Psychosocial risk factors' impact pathway for Social Life Cycle Assessment: An application to citrus life cycles in South Italy.

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ABSTRACT

Purpose Social Life Cycle Assessment (SLCA) was the last tool to be developed within the framework of Life Cycle Thinking, and since the beginning, there has been a struggle to reach a consensus on a standardized methodology. In fact, many different methodological proposals have been published, diverging on many points. The main difference lies in the epistemological position underlying these proposals. The aim of this study is to propose an impact pathway for assessing the social consequences of a product's life cycle—the Psychosocial Risk Factor (PRF) impact pathway. The epistemological posture of this methodology is post-positivist, because it is based on an objective assessment of the possible consequences of the functioning of the life cycle, and therefore it is in line with environmental LCA.

Methods Possible impacts on workers' health were measured in terms of risks, i.e., using the odds ratio, a statistical measure of the intensity of the association between two variables. Odds ratios explaining the relationships between working conditions and health troubles were retrieved from previously published empirical studies. These statistical relationships were used to build an impact pathway that links the product's life cycle to possible social impacts in a quantifiable and probabilistic way.

Results The PRF impact pathway was applied to citriculture in the Calabria region of South Italy. The results showed that the life cycle, from cradle to farm gate, of industrial oranges exposed workers to a risk for about 43,088 hours, against 54,110 hours for the clementine life cycle. In general, musculoskeletal disorders are the highest concern for both products, followed by osteoarthritis, disability, and cardiovascular diseases. For all impact categories, the industrial oranges' life cycle showed the best performance, mainly due to the shorter duration of a single operation. The results are generalizable to other evaluation contexts.

Conclusions The PRF impact pathway was applied to the stakeholders group "workers," but can be extended to other typologies of actor, such as consumers, local residents, and many others. Further, it allowed for an objective assessment of the impacts principally linked to the functioning of the citruses' life cycles, by quantifying and qualifying the hours of work, and can be extended to other fields of application.

KEYWORDS

Healthy Work Environment, Social Life Cycle Assessment, Psychosocial Risk Factors, Odds Ratio, Impact Pathway.

1. Introduction

Assessing the sustainability of human activity is important in all fields and scientific disciplines. Academics, entrepreneurs, and politicians are very interested in sustainable patterns of management, governance, production, and consumption (Adnan et al., 2017). Tools to measure human impacts are required, and, among them, Life Cycle Methodologies have gained a consensus on the evaluation of the potential impacts of products and services on the environment, economy, and society. The novelties introduced by this family of tools relate to the possibility of taking the whole life cycle of a product or service into account, from the cradle to the grave, highlighting burden shifts and hot-spots. However, life cycle tools did not develop simultaneously, nor with the same rapidity.

The first tool to be developed was the environmental Life Cycle Assessment (LCA), today standardized by ISO norms 14040-14044 (ISO, 2006a; 2006b). A set of indicators, corresponding to different impact categories, are calculated using data available from dedicated databases by means of specific software for the impact characterization. The evaluation procedure is organized into four standardized steps: goal and scope definition, inventory analysis, impact assessment, and interpretation.

Life Cycle Costing (LCC) is devoted to making an account of all costs generated along the life cycle. Despite being conceived before than LCA, LCC has standardized procedures in the building sector alone.

Social Life Cycle Assessment (SLCA) was the last tool to be developed, but since the beginning, in the nineties, there has been a struggle to reach a consensus on a standardized methodology (Iofrida et al., 2018a). In fact, many methodological proposals have been published, diverging on many points, as highlighted in the various reviews that have been published (for example, Wu et al., 2014; Fan et al., 2015; Mattioda et al., 2015; Arcese et al., 2018; Di Cesare et al., 2018; Russo Garrido et al., 2016; Dubois-Iorgulescu et al., 2016; De Luca et al., 2017; Kühnen and Hahn, 2017; Petti et al., 2018; Iofrida et al., 2018b). The most frequent points of divergence relate to the object of the assessment (an impact or a performance), the source of the impact (behavioral, i.e., linked to the actions of the actors, or physical, i.e., linked to the functioning of the life cycle), and the assessment method and indicators applied (e.g., a description of the current situation or an explanation of cause-effect relationships).

UNEP-SETAC (2009; 2013) published a guidelines report with a general framework, affirming that SLCA was the same method as LCA, but inherent to social impacts. However, this transposition has not been as obvious as one would think. LCA concerns natural phenomena, environmental impacts that are unambiguously definable and objectively quantifiable, while SLCA is about social phenomena, which are not always quantifiable, and strongly depend on perception and interpretation. As it occurs in the social sciences, the scientific study of social impacts can differ significantly according to the epistemological position of the researcher; indeed, the social sciences are multiparadigmatic (Corbetta et al., 2003), and social phenomena are multi-layered (Iofrida et al., 2018b). The strict rules of the natural sciences and their scientific methods are not always suited to the study of social impacts, and this is the main reason that there is no consensus on a methodology for SLCA.

The purpose of this study is to expand the knowledge about the development of the impact pathway methodologies, i.e., a group of methods dedicated to the analysis and evaluation of those impacts causatively linked to the functioning of products' and services' life cycle. Therefore, this study further developed and fully implemented the impact pathway for SLCA firstly proposed by Gasnier (2012) and Silveri (2014) to allow the assessment of social impacts on workers by means of Psychosocial Risk Factors (PRF). Safe and healthy working conditions are given utmost importance in both European and global policies, and are a major challenge in management processes. Consumers are also becoming more conscious of their choices and require fair products. According to Amiri et al. (2015: 69), "psychosocial risk factors are elements that impact employees' psychological responses to work and work conditions, potentially causing psychological health problems." In this study, the definitions by Cox and Griffith (1995) and Cox et al. (2000) were taken into account; they defined PRF as the aspects and characteristics of work planning and management that can potentially lead to physical or psychological damage.

From a methodological point of view, the psychosocial risks were measured using odds ratios (OR), a statistical measure of association. The data were retrieved from previous scientific studies (literature review) that examined the relationships between specific working conditions and diseases or disorders. The working conditions were outlined by characterizing each working task of the product life cycle, quantifying the working needs in hours; then, each task was associated to a working condition. The literature review allowed to build a PRF Matrix, putting in relation these working conditions with specific risks of disorders or diseases. The PRF pathway was tested on the stakeholder group "workers" because it is the group that has attracted the most attention from researchers in this field; however, as it is highlighted in the conclusions, the boundaries of the study can be enlarged to further stakeholders. The epistemological position on which this methodology is based is rooted in the post-positivist paradigm, and therefore is in line with the environmental LCA because it allows for objective quantification of the possible consequences of the functioning of the life cycle in the medium-long term. Bias attributable to personal judgements or feelings is avoided, and the quality of the data is attributed to its statistical validity. Indeed, the objective of the impact pathways methodologies is to explain a cause-effect relationship, not to describe the current situation.

The PRF pathway here developed was then applied to a case study, i.e., citrus growing in the Calabria region, well known for social issues, especially those related to working conditions. This choice was due to the transformation that is occurring in Calabrian citriculture, where industrial oranges are being abandoned in favor of clementines for fresh consumption, because of the end of European funding for the development of new cultivars. Two typical scenarios, representative of the local reality, were analyzed and compared, taking into consideration the most common diseases and disorders that the agricultural phases of the citruses' life cycles can cause.

The second section describes the theoretical background of the life cycle methodologies, explaining the main epistemological differences among the approaches proposed in the scientific literature up to present. Then, the perspective of the methodology proposed here—the Psychosocial Risk Factors pathway—is covered in detail.

The third section describes the methodological steps applied and the case study, while in the fourth section results and insights are presented and discussed, with a focus on whether changes can be made to improve social conditions for workers. The main benefits of the methodology are also discussed, with stress placed on the similarities between this SLCA proposal and its environmental and economic peers.

2. Theoretical background

2.1 Social Life Cycle Assessment

Life Cycle (LC) methodologies rapidly developed in recent years, and have introduced the concepts of widened boundaries and a long-term perspective to sustainability assessments. In fact, current sustainability appraisal techniques are limited in space and time, focusing on a project, company, or community whose responsibilities are generally attributed to single actors. LC methodologies enlarged the scope of the assessments to all phases of the life cycle, i.e., planning, raw materials extraction, production, processing, distribution, consumption, and disposal or recycling. This focus makes it possible to catch burden shifts and highlight hot spots.

The last tool to be developed, the SLCA, is not yet standardized because no consensus has been reached on a unique assessment process (De Luca et al., 2015a, 2015b, 2015c; Iofrida et al., 2018a, 2018b). In fact, since the beginning, in the nineties, many methodological proposals have been published, diverging on many points. Firstly, there is no consensus on the object of assessment, which can be a performance at a certain moment (e.g., Benoit-Norris et al., 2012; Bouzid and Padilla, 2014; Ramirez et al., 2016) or consequences in the medium-long term (e.g., Feschet et al., 2013; Bocoum et al., 2015). A distinction between the two terms was proposed by Macombe et al. (2013), who described performances as the characteristics of a situation (e.g., gender discrimination, child labor), while impacts are meant to be the consequences of a change caused by the product or service life cycle. Secondly, the social sustainability concept underlying the published studies is very often not explicit. Most of them quote the three pillars model, called Triple Bottom Line in business language; however, it is noteworthy that this approach has also been strongly criticized by many authors (Gibson, 2006; Brown et al., 2009). Furthermore, this theoretical choice is not obvious, because a sociological theory of social sustainability is lacking (Murphy, 2012) and the study of social phenomena can be approached in many different ways. Thirdly, the transposition of environmental LCA procedures to the study of social impacts has been very controversial: the principal difficulties concern the use of a physical functional unit (Zamagni et al., 2011), the choice of system boundaries and cut-off criteria (Lagarde and Macombe, 2013), the lack of dedicated databases for the inventory phase, the inclusion of qualitative data, and the absence of specific software for the calculation of impact assessments. Also, the criteria for indicator selection have been very variegated, giving importance to basic requirements, universal rights, actors' perceptions, the consequences of life cycle functioning, and to many other aspects. Finally, SLCA still lacks a standardized model for impact assessment, and this constitutes the strongest point of difference among the published studies: some attribute social impacts to the very nature of the life cycle or to the actions and responsibilities of actors.

This confusion is due to the fact that SLCA was developed in the technical and academic milieu of environmental LCA, where most scholars are engineers, chemists, or physicians. An attempt was made to frame and shape the study of social impacts in the same way as was done for environmental impacts. However, these methodologies have roots in different disciplines, with SLCA belonging to the realm of the social sciences. While the post-positivist paradigm dominates and is widely accepted in the study of natural phenomena, in the history of social sciences, it is difficult to recognize a dominant paradigm: in fact, the social sciences are multiparadigmatic, social phenomena are multi-layered, and many epistemological positions can be adopted without losing scientific robustness (Tacconi, 1998; Cupchik, 2001; Corbetta, 2003). These different research procedures have declined in many ways, such as the use of quantitative versus qualitative methods, which can be better defined as the debate over hard sciences versus soft sciences, i.e., the scientific procedures of the natural sciences versus those of the social and human sciences, deductive versus inductive thinking, and relativist versus realist ontologies (Phoenix et al., 2013).

The epistemological eclecticism of the social sciences is reflected in SLCA studies. SLCA literature, until now, has tended toward two main poles: a post-positivist family of paradigms and an interpretivist one. In particular, 21% of studies could be ascribed to the post-positivist paradigms group, and 78% to the interpretivist one (Iofrida et al., 2018b). The papers belonging to the first group (Table 1) had in common the search for cause-effect relationships, the use of dynamic indicators to position the very nature of the life cycle in relation to its consequences for humans, and a preference for objectivity and statistical significance. This group provided a generalizable framework that could be extended to many other situations. The papers belonging to the second group (Table 1) had in common a focus on companies' stakeholders, the use of static indicators based on impact categories retrieved from international laws on human rights, and the involvement of actors through participative methods. These studies mainly provided descriptions of current situations, without providing explanations of the consequences of the functioning of the life cycles. They showed a strong adherence to local realities.

Table 1 Differences between paradigms applied in SLCA

	Post-positivism-oriented SLCA studies	Interpretivism-oriented SLCA studies
Ontology: What is reality?	Critical realism. One objective reality.	Relativism. Many realities.
Epistemology: How do you know?	Dualism researcher-research. Reality can be explained.	Subject and object are dependent. Realities can be understood and described.

Methodologies: How do you find it out?	Mainly quantitative. Statistical analysis. Probability sampling.	Hermeneutical, dialectical. Mainly qualitative. Stakeholders' perceptions.
Goodness or quality criteria.	External validity, verifiability. Statistical confidence level.	Intersubjective agreement and reasoning reached through dialogue.
Examples	Hofstetter and Norris (2003); Weidema (2006); Feschet et al. (2013); Baumann et al. (2013); Macombe et al. (2013); Neugebauer et al. (2014) Bocoum et al. (2015); Wu et al. (2015).	Andrews et al. (2009); Benoît Norris et al. (2012); Aparcana and Salhofer (2013); Manik et al. (2013) Hosseinijou et al. (2014); Mathé (2014); Petti et al. (2016); Arcese et al. (2017).

Source: Iofrida et al. (2018:470), modified

More details on this argument are provided in the review by Iofrida et al. (2018).

2.2 The post-positivist stance of the PRF impact pathway

Few SLCA studies developed and applied impact pathways as an impact assessment methodology, until recently. For example, the Preston pathway by Feschet et al. (2013) evaluated the banana life cycle in Cameroon and its impacts on the population's health through the relationship between per capita income and life expectancy at birth. The Wilkinson pathway by Bocoum et al. (2015) evaluated the impacts of a change in a life cycle in terms of infant mortality caused by income inequality, measured using the Gini index.

The methodology proposed here starts from a post-positivist epistemological stance and looks for cause-effect relationships between the functioning of the life cycle and the social impacts on the actors directly involved, i.e., the workers, employees, and entrepreneurs. The social aspect of focus is the psychosocial health of these actors, in terms of risks measured in OR and hours of exposure. More details are provided in the next section.

According to the characteristics of post-positivist philosophies, the ontological posture assumed for this methodology was critical realism, which sees reality as unique and objective, even if not perfectly apprehendable, patterned, or predictable. Therefore, impacts were not assessed according to the feelings and opinions of stakeholders, which would represent many different worlds. From an epistemological point of view, the analysis was approached in a detached and rational way, i.e., without inserting personal beliefs into the research process (dualism researcher-research). However, different from the conception of a pure positivist paradigm, perfect detachment was not possible and some procedural choices were at the authors' discretion.

Indeed, the present methodology looks for cause-effect relationships that are validated by statistical criteria from published empirical studies that previously provided a generalizable explanation of causes by looking at their effects (through inductive processes), and whose results are therefore verifiable, confirmable, and refutable (Velmuradova, 2003). Statistical relationships were used to provide the impact pathway that linked the product life cycle to possible social impacts in a quantifiable and probabilistic way. The results are generalizable to other evaluation contexts.

The purpose of this methodological proposal is to furnish a tool to accompany management decision processing in management systems, demonstrating which effects—in terms of health—the phases of a life cycle could have on workers, and entrepreneurs. The case study to which the methodology is applied, is described in section 3.2.

The health and well-being of workers throughout their working lives is a fundamental concern and a prerequisite to achieve the Europe 2020 employment objectives in the EU (Eurofound and EU-OSHA, 2014). According to statistics from the Italian National Institution for Assurance for Working Injuries (INAIL, 2015), on average, every year, 6% of Italian workers are involved in accidents linked to working conditions (all sectors). In 2012, this entailed an expense equal to 3.6% of Italy's gross domestic product; in detail, 35 billion Euros went to reimbursement for accidents and about 6.8 billion to reimbursement for professional diseases (Bartoli, 2014). According to INAIL (2015), in the 2010–2014 period, 176,690 accidents (confirmed and reimbursed) happened in the agricultural sector (2% of them in Calabria); among all injuries that occurred in 2014 in Calabria during work (all sectors), 14% happened in the agricultural sector. This represents a huge expense for the nation in terms of money, and for farms in terms of job losses. Moreover, labor wages represent more than 50% of farms' overall costs, so it is understandable why healthy working conditions are important to the agricultural economy.

In the published SLCA studies, the impact categories concerning working conditions and workers' health have received the greatest attention and have been the most frequently analyzed and evaluated.

3. Materials and methods

3.1 Methodological phases

The PRF pathway presented here refers to life cycles' working conditions that can potentially expose people to the risk of specific psychosocial health problems; in this study, we considered all typologies of worker, such as farmers, experts, employees, and temporary workers.

This methodological choice was made for many reasons:

- workers' health is one of the main concerns of socially responsible companies;

- "workers" are the most commonly assessed stakeholder group in SLCA studies (Petti et al., 2018);

- some working conditions can negatively affect individuals' psychological and physical health, and organizations' effectiveness (WHO, 2005);

- this kind of methodology allows the further development of impact pathway assessment methods not yet fully developed in the SLCA literature; and

- the epistemological posture of this methodology is aligned with the other life cycle tools that evaluate cause-effect relationships.

The source of the impacts considered is the functioning of the life cycle, from the cradle to the farm gate (system boundary); the functional unit considered is the farm unit (one hectare). Farmers' responsibility is also taken into account: some working conditions, in fact, depend on organizational decisions (e.g., concerning the scheduling and timing of operations). These were gathered using semi-structured interviews with privileged witnesses.

As mentioned above, the present methodology was inspired by the conceptual proposals of Gasnier (2012) and Silveri et al. (2014) about the anticipation of psychosocial risk factors' effects in SLCA, which have been further developed here and applied to a case study.

Even though healthy working conditions are of the utmost importance in both European and global policies, and are a central challenge in management processes, there is no univocal definition of PRFs. According to Amiri et al. (2015: 69), "psychosocial risk factors are elements that impact employees' psychological responses to work and work conditions, potentially causing psychological health problems." For this study, the definitions by Cox and Griffith (1995) and Cox et al. (2000) were taken into account; they defined PRF as those aspects and characteristics of work planning and management that can potentially lead to physical or psychological damage.

In particular, the aim of this study is to take account of the hours spent in working conditions associated with individual operations and characterize them in terms of the intensity of their association with health troubles. Many studies can be found in the literature that quantify the associations between a wide range of working conditions and the risk of health problems as measured by OR (e.g., Karasek, 1979; Siegrist, 1996; Krause, 1997; Bovenzi, 2010; Lahelma et al., 2012; Ng et al., 2015), but few of them focused on the citrus sector; therefore, for this study, some assumptions were necessary in transposing the working conditions found in the literature to the citrus sector. All of the studies gathered measured the association between working conditions and the risk of health problems using OR; for the purposes of this study, they were classified based on the strength of the association (Figure 1).

Fig. 1 The statistical meaning of the odds ratio

		Dependent Variable		
		disease	*no disease*	
Independent Variable	*exposure*	***a***	***b***	a + b total exposed
	no exposure	***c***	***d***	c + d total not exposed
		a + c total cases	b + d total controls	

Source: Bottarelli and Ostanello (2011); Iofrida (2016:79)

The OR is a statistical measure of the intensity of the association between two variables, and it can be defined, in the case of people's exposure to disease risk factors, as the ratio between the odds of exposure for people with a disease (a/b) and the odds of exposure for healthy people (c/d), or with the following formula:

$$\text{ODDS RATIO} = \frac{a \times d}{b \times c}$$

eq (1)

It represents the odds that the disease (or disorder) will occur given a particular exposure, compared to the odds of it occurring without that exposure (Szumilas, 2010). According to Bottarelli and Ostanello (2011), it is a retrospective analysis of a phenomenon, expressed with a non-dimensional value, and it can assume values between 0 and $+\infty$. A value of 1 indicates that there is no association between disease and exposure, while values > 1 indicate a positive association (the risk factor can provoke the disease). Higher values show a stronger association between exposure and disease. The OR is not *per se* a measure of risk, because it refers to the probability of already having a disease; but, if it is assumed that the average duration of a disease is the same in exposed and non-exposed people, then the OR is a good measure of relative risk (Bottarelli and Ostanello, 2011). Therefore, the OR "can also be used to determine whether a particular exposure is a risk factor for a particular outcome, and to compare the magnitude of various risk factors for that outcome" (Szumilas, 2010: 227).

To test the efficacy of this PRF impact pathway methodology, it was applied to a specific case study—two citrus growing scenarios in Southern Italy: the agricultural life cycle phases of industrial oranges and of clementines for fresh consumption in two average fictitious farms located in the Gioia Tauro Plain (province of Reggio Calabria), with the same agricultural surface (3 ha), time boundary (40 years), and farming typology (conventional, not organic). These characteristics are representative of the local reality and are common to most farms. This area of production was chosen for many reasons. It is one of the main areas of citrus production in the Calabria region, it is where most of the processing plants are located, and it is well known for social issues linked to the immigration of foreign seasonal workers during the harvest period.

An inventory sheet for each phase of the life cycle was prepared, listing the hours of work that were necessary (average) for each task (planting, irrigation, pruning, tillage, pesticide treatments, harvesting, etc.). Then, each task was related to one or more working condition (noise, vibration, stress, cold temperatures, high physical demand, use of chemicals, and so on) (Callea et al., 2014). A literature review was conducted to gather scientific studies that correlated these conditions with psychosocial risks to obtain the PRF matrix (see Supplemental Material 1).

Average data were considered for both scenarios according to the grey literature on Calabrian citriculture and internal databases from previous studies on the same sector (Strano et al., 2013); the data were triangulated with the results from direct surveys so as to accurately represent farms in the area. The choice of these two scenarios was based on the current situation in Calabrian citriculture: due to a decrease in financial assistance and the strong position of non-EU countries (Brazil, above all), industrial oranges are declining in favor of cultivars suitable for fresh consumption, especially clementines.

The methodology (Fig. 2) was divided into the following steps:

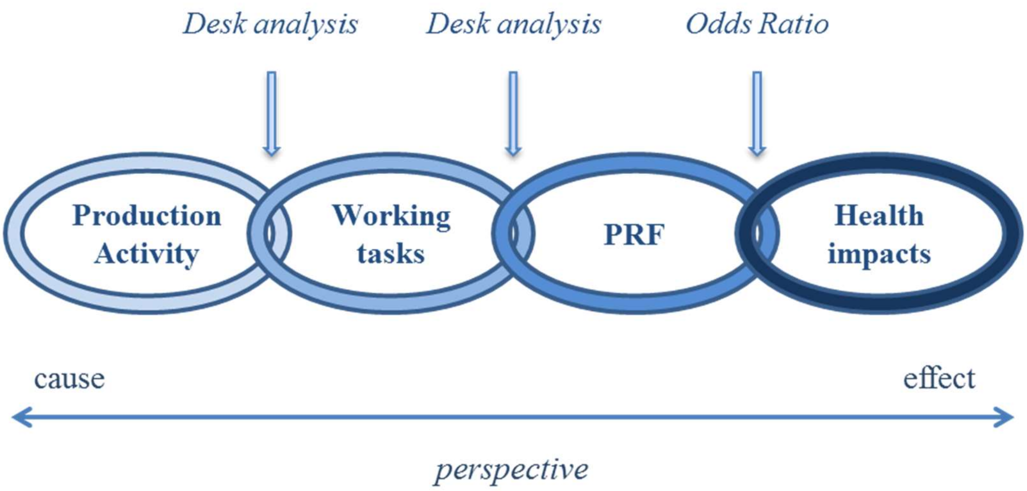
1. An inventory analysis of work hours for each task (such as planting, pruning, harvesting, phytoiatric treatments, etc.) and agricultural phase, classifying the work typology (manual, mechanical, etc.).

2. A literature review of studies on particular working conditions that entail exposure to psychosocial risk factors. Each statistical association was classified according to its intensity.

3. The construction of a PSR matrix, where every working condition that occurred in the scenarios was linked, through the previous statistical relationship, to a physical or psychosocial disease.

4. The assessment of social impacts through the quantification of work hours when workers are potentially exposed to one or more diseases (physical or psychological).

Fig. 2 PRF impact pathway methodology



Source: Iofrida (2016:78)

The inventory analysis was conducted according to the available grey literature, considering average data and taking into account the knowledge of local experts in the field of study. The inventory consisted of 12 sheets covering each life cycle phase and each scenario, task, duration, and work typology.

The literature review was conducted using the principal scientific research databases, such as Scopus and ScienceDirect. The keywords used for the queries related to particular working conditions (e.g., vibrations, noise, cold temperature, etc.) associated with the terms "odds ratio," "psychosocial risks," and "cohort study." Once the studies had been reviewed, the ORs were classified according to the degree of intensity.

The total number of hours of exposure per psychosocial risk were then calculated and characterized according to the intensity of the association. Some assumptions were necessary, e.g., when a work condition was linked to several psychosocial risks at the same time, the corresponding work hours were counted more times. Not all of the literature analyzed referred specifically to citrus cultivation; therefore, situations were assumed to be similar. Also, crossed effects were not taken into account. Despite these assumptions, the scenario comparison did not lose its meaning.

3.2 The field of application: Citrus growing in the Calabria region

Citriculture is an important part of the Italian economy, representing 3% of the nation's agricultural gross saleable production (Scuderi, 2008). According to the last agricultural census by ISTAT (2012), the overall surface area cultivated with citrus fruits was approx. 128,921.07 hectares in 2010, mostly concentrated in the south, especially Sicily (as the first national producer) and Calabria, which together represent 82% of national citrus production. In detail, Sicily is the principal producer of oranges and lemons (65% and 89% of national production, respectively), while Calabria is the main producer of clementines (60% of national production) and small citruses (61% of national production, especially bergamot and cedars).

Actually, in Calabria, citrus growing is the second-most important field in terms of surface area, with a total of 35,185.3 hectares in 2010, as shown in Table 1 (ISTAT, 2012; Iofrida, 2016). Furthermore, 9,005 ha (about 25% of the total citrus growing area) are farmed according to the standards of organic farming practices (De Luca et al., 2014).

Table 2 Citriculture surfaces and farms in the five Calabrian provinces (2010)

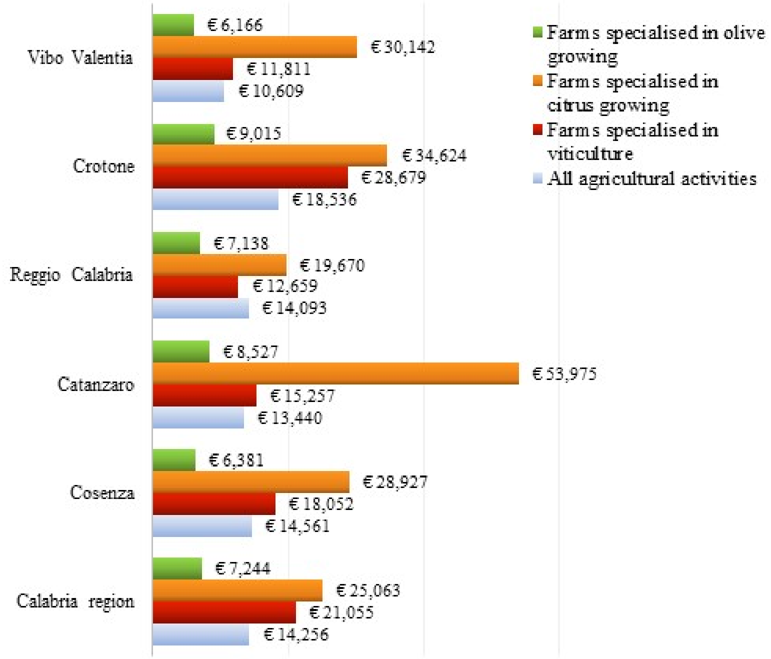
	Total citruses	**Orange**	**Clementine and hybrids**	**Other citruses**	**Mandarin**	**Lemon**
Surfaces (ha)						
Italy	128,921.1	79,551	20,916.3	4,548.3	8,481	15,424.5
Calabria	35,185.3	16,257.74	12,530.83	2,792.27	2,984.77	619.69
Cosenza	13,229.77	3,269.89	8,664.31	253.36	695.39	346.82
Catanzaro	3,523.52	1,982.44	853.06	231.45	402.97	53.6
Reggio C.	14,853.71	8,801.53	2,224.84	2,134.98	1,505.9	186.46
Crotone	1,408.33	1,036.19	153	50.69	161.49	6.96
Vibo V.	2,169.97	1,167.69	635.62	121.79	219.02	25.85
Farms (n.)						
Italy	79,589	57,724	12,996	5,308	15,083	19,389
Calabria	20,974	14,148	6,002	2,158	3,823	1,354
Cosenza	6,987	3,321	3,889	373	1,037	663
Catanzaro	1,552	1,317	266	102	487	74
Reggio C.	10,306	7,711	1,493	1,525	1,827	459
Crotone	862	758	63	64	159	32

Vibo V.	1,267	1,041	291	94	313	126

Source: ISTAT (2012); Iofrida (2016:71)

However, in terms of average standard production (Fig. 3), expressed in € farm^{-1} year^{-1} and calculated as the total value of standard production (ISTAT, 2012) divided by the number of farms, citrus growing shows better economic performance than other agricultural sectors (Iofrida, 2016). On the land used to grow citrus, 12,530.8 hectares of clementines and their hybrids are grown, confirming the importance of this product at the regional and national levels (Table 2).

Fig. 3 Average standard production (€ farm^{-1} year^{-1})



Source: Iofrida (2016:72)

In Calabria, citriculture is mainly concentrated in the plains near the coast, especially in the provinces of Cosenza and Reggio Calabria. In Sibari Plain, in the province of Cosenza, about 12,381.35 hectares are dedicated to citrus. This area specializes in the production of clementines: about 70% of the region's production is concentrated there, and most of the clementines (795.4 in Calabria) are labelled with the Protected Geographical Indication, as regulated by the Commission Regulation n. 2325/97 (De Luca et al., 2015a). Gioia Tauro Plain's surface, in the province of Reggio Calabria, is occupied by 11,201.778 hectares of citrus; here, citriculture is focused on oranges, half of which were destined for industrial processing to produce juices, until the last decade (De Blasi and De Boni, 2001).

European agricultural policies have always had repercussions for Calabrian agriculture, due to the sector's dependency on communitarian grants and funds. In the 1960s, common market organizations (COMs) were created to regulate and orientate the fruit and vegetable markets (Reg. EEC n. 159/66), and the first so-called "Citruses Plan[1]," funded by the European Community (Reg. EEC n. 2511/69), came into effect. The aim of these interventions, both at the European and national levels, was to furnish temporary help for structural modernization and the conversion of old cultivars into new ones based on market fluctuations. They also provided grants for industrial processing, the opening of markets, removing phytosanitary barriers, forming agreements with non-EU countries, etc. However, as highlighted by Scuderi (2008), the situation evolved differently from the original intent: the funding changed from temporary to permanent and, after that, citriculture—especially in Calabria—received significant economic resources. These were devoted to improving farming techniques to increase yield (to the detriment of quality), and also to provide the assurance of an industrial way out (or at least, set-aside procedures); this mechanism ensured fair incomes for farmers without assuming market risks.

Then, the European reform of the COM of fruit and vegetables (Reg. EC n. 1182/2007) came into force without any transitional period. This entailed a reduction in citrus production to 2,691.2 thousand tons in 2008/9, (926,000 tons less than the previous year), of which 856,000 tons was oranges (92%) (Source: CLAM data, courtesy of CIRAD Montpellier); moreover, a decrease occurred in the number of producers associations that gathered products both for fresh consumption and for processing, thus guaranteeing the existence of an end market.

This further damaged the already weak Calabrian citriculture and its supply chain. Indeed, according to a study by De Blasi and De Boni (2001), the structure of citrus-growing in the early 2000s lacked profitability and competitiveness and was oriented more toward quantity than quality (more in Calabria than in Sicily), which was intensified by the weak bargaining power available to producers when dealing with the processing industries. Moreover, in Calabria, the changes introduced by the reform worsened an already delicate social situation. For decades, many well-known social issues have been linked to Calabrian agriculture, especially concerning harvesting and the involvement of illegal foreign workers.

This migration phenomenon has been the subject of many local and national reports (CNEL, 2002; Medici senza Frontiere, 2008; Cicerchia and Pallara, 2009; Osservatorio Placido Rizzotto, 2012; Dedalus, 2012). Two principal typologies of migration flow gain interest every year in the region: foreign migrants who come for the first time from their countries of origin (principally sub-Saharan Africa), and foreign migrants who travel all around the country following different harvest periods (e.g., in Apulia during summer for the tomato harvest) and then return to Calabria for citrus harvesting during winter. Seasonal migration is concentrated in the main citrus growing areas, the Plain of Sibari and the Plain of Gioia Tauro, in particular. Following a report by Osservatorio Placido Rizzotto (2012), the main social issues concerning migrants are work and housing

[1] The "Citruses Plans" (Piani Agrumi) are Italian programming documents for mid-term periods promoted by the Ministry of Agricultural, Food and Forestry Policies, funded by the European Union, aimed at boosting innovation and re-organization of national citriculture.

exploitation, irregular employment, fraud and deceit (e.g., non-paid wages and outstanding labor contracts), illegal recruitment of day laborers, and the requisition of documents.

When the economic effectiveness of a productive system decreases, often, the solution is assumed to be cutting costs, and labor is the main target. Therefore, the decrease in the economic performance of the citrus sector had direct consequences on the quantity and quality of work available, in terms of organization and management.

4. Results

The first phase (inventory) started with the definition of each cultural phase, namely: Plantation (y_0), Growing Phase (y_{1-4}), Increasing Production (y_{5-8}), Constant Production (y_{9-32}), Decreasing Production (y_{33-40}), and Disposal (y_{40}). Their study of the agronomic literature, and surveys of representative farms, allowed the authors to conduct the life cycle inventory—i.e., two technical sheets (one per scenario)—with each of them reporting on the agricultural operations specific to each phase. To go into more detail,

- the characteristics of the orchard, e.g., planting density (6x5 m for industrial oranges; 5x4 for clementines), number of plants (1,000 orange trees; 1,500 clementine trees) that were constant for all phases; average yield (300 q of oranges and 350 q of clementines during the constant production phase), duration of the phase, residual biomass per year;
- fertilization and soil management, e.g., spreading fertilizers (N, P, K), harrowing, etc.
- pruning, i.e., shaping interventions or wood cutting, biomass removal (charge, transportation, and discharge);
- irrigation, i.e., watering and maintenance of installations (no particular working conditions were found to be significant for this task);
- pest and disease control, e.g., spraying fungicides, insecticides;
- harvesting, i.e., manual harvesting, crate charge and discharge, transportation; and
- organization and management, e.g., organization of tasks, intellectual work, bureaucracy, agronomic consultancy.

In the second phase, a literature search was conducted to gather scientific studies on the association between the working conditions detected and diseases. Most of the studies were retrieved from medical journals. The search focused on papers that quantified the correlations in terms of OR (Fig. 1).

The OR is a statistical measure of the intensity of the association between two variables. It can be expressed, in the case of people exposed to risk factors for disease, as the ratio between the odds of exposure in sick people (a/b) and the odds of exposure in healthy people (c/d), or as the following formula:

$$\text{ODDS RATIO} = \frac{a \times d}{b \times c}$$

eq (1)

It represents the odds that an outcome will occur given a particular exposure, compared to the odds of the outcome occurring in the absence of that exposure (Szumilas, 2010). As affirmed by Bottarelli and Ostanello (2011), it is a retrospective analysis of a phenomenon, a non-dimensional value, and it can assume values between 0 and + ∞. A value of 1 indicates that there is no association between disease and exposure, while values < 1 indicate a negative association (the risk factor can protect one from disease). The higher the value, the stronger the association between exposure and outcome. However, to validate the consistency of a cause-effect relationship, a statistical significance test should be conducted (as was done in the studies that were reviewed). Furthermore, the OR is not *per se* a measure of risk because it refers to the probability of already having a disease; but, if it is assumed that the average duration of a disease is the same in exposed and non-exposed people, then the OR is a good measure of the relative risk.

All of the ORs gathered from the literature search that explained some relations between the working conditions of the two scenarios and some typology of disease were used to build and complete the PRF matrix (see Supplemental Material 1). Few of the studies referred to agricultural working situations; therefore, for this study, it was assumed that they were applicable to the case study. Furthermore, as this study makes a comparison between two scenarios, if there was a margin of error, it was repeated in both scenarios. For example, according to the study by Bovenzi and Betta (1994), professional drivers are exposed to vibrations and are forced to assume certain postures, and therefore they are exposed to the risk of sciatic pain with an OR of 3.9 (16–25 driving years). This result was applied in this study in reference to tractor drivers for agricultural operations.

The ORs were classified in accordance with Bottarelli and Ostanello (2011), as shown in Table 3.

Table 3 Odds ratio classifications

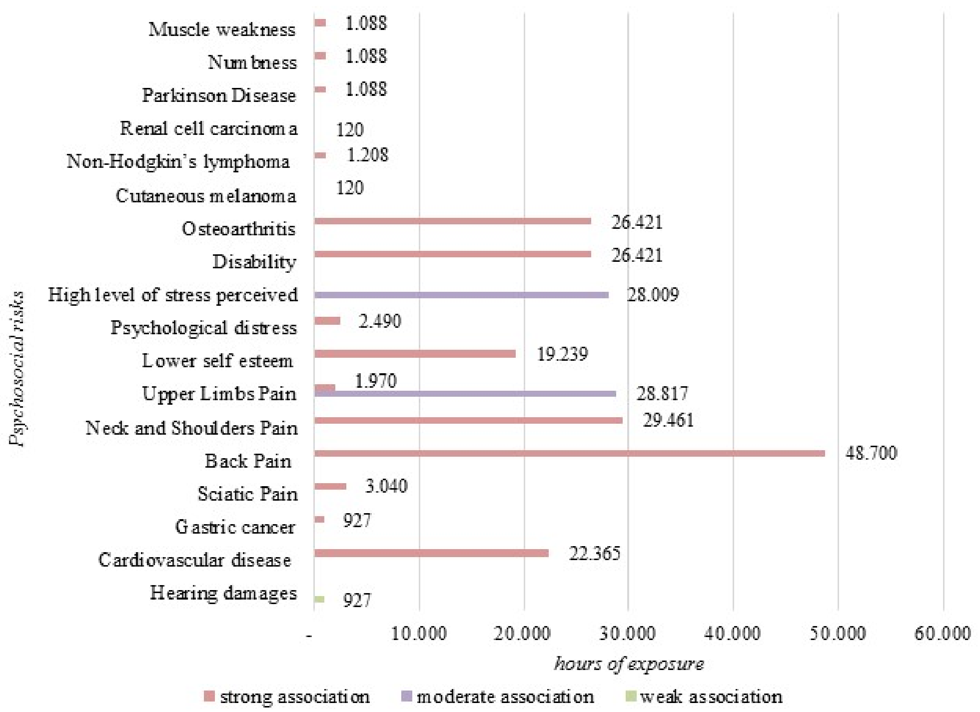
Negative association	**No association**	**Weak**	**Moderate**	**Strong**	**Very strong**
0<OR<1	OR=1	1<OR<1.3	1.3<OR<1.7	1.7<OR<8	OR>8

Source: Bottarelli and Ostanello (2011); Iofrida (2016:80)

Finally, total hours for each working condition were grouped; when a situation exposed someone to more PRFs, it was counted twice, i.e., once per risk factor. This study did not take into account interactions between more PRFs, because no pertinent references were found. Nevertheless, it would be an interesting direction for future research, as would the inclusion of more stakeholder typologies, such as consumers and local communities.

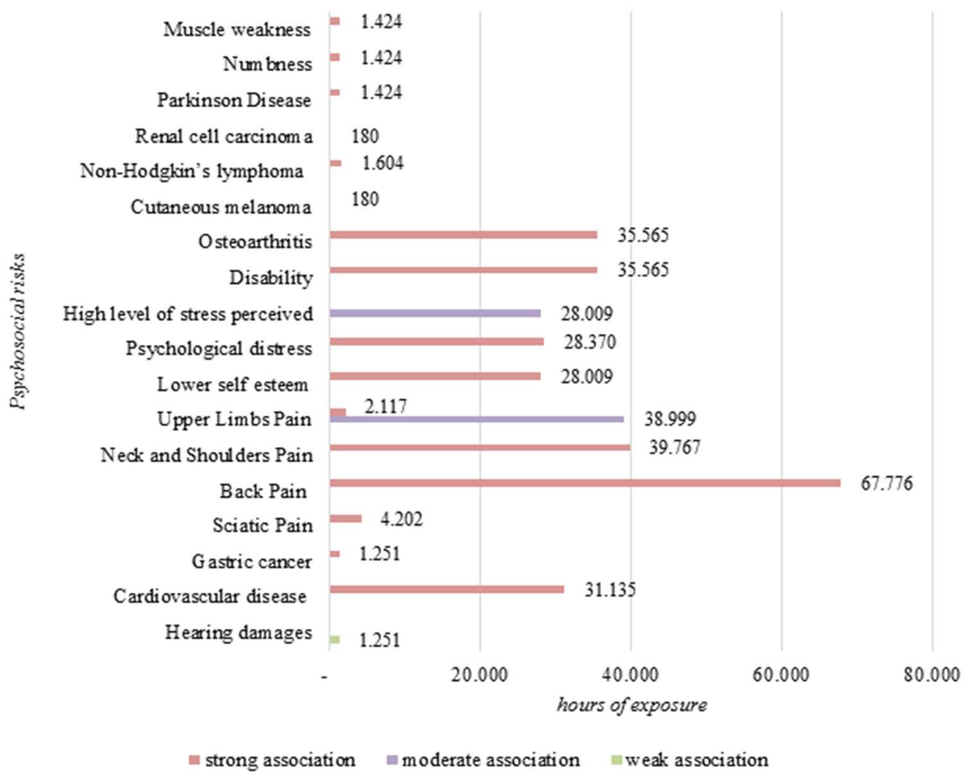
Social impacts were quantified and then characterized based on Table 3. The results showed that the full life cycle of industrial oranges involved about 43,088 hours of work, against the 54,110 hours of the clementine life cycle (Figures 4 and 5). The difference was mainly due to the yield sizes (lower for oranges) and the duration of the harvesting phase, which is longer for clementines because they are destined for fresh consumption, so workers have to pay attention to avoid damaging the fruits.

Fig. 4 PRF impact pathway for the life cycle of industrial oranges



From a qualitative point of view, and for the same reasons as mentioned above, the clementine life cycle potentially exposes stakeholders to the risk of back pain for 67,776 hours, with a strong association (Bovenzi and Betta, 1994; Domenighetti et al., 1999; Raeisi et al., 2014), against the 48,700 hours for the orange life cycle. In general, musculoskeletal disorders are of the highest concern for both products, followed by osteoarthritis (Rossignol et al., 2005), disability (Lahelma, 2012), and cardiovascular diseases (Siegrist, 1996). For all impact categories, the orange life cycle showed the best performance, mainly due to the shorter duration of each single operation. The authors verified the results while also considering the different yield sizes: during the constant production phase, 350 q/ha of clementines are produced against 300 q/ha of oranges. The ranking does not change if the functional unit considered is the quintal. For example, on average, 1 q of clementines exposes people to the risk of back pain for 2.01 hours, while for oranges it is 1.68 hours.

Fig. 5 PRF impact pathway of the clementine life cycle



Regarding the impact categories, some considerations are necessary. Even if impact categories such as non-Hodgkin's lymphoma, cutaneous melanoma, Parkinson's disease, and gastric cancer showed a lower risk of exposure in both life cycles, they are diseases with fatal consequences. This suggests that, for the future development of this methodology, we must take this qualitative difference into account, as well as the impacts on other stakeholder typologies. Deeper research on the psychosocial risks and ORs relevant to agriculture would be an asset, and a comparison between farming techniques (e.g., organic versus conventional) would be interesting too and might help move farming toward more sustainable management patterns.

5. Discussion and conclusion

The methodology applied in this study, i.e., the PRF impact pathway, was framed in the realm of post-positivist paradigms, and allowed the authors to quantify cause-effect relationships between citruses' life cycles and their potential psychosocial impacts on affected workers. The ontological posture assumed was critical realism, which had the aim of explaining the reality, but did involve some assumptions and did not entail disregarding stakeholders' opinions. It allowed for an objective assessment of the differences between two productive scenarios, and the methodology is generalizable and applicable to other contexts. It was limited to a group of affected actors (workers), but it will be possible to extend the study to other typologies of affected actor. The further development of this methodology is possible: more impact categories and stakeholder groups could be included in the assessment, enlarging, for example, the scope of the analysis to consumers, residents, actors in the supply chain, and many others.

The principal strength of this methodology lies in the possibility of predicting the consequences of organizational or structural changes in the life cycle. Private and public actors can find in the PRF matrix a valuable instrument for supporting their decisions, both at the farm level and in the context of policy making. Furthermore, this methodology allows for social evaluations that are epistemologically in line with the environmental Life Cycle Assessment (Iofrida et al., 2018a), based on cause-effect relationships between inventories of matter and energy flows and impact categories. This will facilitate the development and improvement of Life Cycle Sustainability Assessment (LCSA), currently intended by most as a harmonization between eLCA, LCC, and SLCA (De Luca et al., 2018). The impact pathway methodologies well serve this aim of unification, being framed in the same paradigmatic perspective.

A limitation of this study is that the composition of the PRF matrix depends on the availability of previous scientific studies examining associations in terms of OR, and it is necessary to make assumptions in cases where these studies focus on different working contexts.

It is of utmost importance, when a methodological procedure is undertaken, to answer some epistemological questions, not only to improve the scientific grounding of SLCA (Grubert, 2018), but especially when social impacts are the focus and it is necessary to merge methods together, as it is in LCSA. In fact, one of the unsolved problems with LCSA is the alignment of LCA, LCC, and SLCA in one assessment; as a result, in most cases, the final results of separate analyses are merged, balanced, or just compared (De Luca et al., 2017). Life Cycle Assessment was the first tool to be developed with the precise aim of analyzing cause-effect relationships and explaining how a product's life cycle can have one or more impacts. SLCA is considered to be the translation of LCA into the realm of social phenomena, but this transposition is not obvious due to the very different nature of social impacts. In fact, most of the applications available in the scientific literature involve methods that do not allow the prediction of effects and do not explain causes, but rather provide a description of the current situation (Iofrida et al., 2018b).

The impact pathway methodologies, therefore, deserve to be placed epistemologically in line with the other life cycle tools.

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	Psychosocial Risk Factors (working conditions)	Hearing damages	Cardiovascular disease	Gastric cancer	Metabolic syndrome	MSDs				Lower self esteem	Psychological distress	High level of stress perceived	Disability	Osteoarthritis	Cutaneous melanoma	Non-Hodgkin's lymphoma	Renal cell carcinoma	Parkinson Disease	Numbness	Muscle weakness
						Sciatic Pain	Back Pain	Neck and Shoulders	Upper Limbs											
A	Noise								Often/very often 1,58 - men (Stock et al., 2006)											
B	Total Boby Vibrations (tractor driving)					3,9 (Bovenzi and Betta, 1994)	1,83 (Bovenzi and Betta, 1994)	2,07 - men (Stock et al., 2006)												
C	Vibration manual tools(chain saw)								2,44 (Stock et al., 2006)											
D	High physical demand and heavy manual labour						LBDs 4,4 (Raeisi et al. 2014)	2,1 (Stock et al. 2006)	1,66 men (Stock et al.)				2,02 (Lahelma, 2012)	2,8 in agriculture (Rossignol et al., 2005)						
E	Temporary employment						2,00 (Domenighetti et al 1999)			2,9 (Domenighetti et al., 1999)		1,6 (Domenighetti et al, 1999)								
G	Citrus chemicals exposure (fertilizers and pesticides	1,19 (Crawford et al. 2008)		2,88 (Mills and Yang 2006)																
H	Long working hours >8 to 9 hours/day				Adjusted: 8-9 hours/day 1,66; (Kobayashi et al., 2012)															
I	Work pressure		3,45 (Siegrist 1996)																	
L	Effort-reward imbalance		6,15 (Siegrist 1996)																	
M	High psychological demand (quantity of work, intellectual requirements, time constraints)										2,04 (Bourbonnais, 1996)									
N	Organophosphates insecticides exposure															2,11 (Fritschi et al., 2005)		1,8 (men) (Elbaz et al., 2009)	3,45 (Hongsibsong et al., 2017)	3,79 (Hongsibsong et al., 2017)
O	Glyphosate and sun exposure														4,68 (Fortes et al., 2016)	3,28 (Fritschi et al., 2005)	1,6 (Hu et al., 2002)			

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