on the fact that for them, going organic was the soundest solution and most viable option, since organic agriculture is backed up by the most relevant volume of scientific literature. However, scholars have argued that the concept of organic agriculture is not fully consolidated (Dinis *et al.*, 2015), and due to an increased role of agribusiness firms in the organic world, and the perceivable ample breadth given by the EU normative in terms of management (e.g. general indications and allowed inputs), a great heterogeneity of opinions and approaches to farming raised up, diverging on to what degree farms get integrated in the global market and incorporate core values in their business. Moreover, there is no exact interpretation of these values and some of them are difficult to capture in physical terms (e.g. agrobiodiversity enhancement or engagement with peers and communities), especially regarding control and certification procedures. Indeed, evidence gathered from the interviews demonstrated that the field, practical in particular, offers multiple possibilities, sometimes even going beyond organic agriculture.

Examples of biodynamic farming have been encountered, operating in Veneto, North-Eastern Italy, with a relevant degree of economic success, which have stemmed from a ‘100% organic’ approach to production, as presented by the growers involved. This approach to alternative productions refers particularly to fertility management, since it has been often remarked that without a good soil, there is no good food or good environment, so in these cases agronomic practices include on-farm production of compost, wide rotations and large use of green manures, with the intent of employing as fewer external resources as possible. A similar consideration can be made for ‘Shumei Natural Agriculture’, encountered in Wiltshire, England (United Kingdom), which suggests that a different way of producing food is not just a hippie-style-induced vision of the future of agriculture, but a possible and practically viable option for a more sustainable and resilient system to produce food.

In protected cropping, maintaining a **healthy and fertile soil** especially becomes a priority because the different environmental conditions inside a greenhouse and the variability of intensiveness of the cropping system make fertility management different as well, and having a vital soil is a key feature of a healthy and productive farming system. Organic growers have agreed on the fact that constant care for the soil is one of the main points that distinguish them from conventional producers and especially if greenhouse crops follow narrow rotations throughout the year or even monoculture is employed, having the possibility and resources to work continuously on preserving -and also improving- the fertility of their soil without it being detrimental to their income is imperative. Indeed, results from the survey confirmed that fertility management is considered the most important issue by most growers from both countries when it comes to sustainable and resilient farm management.

Strongly linked to fertility management and representing another basic feature in resilient farming systems, **diversification** is another focus point for organic growers, widely recognised as a fundamental strategy to adapt to climate change and especially when it comes to horticulture, the preservation of agrobiodiversity and the enhancement of both crop and product diversification are two key passages to the reduction of losses and the ultimate survival and well-being of human societies. Results from the survey indeed showed that fostering biodiversity, at farm and landscape level as well, is especially important for Italian growers, but it was given an average relevance by British producers. However, both groups of respondents agreed on the fact that it is a relevant part of the nature of organic management to avoid monoculture as much as possible and to rely on growing a high number of crops through rotations, cover crops, intercropping which, in combination with the limited use of synthetic inputs, represent a series of agronomic practices that help foster greater variability in terms of biodiversity and habitats. Moreover, this is also about diversification among farms, not only within the single unit, and at landscape level, which helps promote *'higher heterogeneity across different agroecosystems'* (Gomiero *et al.*, 2011). Indeed, results from the survey showed Italian producers giving higher relevance to other levels of diversification, e.g. for products and market outputs, while British growers assigned these issues an average importance.

There is a general strong conviction that a rational choice of growing techniques in tune with agro-ecological principles is agreed to be the most desirable decision, adapted to the local situation, interrelated with well-thought management plans for an optimal use of resources already verging on the 'scarce' side (water, for example) and the maintenance of soil fertility, especially for an intensive cropping system such as a greenhouse, in order to maintain and desirably *'improve the overall long-term health of a farm'* (Koohafkan *et al.*, 2011).

### PRODUCERS AS CORE FIGURES FOR TRANSFORMATION

Being at the centre of all decisions regarding their farm management, producers represent the core figures of the food production system and the direct link to consumers. However, interviews with growers from both countries have revealed a spreading feeling of mistrust for the authorities and abandonment, since they are aware that without the support from institutions and governments, which has repercussions on their chance to find a place on the market, organic growers, especially if small-scaled, tend to get isolated and have worse chances in overcoming competition from larger organic businesses or even conventional ones. In relation to this, growers gave great relevance to the ethics of work and the possibility to form cooperatives. About the former, there is an obvious general agreement that running a farm requires hard work and great effort, not just because it is partly a physical job but also because there are several trade-offs and compromises to confront with every day. However, given the fact that organic growers, especially if small-scaled and still attached to core values, have to navigate stormy waters thanks to larger businesses infiltrating the market and the certification system, and the competition with conventional / conventionalised systems in terms of both prices and principles, they feel that a dose of 'extra-work' and self-sacrifice, physical, mental, economic, is inherently required to keep their business alive both in the short- and long-term. Sometimes, getting burned out in the process because working the land straddles a thin line between being a simple job and the dedication of a lifetime. About the latter, indirectly linked to the former, many producers, particularly in Italy where most land properties are relatively small and tend to be heavily fragmented, have also expressed the desire to form **cooperatives**, since they are strongly convinced that grouping farmers together, united under the same values and agenda, could boost their production as single businesses and, additionally, diversify their range of products as a community of businesses, while preserving their localness and specificity. In these situations, growers felt that getting incentivised to form such associations could be a relevant issue if the focus is reoriented to support sustainable agriculture, especially if the future food system aims to increase productivity so that it will 'bear the cross' of having to feed 9 billion people by 2050, while letting agroecosystems supply ecosystem services.

The pursuit of an increasingly sustainable production system would also require a wider availability of training and education for all those involved, especially organic growers for they feel their 'narrow' field of expertise requires a wider set of skills and competences, and the facilitation of information exchange between scientists or academics and producers. In this case, issues like **knowledge exchange and formation** have been deemed highly relevant by both groups of producers through the survey but during the interviews, British producers showed a greater interest in the necessity to foster the passage of information across generations and groups of peers, mostly because knowledge is strongly experience- and context-related and growers also see important gaps, in acquired skills, that might be difficult to fill in, starting from what they perceive as a lack of educational structures involved in sharing practical and up-to-date information. Moreover, results from both surveys and interviews showed that small-scale producers still represent a large percentage of the total, deeply rooting their practices into local contexts and mostly focusing their financial and social survival on **short supply chains**, especially since they are organic producers, therefore still considered a niche. For both groups of respondents, short supply chains represent a point of transformation towards an increasingly sustainable food system, concerning not only the economic dimension of market exchange, but also the maintenance of environmental integrity and the fostering of social and ethical aspects of food production, what with consumers' demands, habits and relationship with producers changing to a more direct approach (Sayadi and García, 2017), which helps growers give new value to their produce and bring attention to a more responsible management of local resources.

## LINKING SUSTAINABILITY AND RESILIENCE: FROM THEORY TO PRACTICE

How can a sustainable and resilient agroecosystem be defined? Tobin (1999) gave an example while referring to communities and their capacity to respond to geophysical hazards, describing them as *'structurally organised to simultaneously minimise the effects of disasters and have the ability to recover quickly by restoring their socio-economic vitality'*, and suggesting that sustainable and resilient systems would be equipped so that their components -natural, human and technological- are rendered less vulnerable to external events, that the planning process is continuous and launched towards the long-term, that the transition is supported by authorities and the systems cooperate with them, that said systems are integrated in social networks, and that all scales of operations are involved in the process.

Theoretical conceptualisations are, however, easier to formulate than practical applications and it can be agreed on that sustainability and resilience do differ, from a theoretical point of view. Moreover, one thing that the present study has shown is that agroecosystems are complex universes, and producers are subjected to multiple factors they have little to no control over, therefore planning for the short- and long-term in such sense would be just as complex and require integration of socio-economic and political factors, as well as environmental ones. Nonetheless, sustainability and resilience do connect in practice, and it is through management: a management that needs to be adaptive, through learning processes that monitor changes in resources and gradually incorporate new knowledge. Several examples have been given by organic growers of agronomic practices and management decisions that help build up a sustainable and/or resilient agroecosystem, mostly focusing on diversifying the environment, maintaining soil fertility and fostering local economies.

Simplifying the system might be considered sustainable in the short-term, at least economically because of yields increase, while giving the impression that natural variations can be controlled (Folke *et al.*, 2002) but it has negative repercussions on long-term resilience, especially in highly intensive cropping systems. Practices that help build the organic matter content in soils (e.g. rotations, green manures, compost integration) are pivotal for short- and long-term sustainability, while also reducing agroecosystems' vulnerability to most expected and unexpected changes (e.g. pests outbreaks). Small-scaled farm businesses are more likely to be both sustainable and resilient, being embedded in local economies through direct contact with peers and consumers and engagement with their communities, if properly supported by policies and authorities. Incentivising organic growers to transform their farming systems in this sense, through modified policies (e.g. CAP reform to include measures 'awarding' agroecological approaches to production) and reviewed regulations (e.g. specific directives for protected cropping, in this case), would gradually help create a cluster of small agroecosystems, working towards new states of sustainable and resilient development, interconnected through an expanding network of shared local knowledge, both traditional and modern.

## LIMITATIONS OF THE STUDY

In the beginning, the primary objective of this research was to devise a new tool (or implement an existing one) for the assessment of the sustainability of organic greenhouse horticulture, given its specificity and rising importance, and to add resilience-related indicators to this to-be-born evaluation method. For this, two existing methods were taken as reference bases:

a) Life Cycle Assessment or LCA (US EPA, 2006), one of the most well-developed and established tools, having been used for decades to evaluate the environmental impacts of products, services or processes throughout their life cycle (i.e. 'cradle-tograve' approach), giving a numerical value to said impacts but failing to integrate aspects other than environmental ones;

b) Public Goods or PG Tool (Gerrard *et al.*, 2011), developed because of the increasing interest amongst policy-makers in defining what kind of 'public goods' a farm could provide beyond the simple food production (i.e. improved environment, better water quality), thus offering a comprehensive view of the performance of a farm regarding all three dimensions of sustainability.

Afterwards, a trial of this combined assessment tool was planned among organic farms, employing greenhouses, in different European countries (i.e. United Kingdom, Spain, Switzerland, Italy, Slovenia for their importance in the organic horticultural world), and though it was scientifically relevant, leading to two different publications (Foresi *et al.*, 2016 and Foresi *et al.*, 2017), the initial conception of this study ultimately proved to be unfeasible (i.e. lack of adequate financial support, required skills in developing indicators, time constraint, difficult reachability of growers in too many countries), therefore a shift in the research objective was required. Only two countries were selected in the end (Italy and the United Kingdom) but they were targeted with an in-depth analysis that gave the research a different cut, thus putting the perceptions of organic growers employing protected structures at the centre of the study rather than the use or development of a rigid assessment tool. Moreover, many of the sustainability issues the tools attempted to tackle were retained in the research and resilience was added, which is not directly addressed by either of those tools or other tools (Foresi *et al.*, 2016).

The shift to the new research approach had brought issues as well, which were mainly related to the sampling process and the samples themselves. The first issue was presented with the relative inaccessibility of the populations in question for their specificity, which made accessing names and contacts perceivably difficult. In this case, a more formal approach, as in having the Research Centre issuing an official request for contacts to the competent authorities and certification bodies, might have partly solved the problem by supplying the study with larger samples of organic growers from both countries. The second issue, which directly relates to the first, concerned the maximum number of growers to consider for the interviews, as to not incur in information saturation. It is true that there is no reference in literature that agrees on this number, therefore it is in the researcher's possibility and interest to decide. In this case, the study might have either concentrated on fewer 'real' case studies, e.g. in the United Kingdom, given the limited number of potential participants, or considered a larger number of interviews, e.g. in Italy's case, so that it would have been proportional to the initial population of organic growers and had a broader geographical scope. The third issue may be a consequence of the previous two, and it concerned the possibility of planning second visits and interviews or organising a conclusive focus group to bring all opinions and ideas together and potentially increase the validity of the research methodology and the obtained results as well.

## RESEARCH OUTCOMES AND FUTURE POSSIBILITIES

In the light of the amount of information that transpired from the literature review and the eventual gaps in the story of organic greenhouse horticulture, with special regards to the level of sustainability and resilience of its management practices as perceived and lived by the growers themselves, this study was designed to have multiple potential outcomes.

The methods that were chosen to undertake this research represented an alternative and novel approach to the analysis of a growing sector and a specific reality within organic farming, such as protected horticulture, which has been raising contrasting views among scholars in terms of how sustainable and resilient it is and can be as a production system. In this case, an in-depth study of a limited sample of farm businesses might not have been enough in terms of making generalisations with the findings, but it gave the research a cutting edge in discovering and understanding the point of view of growers, the possessors of local knowledge and first providers of food and services in the community, thus going straight to the source of information and collecting important primary data on issues related to protected productions such as current practices, potential innovations, and future perspectives for the sector and the producers.

Although with a limited breadth, one thing that the present research has managed to demonstrate is that farms are indeed complex and dynamic systems and they widely vary in time and space, so there is the belief that no models can provide producers with specific or even predictive guidance: there is a farm and a way to manage resources for every producer. For this purpose, the choice of employing a mix of both quantitative and qualitative research methods, which had included specifically constructed questionnaires and face-to-face interviews, had represented an important opportunity for the collection of information on a set of specific cases, since farming practices are always context-related, thus embedded in local situations. This way, people getting involved in uncovering the multifaceted nature of alternative types of agriculture would be partly aided in achieving a wider understanding of how single producers, of any size and provenance, perceive sustainability and resilience, what actions they undertake to implement such concepts in practice, what are the factors that have a major influence in their decisions regarding any issue related to their management system. Getting in direct contact with growers, as an integral part of the employed methodology, if applied on a larger scale, would potentially help in building the foundations of a knowledge sharing network, and the information collected would integrate the current literature with a range of sustainable and resilient practices pertinent to the protected cropping sector to the current literature, thus bridging the distance with the academic world, and opening the stage to a comparison between scientific knowledge and practical expert-based, proved and tested 'traditional' knowledge, in order to find ways in which they can complement each other. Moreover, this direct confrontation would represent a step forward in aiming to expand the scope of current organic regulations, as to consider additional rules tailored to protected cropping management, since several growers have expressed themselves in favour of this process of rule integration.

The study had also served as a comparative analysis between two different countries such as Italy and the United Kingdom, highlighting the differences between growers' views and food cultures belonging to diverse geographical, environmental, social, economic and political situations, but also helping to find common issues, views and future perspectives. In such sense, a future potential development for this research might include bringing in an increasing number of case studies, starting from the two countries object of the study and potentially expanding to other countries in the European Union and beyond, thus building on and updating currently existing demographic data and collecting primary information on sustainable and resilient practices on a larger scale.

## FINAL CONSIDERATIONS AND RECOMMENDATIONS

Agricultural systems face constant changes and these changes are triggered by multiple factors: population dynamics, global market forces, investments, advances in science and technology, climatic variability, consumers' demands, subsidies, social movements demanding food sovereignty, and land reform (Koohafkan *et al.*, 2011). When it comes to alternative farming methods, many support the idea that in the future, the focus should also stay on longer-term research, farmer engagement, appropriate policy, institutional support, and practice-testing processes (Kassam *et al.*, 2012).

This research humbly aimed to be a small amplifier for the voices of real producers, in only two of the many countries where organic horticulture is practiced and protected structures are employed worldwide. However, it served as an appetiser of what a bottom-up approach to sustainable development would be, which would bring the personalities of growers, farmers and producers, at the centre of decision-making processes concerning the use of natural, human and technological resources in a systematic way, especially since most of them are small-scaled and tend to populate rural and remote areas. This could be an important development in the specific case of horticultural producers, especially if organic, for it is believed that organic productions are a large contributor to social equity and have a fundamental role in boosting production in rural areas, since it makes better use of local resources, thus facilitating access to market for smallholders, relocating food production in marginalised zones (Scialabba, 2013), potentially generating green jobs and revitalising rural areas (Gomiero *et al.*, 2011).

Horticulture greatly contributes to food security of rural and urban poor areas, with low initial costs, high yields per unit of time and land and products with high market value, factors that play an important role for local economic development (Lutaladio *et al.*, 2010). This can be especially true if growers employ protected structures: horticulture is a highly flexible -even ubiquitous- agricultural sector, being potentially implemented at every latitude on the globe, and protective structures, glasshouses and plastic tunnels alike, have the inherent power to enhance this flexibility. However, the next few decades will be pivotal in the development of agricultural practices towards higher levels of sustainability and resilience, and the impacts on the global environment, given the inherent capacity of agriculture to transform landscapes through its practices.

Policies at every level, regional and national and international, will need to take the adaptive aspect of organic farming practices into consideration to direct the focus of public management and research on further optimizing the natural production potential of agroecosystems, mixing traditional knowledge with modern information (Scialabba and Müller-Lindenlauf, 2010). Another future policy issue will likely be the protection of small-scale businesses, as the population grows and the global demand for food increases with it, to put the pressure to expand their operations off them (Gomiero *et al.*, 2011). This pressure could also translate into an indiscriminate expansion of the greenhouse area at world scale, which would be the incorrect answer to the 'climate change and future development' question and tip the balance towards a lower level of sustainability, for the volume of resources employed, or even a resilient level too high to still be consider 'natural'. Therefore, in the future, it is recommendable to include measures concerning protected cropping in policies (e.g. next CAP reform) to support and incentivise the setting up of horticultural operations -a sort of ‘greenhouse clause’ to help growers face the initial investments-, with a particular focus on small producers (e.g. under 10 ha, family-owned, in marginal areas, with fragmented land, or part of local networks) and non-specialised businesses, since the present study has revealed that greenhouse crops can represent a relevant percentage of a total turnover of a farm, and at the same time putting a limit to the farm area hosting protected structures (e.g. no more than 10%, also referring to survey average results for both countries).

In the end, we should all remember a simple but important fact: we inescapably depend on agriculture and horticulture, even though it has been considered a mere economic activity for too long and in response to that, ill-planned management has heavily damaged the agroecosystem in many ways in the past century (Gomiero *et al.*, 2011). Unlike any other economic activity, agriculture is the only one that cannot be dismissed or lost because it is the ultimate source of human sustainment and life.

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## APPENDIX I – SURVEY

*General information on business operation*

Q3. Geographical position: ___________

Q4. Years of use of greenhouses: _____

Q5. Years of experience with greenhouses: _____

Q6. Years of organic certification: _____

Q7. Membership with sectorial organizations: ___________

Q8. Total farm size (ha): _____

Q9. Area covered by greenhouses (ha or $m^2$): _____

Q10. Type of protected structure (multi-tunnels, polytunnels, other): ___________

Q11. Heated structure: Yes / No

Q12. Main crops grown inside greenhouses: ___________

Q13. Crops and/or livestock present outside the greenhouse: ___________

Q14. Number and type of employees (fulltime, part-time, volunteers): ___________

Q15. Annual turnover (estimation): ___________

Q16. Percentage of turnover represented by protected crops (estimation): _____ %

Q17. Market channels used (farm shop, box scheme, online, large distribution): ___________

Q18. If more than one, please give percentages: _____ % from ___________, _____ % from ___________, _____ % from ___________, _____ % from ___________, _____ % from ___________.

Q19. What's the main reason for greenhouses on your farm? ___________

*Views on sustainability and resilience*

Q20. Give a score from 1 (low) to 5 (high) of your understanding of the concept of 'sustainability'. _____

Q21. How important is sustainability for your farm, on a scale of 1 to 5? _____

Q22. How important are the single components of sustainability (environmental, social, economic), on a scale of 1 to 5?

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Environmental sustainability | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Social sustainability | | | | | |
| Economic sustainability | | | | | |

Q23. Give a score from 1 to 5 to your understanding of the concept of 'resilience'. _____

Q24. How important is resilience for your farm, on a scale of 1 to 5? _____

Is your farm subject to extreme events (i.e. floods, drought, snow, market fluctuations)? __________

Q25. If possible, make one or two examples. __________

Q26. How do you cope with such events? __________

Q27. On a scale of 1 to 5, give a score to the importance the following practices/issue related to sustainability have for you. In case, add more.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Weed management | | | | | |
| Soil fertility management | | | | | |
| Waste recycling / reusing | | | | | |
| Wildlife protection | | | | | |
| Energy efficiency | | | | | |
| Use of renewable energy | | | | | |
| Water conservation | | | | | |
| Carbon emissions | | | | | |
| Environmental auditing (LCA, footprinting) | | | | | |
| | 1 | 2 | 3 | 4 | 5 |
| Profits | | | | | |
| Financial survival | | | | | |
| Financial benefits | | | | | |
| Events sponsorship | | | | | |
| Short food supply chain | | | | | |
| Local community engagement | | | | | |
| Landscape and heritage protection | | | | | |
| Public access to farm | | | | | |
| Products traceability | | | | | |
| Job training, education and development | | | | | |
| Work safety | | | | | |
| Traditional knowledge | | | | | |

Q27a. What are the two most important issues related to sustainability for your farm? If you wish, please refer to the related table.

Q28. What sort of benefits would you expect from their eventual implementation? Give them a score of 1 to 5.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Environmental benefits | | | | | |
| Social benefits | | | | | |
| Economic benefits | | | | | |

Q29. For you, which factors could help or stop (positively or negatively influence) their implementation? Give a score of 1 to 5 per the importance they have for your farm. In case, add more.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Feasibility / bureaucracy | | | | | |
| Farm size | | | | | |
| Regulations in force | | | | | |
| Investment costs | | | | | |
| Subsidies / financial aid | | | | | |
| Perception of benefits | | | | | |
| Perception of risks | | | | | |
| Consumers' demands | | | | | |

Q30. On a scale of 1 to 5, give a score to the importance the following issues related to resilience have for you. In case, add more.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Crop diversity | | | | | |
| Diversity on the market | | | | | |
| Enterprise diversity | | | | | |
| Knowledge/information exchange | | | | | |
| Capacity to face changes | | | | | |

Q30a. What are the two most important issues related to resilience for your farm? If you want, please refer to the related table. ___________

Q31. In your opinion, what could be the most relevant issues related to both sustainability and resilience for your farm in the future? If you wish, refer to the related tables. ___________

*Concluding questions*

Q32. Are you willing to receive further information about this research? Yes / No

Q33. I am planning on-farm visits to find out more about what growers think about sustainability and resilience. Would you be interested in participating? Yes / No

Q34. Please add your preferred contact detail (e-mail, phone): __________

Q35. If you know of any other organic greenhouse grower that might be interested in the study, would you mind giving me a name or a means of contact? ___________

Q36. If you have any comment or observation about this research, please add them below.

## APPENDIX II – SEMI-STRUCTURED INTERVIEW

*General information*

How long have you had greenhouses on your farm?

Why did you decide to use them?

What are the positive / negative aspects of having greenhouses, in your opinion?

Would it be possible to take a walk around the farm to discuss more openly if you think the interview setting is too formal?

*Sustainability and Resilience*

Can you tell me more about your personal understanding of the concept of sustainability?

Can you tell me more about your personal understanding of the concept of resilience?

Let's go back to the survey responses. According to what you chose, would you mind giving me more information on the factors that you think impact your decisions the most, like *feasibility / bureaucracy, farm size, regulations in force, investment costs, subsidies / financial aid, perception of benefits, perception of risks, consumers' demands*? In what measure, do they affect your decisions?

*Environmental issues*

Let's go back to the survey responses. According to what you chose, would you mind giving me more information on your own practices, like *weed / pest control, soil fertility, water conservation, waste disposal, energy efficiency, biodiversity protection*? What you do, how you do it, why you do it that way, if there's anything you might do differently.

Compared to other growers like you in the area or that you know of, do you think what you are doing is different from what they do? Would you mind giving me a couple of examples?

*Socio-economic issues*

Let's go back to the survey responses. According to what you chose, would you mind giving me more information on issues that are more important in your opinion, like *financial survival, financial benefits, short food supply chain, local community engagement, landscape and heritage protection, products traceability, job training,* *education and development, traditional knowledge*? What you do, how you do it, why you do it that way, if there's anything you might do differently.

Compared to other growers like you in the area or that you know of, do you think what you are doing is different from what they do? Would you mind giving me a couple of examples?

*Concluding thoughts*

If you have any other comments on the research, feel free to add them.

Thank you again for your time and your invaluable inputs. One last thing: as a repayment for the time 'lost' on the interview, would you accept me as a volunteer on your farm for a day?

**APPENDIX III – GROWERS' IDENTITY (ITALY)**

**GRO01 (PD, Veneto) 07/09/2016.** Family-conducted business started in 1978 with 2 ha of conventional I° range salads. In 1988, washing and packaging stages were added to give extra value to products. Converted to organic in 1999 and currently growing 2 ha of IV° range salads inside greenhouses (specialized product), plus 35 ha of various vegetables, legumes and cereals.

**GRO02 (PD, Veneto) 12/09/2016.** Born as a project for work reinstatement for people with mental disabilities. In 2006, integrated with an organic horticulture programme. The cooperative possesses 0.5 ha of organic land, certified in 2003 and initially cultivated with cereals, and one hectare recently acquired and currently in conversion. A greenhouse of 500 square metres is used to protect crops and lengthen their season.

**GRO03 (RM, Latium) 15/09/2016.** Farm linked to a receptive structure that uses all the produce. Total area is 107 ha and production is diversified (cereals, forest, olives, pigs); vegetables occupy a few hectares and greenhouse is currently used as a storage for machinery. However, future project is to build 2 tunnels for a total of 400 square metres.

**GRO04 (RM, Latium) 21/09/2016.** Business born from owner's 20-year-long experience with protected structures. Not certified organic and experimenting with substrates and structures for growth, with 1000 $m^2$ of automatized greenhouses.

**GRO05 (VT, Latium) 22/09/2016.** Organic farm born in 2011, currently converting to biodynamic, with a single body of 17 ha and a diversified production (olive trees, vineyard, forest, cereals, beekeeping, fruit trees). Vegetables occupy 1 ha, employing a small greenhouse essentially used for propagation. Farm linked to a receptive structure that uses part of the produce, while the rest is transformed and sold on the farm.

**GRO06 (BA, Apulia) 06/10/2016.** Organic farm of 19 ha with a diversified production (cereals, fruit trees, agroforestry, vegetables), planning to integrate activity with a receptive structure. Vegetables occupy 2 a and a small structure is used as a greenhouse for propagation; however, plan is to build 4 greenhouses with multiple purposes (larger propagation area, support to production, exotic plants and tropical fruit trees).

**GRO07 (VR, Veneto) 07/10/2016.** Located 40 km south-east of the interview point. Small farm born in 1982 and entirely voted to vegetable production, 15% of the total area covered by greenhouses. On the way to biodynamic certification. Dedicated to local distribution.

**GRO08 (VR, Veneto) 07/10/2016.** Farm completely invested in greenhouses (2.5 ha of vegetables plus 4 ha of kiwis). Born in 1982 as an organic business, passed onto the next generation in 1997, certified biodynamic since early 2016. Voted to large distribution, distributes produce to foreign markets.

**GRO09 (VR, Veneto) 07/10/2016.** Farm located 20 km south of the interview point. Total area of 8 ha, 6 of which are productive and split in half between open field and protected crops; plan is to increase greenhouse-voted area. Certified biodynamic since early 2016. Distributes produce to foreign markets.

**GRO10 (BA, Apulia) 30/12/2016.** Organic farm of 30 ha with a diversified production (cereals, cherries, almonds, grapes). Vegetables used to occupy 0.5 ha under protection, endeavour was abandoned 5-6 years ago due to lack of time and labour.

Table 12. List of Italian growers that took part in the interviews, with a short recap of basic information on their businesses.

| ITALY | Farm size | Covered area | Type of structure(s) | Crops grown under cover | Distribution channel(s) |
|---|---|---|---|---|---|
| **GRO01** | 50 ha | 2 ha | Glasshouse + multitunnel | Rocket, spinach, lettuces | Large distribution |
| **GRO02** | 1.5 ha | 300 $m^2$ | Single polytunnel | Tomatoes (sum), lettuce, chard, chicory (win) | On-farm sales, home delivery |
| **GRO03** | 167 ha | 150 $m^2$ | Single polytunnel | Tomatoes, courgettes | On-farm sales, home delivery, self-consumption, 'agritourism' |
| **GRO04** | 3.5 ha | 2000 $m^2$ | Multitunnel | String beans, strawberries | On-farm sales, home delivery, supply to fruit shop |
| **GRO05** | 17 ha | Less than 100 $m^2$ | Single polytunnel | Propagation | Self-consumption, 'agritourism' |
| **GRO06** | 19 ha | Less than 100 $m^2$ | Single polytunnel | Propagation | On-farm sales, local markets, self-consumption |
| **GRO07** | 14 ha | 1800 $m^2$ | Polytunnels | Tomatoes, lettuce, peppers, aubergines, courgettes | On-farm sales, large distribution |
| **GRO08** | 6.5 ha | 6.5 ha | Multitunnel | Lettuce, chard, celery, fennel, cabbages, kiwis | Large distribution |
| **GRO09** | 8 ha | 3 ha | Multitunnel | Mainly lettuces | Large distribution |
| **GRO10** | 30 ha | 5000 $m^2$ | Polytunnels | All vegetables, grapes, cherries | On-farm sales, local markets |

## APPENDIX IV – GROWERS' IDENTITY (UNITED KINGDOM)

**GRO11 (Gloucestershire, England) 30/11/2016.** Organic farm of 625 ha, with diversified production (arable, pastures, cattle, sheep, laying hens). Vegetables occupy 7-8 ha, in three different types of production (field crops, market garden, polytunnels), all going to the farm café and market.

**GRO12 (Oxfordshire, England) 12/12/2016.** Organic business with over 40 years of history of producing vegetables. Farm of 8 ha, 0.2 of which under protection. Production devoted to local distribution.

**GRO13 (Wiltshire, England) 17/01/2017.** Organic farm of 11 ha. Mostly producing vegetables, almost 1 ha under protection. Distribution of produce quite diversified (local markets, online, on-farm).

**GRO14 (Lancashire, England) 27/01/2017.** Historical organic farm in the Blackpool vegetable production area. Started producing 30 years ago. Comprising 2 ha, 6% of which grown in tunnels. Strongly devoted to local production.

**GRO15 (Wiltshire, England) 06/02/2017.** Vegetable-producing farm voted to principles of natural farming. Comprising 3 ha, half grown in a rotation and half under monoculture. Two polytunnels on site mostly for propagation, salads and the likes.

**GRO16 (Devon, England) 22/02/2017.** Organic production of 1 ha of vegetables, as part of a bigger and diversified farm of 150 ha (pastures, cattle, orchards, agroforestry). Protected production taking up 10% of vegetable area, all produce going to local restaurants.

**GRO17 (Scotland) 27/02/2017.** Organic farm of 55 ha, with diversified production (sheep, pigs, turkeys, laying hens, orchards, soft fruits). Vegetables occupy 1 ha, with a fifth under protection, all produce going to the farm café and market.

**GRO18 (Gloucestershire, England) 08/03/2017.** Organic production of 3 ha of vegetables, as part of a bigger and diversified farm of 800 ha (pastures, cattle, orchards, agroforestry). Protected production taking up 3% of vegetable area, produce distributed in varied ways (on-farm market stall, local restaurants and cafés, processing).

**GRO19 (East Sussex, England) 16/03/2017.** Organic farm started in 2001. Comprising 2 ha, with 30% of the area under glasshouses. Produce distributed locally.

**GRO20 (Isle of Wight, England) 04/04/2017.** Farm business started in 1949. Currently with 8 sites around the United Kingdom, Isle of Wight being the most recent with 26 ha of glasshouses and multitunnels, 6 of which managed organically. Production focused on tomatoes and cucumbers, and voted to large distribution (largest tomato supplier in the country).

Table 13. List of British growers that took part in the interviews, with a short recap of basic information on their businesses.

| UK | Farm size | Covered area | Type of structure(s) | Crops grown under cover | Distribution channel(s) |
|---|---|---|---|---|---|
| **GRO11** | 625 ha | 3600 m$^2$ | Polytunnels | Wide range of salads and vegetable crops | On-farm sales |
| **GRO12** | 8 ha | 2000 m$^2$ | Multitunnel | Wide range of vegetable crops | On-farm sales, box scheme, wholesale |
| **GRO13** | 11 ha | 950 m$^2$ | Polytunnels | Salad, carrots, tomatoes, garlic, onions, spinach, cucumbers | On-farm sales, online, large distribution, local markets |
| **GRO14** | 2 ha | 1200 m$^2$ | Multitunnel | Tomatoes, cucumbers, spinach, salads, onions, rocket | On-farm sales, box scheme |
| **GRO15** | 3 ha | 500 m$^2$ | Polytunnels | Salads, rocket, onions, garlic | On-farm sales, local shops, restaurants |
| **GRO16** | 1 ha | 1000 m$^2$ | Polytunnels | Winter salad, tomatoes, French beans, cucumbers, peppers, herbs, spring onions, fennel | Restaurants, market stall |
| **GRO17** | 55 ha | 2000 m$^2$ | Polytunnels | Salads, beans, chard | On-farm sales, farm café and restaurant |
| **GRO18** | 800 ha | 800 m$^2$ | Polytunnels | Tomatoes, garlic, celery | On-farm sales, large distribution, restaurants, processing |
| **GRO19** | 2 ha | 6000 m$^2$ | Multitunnels | Wide range of vegetable crops | On-farm sales, box scheme |
| **GRO20** | 26 ha | 26 ha (6 ha organic) | Glasshouses + Multitunnels | Tomatoes, cucumbers | Large distribution, processing, local shop |