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Editorial

This issue includes some selected papers presented at the 53rd annual Conference of the Italian Society of Agricultural Economics (SIDEA), held in San Michele all'Adige/Bolzano on the 22th-24th of September 2016.

The theme of the Conference was "The future of agriculture between globalization and local markets". The choice of this theme aimed to stimulate a scientific debate on the future of agriculture which is marked by the dualism of opening global markets and the growing demand for local products linked to the territory and traditions. The dichotomy of liberalism versus localism involves multiple challenges requiring appropriate answers to guarantee a sustainable path of local and global agricultural development. It will also require policy changes with implications for all actors along the supply chain and for agriculture's role in economic, social and environmental terms.

The 53rd SIDEA annual Conference hosted the scientific debate on selected subjects by means of plenary and parallel sessions.

The parallel sessions were focused on several topics including: International trade regulation and market organization; Market structure of local and global demand; New frontiers of organizational development, Cooperation and networking; Innovations towards sustainable production and market development; Sustainable consumption patterns and Agricultural policies beyond 2020.

The papers presented at the Conference were selected on the basis of a peer review process developed by means of a double blind review of each submitted paper. The reviewing process has been realized with the support of many reviewers that we would like to thank for their contribution. Comments and evaluations from the reviewers were sent back to the Authors, inviting them to revise the papers according to the suggestions received. The final revised papers were considered by the Conference Program Committee for publication on the SIDEA Journals or on the Conference Proceedings.

At the end of this process, the 53rd SIDEA Conference Program Committee and the Editorial Team of the "Rivista di Economia Agraria/Italian Review of Agricultural Economics" selected some papers for publication on this Journal based on the consistency between the topics addressed in the papers and the aims of the Review. The five papers selected were finally subjected to the standard peer review process before being accepted for publication on the Journal.

Papers presented in this issue deal with some of the most relevant themes addressed in the Conference and contribute to the debate under both a meth-

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odological and empirical points of view. Indeed, a quite visible thread connecting the five papers is their attention towards the environmental, economic and social challenges and perspectives related to the agricultural sector that will strong affect its evolution in the above dichotomy.

A first topic refers to the food waste issue that is addressed in two papers contributed within a project supported by the Italian Ministry for the Environment.

The paper by Tua *et al.* reports on "*The REDUCE project: definition of a methodology for quantifying food waste by means of targeted waste composition analysis*". A standard methodology for the quantification and classification of food waste is a prerequisite that may contribute to raise awareness among citizens as well as to support the definition and the monitoring of specific preventive measures. A classification based on several criteria (by subcategories of avoidable, possibly avoidable and unavoidable waste; by product type; by packaging materials) was tested on representative some samples of residual waste thanks to the cooperation of the National Consortium for Packaging waste (CONAI). Preliminary results of the study were useful in order to quantify the food waste fraction in residual waste at some incineration plants and to highlight the weight of avoidable food waste. Furthermore, the classification criteria have been applied to measure the composition of the food waste fraction revealing areas of future in-depth analysis and difficulties associated to the unclassifiable waste fraction.

In the context of the REDUCE Project lies the second paper of Boschini *et al.* that reports a "*Preliminary assessment of a methodology for determining food waste in primary school canteens*". Italian data on food waste at this stage of the food chain is scarce. They are often qualitative data derived from researches conducted on large samples or quantitative data obtained from a limited number of schools. A case study implemented in a primary school involving kitchen employees, teachers and pupils, was reported in the paper allowing to measure the percentages of total food waste of non-consumed and non-served food per each daily meal offered in the canteen. From a methodological perspective, the case study revealed the feasibility of implementing a data gathering on food waste in school canteens and the importance of actively involving all concerned actors.

The paper "*Social life cycle assessment for agricultural sustainability: comparison of two methodological proposal in a paradigmatic perspective*" by Iofrida *et al.* addresses the social dimension of sustainability, a very interesting and topical issue. A review of studies dealing with social impacts in a life cycle perspective was carried out and two opposite paradigms (post-positivism or interpretivism oriented) were detailed in their strength and weaknesses points. The two methodological proposals setting up from the above paradigms were applied to the citrus growing sector in Calabria and compared in terms of research process and typology of insights. The study highlighted the possible consequences of different paradigmatic stances in Social Life Cycle Assessment studies (in terms of procedures, assumptions, methodological choices, study purposes) and provided some useful suggestions in steering the choice of the most appropriate methodology.

A focus on the social dimension together with the environmental perspective is presented in the paper of Prete and co-authors that deals with "*Well-being and rurality: a spatial tool for rural development programs evaluation*". The paper aimed to realize a spatial decision support tool able to define a Quality of Life (QoL) index at local level. The QoL index was based on the opportunities provided to populations (living conditions, health care services, education, work-life balance, environmental health and protection) and on indicators grouped in thematic areas and further categorised in relevant dimensions (economic, social and environmental). The QoL index was measured for the municipalities of Basilicata region and compared with the index of rurality. Results revealed a negative correlation between the two indexes and drew attention to the weaknesses of the smallest and rural areas compared with other territories. The proposed methodologies might be usefully applied in both ex ante and ex post assessment of rural development policies.

Within the recent European debate about a bioeconomy strategy, the paper by Drejerska and Gołębiewski aims to measure "*The role of Poland's primary sector in the development of the country's bioeconomy*" for the periods 2004-2006 and 2010-2012. Authors analysed and quantified the national bioeconomy potential at a low level of territorial scale by means of a spatial autocorrelation analysis applied to the share of the primary sector in the gross value added. The results showed that biomass production in Poland differs considerably by region, justifying an interregional approach in strategic and policy planning in order to facilitate the development of the bioeconomy in the Country.

In our opinion, these five papers show the contribution of the SIDEA in discussing such topics, propose approaches, and show empirical findings that will fuel the future scientific and political debate. The papers in this issue provide useful insights regarding some of the main issues the farm sector is currently facing and that will shape its evolving role between globalization and future markets.

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Social Life Cycle Assessment for agricultural sustainability: comparison of two methodological proposals in a paradigmatic perspective

The purpose of the present research is to provide an explanation about the diversity of methodological approaches proposed until today for SLCA, tracking down its roots in the cultural and scientific heritage of social sciences, especially sociology and management sciences. This will help to shift the current methodological debate in SLCA to an epistemological level, through a critical review about the underlying paradigms that have been applied in SLCA literature until now. Secondly, the research highlights the possible consequences of different paradigmatic stances in SLCA by means of the application, to an important agricultural sector in Calabria, of two different methodological proposals set up from opposite paradigms (post-positivism and interpretivism) and compared in terms of research process and typology of insights.

1. Introduction

Social Life Cycle Assessment (SLCA) is the latest tool developed in the conceptual framework of Life Cycle Thinking (LCT) and is devoted to the assessment of social impacts generated by the life cycle of a product or service (Zamagni *et al.*, 2016). The methodology is not standardised as it is for its environmental and economic peers, i.e. Life Cycle Assessment (eLCA or LCA) and Life Cycle Costing (LCC). Indeed, there is neither consensus about the impact assessment methods, nor clarity on the underlying social sustainability concepts. Consequently, many different methodologies have been proposed, whose objectives payed attention to different aspects (Jørgensen, 2013; Iofrida *et al.*, 2016), such as:

- the social performances (UNEP-SETAC, 2009; Franze and Ciroth, 2011; Martìnez-Blanco *et al.*, 2014; Mattioda *et al.*, 2015; Hannouf and Assefa, 2017);
- the presence of hot-spots (Benoît-Norris *et al.*, 2012; Dong and Ng, 2015);
- the consequences of a change in life cycle (Feschet *et al.*, 2013; Bocoum *et al.*, 2015);
- externalities (Swarr, 2009);

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- and the stakeholders involvement (Mathé, 2014; De Luca *et al.*, 2015b).

Even in the definition of SLCA there is no consensus; indeed it has been defined at the same time as: a a systematic process (Benoît *et al.,* 2010), a framework (Benoît-Norris, 2012), a technique (Benoît Norris *et al.*, 2012; Ugaya *et al.*, 2011), a technology (Fan *et al.*, 2015), a method – not a technique – (Macombe *et al.*, 2011), a phenomenon (Benoît-Norris and Reverét, 2015).

This plethora of methodological proposals in SLCA is probably due to its development in the engineering milieu of eLCA, which led practitioners to deal with social impacts in the same way they were used to do with environmental impacts in eLCA (Iofrida *et al.*, 2016). However, the inherent nature of environmental and social impacts can be strongly different: in fact, SLCA and eLCA have their roots in different fields of study and disciplines (O'Brien *et al.*, 1996; Iofrida *et al.*, 2016). While environmental phenomena are the object of study of natural sciences, social phenomena are the object of study of sociology, that not only has a variety of methodological approaches to research, but also it is considered a multiparadigmatic science (Corbetta, 2003), in which even many realities can exist according to the perception of stakeholders. According to Iofrida *et al.* (2016), this implicitly had consequences in SLCA too.

Concerning the main field of application of SLCA studies, according to a recent review by Petti *et al.* (2016), manufacturing and agriculture are the most assessed sectors. For more information about the SLCA applications in agriculture, see for example De Luca *et al.* (2015a) and Gulisano *et al.* (2018). The typology of actors concerned can vary according to the typology of study, such as a population (Feschet *et al.*, 2013; Bocoum *et al.*, 2015), children (Arvidsson *et al.*, 2015), but workers are the most assessed category above all. UNEP-SETAC (2009) Guidelines proposed 5 possible stakeholder groups to evaluate, namely workers, local community, society, consumers and value chain actors. However, no information is provided about how to clearly distinguish them, and most of the procedural choices remains at discretion of the researcher.

In SLCA literature, it is difficult to outline a general common procedure for the assessment of social impacts. Following De Luca *et al.* (2015a), the different methodologies can be distinguished according to which are recognised as sources of social impacts, e.g. the very nature of processes, actors' behaviours, variations of capitals, stakeholders' desiderata. The "impact pathway methodology" is epistemologically similar to eLCA (Weidema, 2006; Norris, 2006; Feschet *et al.*, 2013; Macombe *et al.*, 2013; Neugebauer *et al.*, 2014; Bocoum *et al.*, 2015). This typology of impact assessment procedure evaluates the consequences of a change in the life cycle of a product or service, explained in terms of cause-effect relationships (Iofrida *et al.*, 2016). The principal aim of this methodology is to provide explanations and generalizable findings.

UNEP-SETAC (2009; 2013) published the "Guidelines for SLCA" and the Methodological Sheets to furnish a practical framework to assess performances of a system at a current status. The Guidelines boosted the publishing on SLCA themes, especially applicative works. In the Guidelines it is suggested to follow the same general structure of eLCA (ISO, 2006a; 2006b), i.e. the four phases of "goal and scope", "life cycle inventory", "life cycle impact assessment", "interpretation of results". They provide an orientative list of indicators inspired to international laws and norms on human rights. The assessment framework in the Guidelines is mainly inspired to the above-mentioned Corporate Social Responsibility (CSR), therefore, the applications published according to this framework mostly paid attention to the social performances of companies in terms of companies' behaviours.

The "capabilities or capacities approach" (Reitinger *et al.*, 2011) is inspired to the work by Sen (2000), and takes into account the capabilities (set of alternative lives) that people can choose, and it is focused on what people consider to be important for their lives (Iofrida *et al.*, 2016). Within this framework, Garrabé and Feschet (2013) proposed a model to assess the variations of capital stocks (human, technical, financial, social and institutional capitals) due to the functioning of the life cycle and their influence on people's capacities (Iofrida *et al.*, 2016).

Finally, some other approaches have put more attention on what is important for stakeholders (intended as those actors interested by the functioning of the life cycle) and how to involve them in the assessment (Mathé, 2014; De Luca *et al.*, 2015b).

The reason of this methodological diversity is here tracked down in the scientific and cultural heritage of the disciplines linked to SLCA, i.e. sociology and management science. Indeed, the object of evaluation of SLCA are social impacts (social phenomena), that are also the object of study of sociology; furthermore, LCT tools are devoted to the support of decision-making process in management practices (De Luca *et al.*, 2015a). A brief review highlighted which paradigms have been applied in SLCA literature. Then, two methodological proposals from opposite paradigms have been applied to the same case study, i.e. citriculture in Calabria (Italy), and compared in terms of research processes and typology of insigths.

2. The scientific roots of SLCA and social research paradigms

2.1 The disciplinary fields of SLCA

The nature of the impacts under assessment are different in SLCA from eLCA, and these methodologies have their roots in different fields of study and disciplines (O'Brien *et al.* 1996). Both methodologies have been conceived to solve management issues towards more sustainable practices. However, the impacts assessed in eLCA are typically the object of study of disciplines such as biology, physics, chemistry, etc., that belong to the realm of natural sciences (also called "hard sciences"); on the contrary, social impacts are the object of study of sociology. Both sociology and management science belong to the realm of social sciences and are therefore *multiparadigmatic* sciences characterized by an epistemological eclecticism, being social phenomena multilayered events (Corbetta, 2003). Indeed, while the post-positivism philosophy dominates and is well accepted in scientific research of natural sciences, in the history of social sciences it is difficult to recognise a dominant paradigm shared by all scientists. Several epistemological positions are possible in these disciplines, tending to two main opposite paradigmatic positions: post-positivism and interpretivism.

2.2 Main families of paradigms in social and management sciences: post-positivism and interpretivism

The concept of paradigm as a set of theoretical beliefs and methodological techniques is not new in social research (Iofrida, 2016); Kuhn (1962) gave notoriety to this term describing as "normal science" the period when a scientific community consensually shares a paradigm. Despite the critics received by Kuhn, the concept of paradigm still remains up-to-date and preserve its centrality in the meta-research debate of social sciences and management sciences (Thiétart, 2014; Iofrida, 2016; Iofrida *et al.*, 2016).

A paradigm consists of three elements (Tab.1): the researcher's conception about the nature of reality (ontology), the relation between the knower and what is under study (epistemology), and how the researcher can find out knowledge (methodology) (Guba and Lincoln, 1994). These elements are strongly interrelated, and together guide the design, planning and implementation of the research (Iofrida, 2016). The methodology is the formalization of the epistemological position into practices, and shapes methods design for data gathering and analysis. Corbetta called "the delicate phase of operationalization" (Corbetta, 2003: 4) the bridge between theory and practice, the passage from hypotheses to concepts, indicators and variables. A wide number of paradigm exists but, as the lines between paradigms are often very fine, Table 1 reports two principal families of what can be considered the opposite poles to which almost all paradigms tend, comparing them in the light of their main components, i.e. ontology, epistemology, methodology and quality criteria. The aims of the two families of paradigms can be very different in terms of re-

Tab. 1. Main Families of scientific paradigms in social sciences

	Positivism-oriented	Interpretivism-oriented
Ontology: *What is reality?*	Critical realism. One objective reality probabilistically apprehendable.	Relativism. Subject and object are dependent. Realities are about perceptions.
Epistemology: *How do you know?*	Dualism researcher-research. Replicated findings are probably true. Explanation of reality.	Knowledge is interpreted. Reality can be understood and described.
Methodologies: *How do you find it out?*	Nomothetic, mainly quantitative. Experimental or statistical analyses. Probability sampling.	Hermeneutical, dialectical. Mainly qualitative methods. Stakeholders' perceptions.
Goodness or quality criteria.	External validity, verifiability. Statistical confidence level.	Intersubjective agreement and reasoning reached through dialogue.

Source: Guba 1990; Guba and Lincoln (1994); Girod-Séville and Perret (1999); Lincoln *et al.* (2011); Hesse-Biber and Leavy (2011); Phoenix *et al.* (2013); Iofrida *et al*. (2016).

search process, objectives, results obtained. Positivism-oriented paradigms are almost value-free and look for objectivity and generalisability of cause-effects relationships, while interpretivism-oriented paradigms are devoted to the in-depth description of the values and significances of social phenomena.

In the light of these considerations, a critical review of scientific literature on SLCA has been implemented in the following section, to retrace which epistemological positions have been applied and to highligth which consequences they had at practical level. A deepened analysis can be found in Iofrida *et al.* (2016).

3. Shifting the debate to an epistemological level

3.1 Scientific paradigms in SLCA literature: a critical review

To highlight which paradigms have been applied in SLCA literature, a critical review has been conducted on studies gathered with the help of on line scientific databases and research engines, by means of specific keywords (within article title, topic, abstract, keywords), and Boolean operators (AND, OR, NEAR). All scientific literature about the assessment (and synonyms) of social impacts in a life cycle perspective were included. From the first population of 209 works, grey literature, short papers and reviews were excluded. As a result, 78 scientific works have been selected, and a classification matrix has been developed.

Studies were classified according to the following criteria: identifiers, typology of literature, field of application, research paradigm applied, methodologies applied SLCA (alone or in combination with other assessment tools), impact assessment method (impact pathways, UNEP-SETAC guidelines, participative methods, capabilities/capacities approach, multicriterial decision analysis, etc.). Among these criteria, impact assessment methodology is a question of utmost importance in life cycle oriented tools, and the principal source of diversity in sLCA proposals too; therefore, it has been the core criterion to classify the literature gathered. However, as the methodological features alone are not sufficient to disclose which paradigm is underlying the research (Iofrida, 2016), an assessment grid has been set up to check and verify the presence of topical elements (literal criteria) that helped to attribute papers to one or another family of paradigms. These literal criteria are keywords and sentences providing information about the typology of indicators applied, the reasons behind their choice, the source of impacts, the priority given to the generalizability or to the local specificities, the degree of stakeholders'involvement, etc. (Iofrida *et al.*, 2016).

Results showed that 78% of the selected studies could be ascribed to the group of interpretivism-oriented paradigms, only the 21% can be ascribed to the post-positivist ones, and 1% of studies presented characteristics of both families. These data deserve some attention, because since the beginnings of SLCA, most of the scholars supported the idea that the same assessment perspective of eLCA should be applied to social impacts (Hunkeler 2006; Chhipi-Shrestha *et al.* 2015).

3.2 Strength and weaknesses of paradigms and methodological consequences for SLCA

Each paradigms family has its strengths and weaknesses (Tab. 2). Papers belonging to the post-positivism oriented group provided a smaller range of impact categories, focusing only on few social aspects, but furnished explanations of the cause-effect relationships between inventory data and impacts. This could allow predicting which changes would be suitable in life cycle management to obtain more sustainable results and impacts. The most applied impact assessment methods were impact pathways and capacity/capabilities approaches.

Papers belonging to the interpretivism-oriented group provided a broad assessment of several impact categories, furnishing a complete description of a situation at a certain moment at a certain time. Very often, they involved stakeholders at different points of the research process, such as the choice of

Tab. 2. Strength and weaknesses of the opposite families of paradigms

	Post-positivism-oriented paradigms	Interpretivism-oriented paradigms
Strength	Context free	Rich in meaning and values
	Generalizable	Holistic
	Value-free, objective	In-depth investigation
	Affordable and quick	Comprehensive understanding
Weakness	Reductionism	Context-bound
	Poor in values	Subjective
	Simplification	Long and costly
		Weak in generalizability

Source: Iofrida (2016); Iofrida *et al.* (2016).

what is worth assessing (impact categories), the choice of the most relevant indicators, or scoring tasks to discriminate the importance of results. They often took into account the experience of privileged witnesses, as well as the expertise of local actors, thus performing a more coherent context-based assessment. Most of this kind of evaluations focused on performances at a specific temporal moment, and referred, among others, to UNEP-SETAC (2009) guidelines and methodological sheets, or the Social Hotspot Database. Both realism and relativism can be suitable for social impacts evaluations, but the choice should be done in accordance to the purposes of the studies and with the awareness that results can differ in terms of significance.

In this pre-scientific phase of SLCA development, it is of utmost importance to shift the academic debate to an epistemological level in order to solve methodological problems about indicators and impact assessment methods in a coherent way.

4. Comparison of two methodologies from opposite paradigms

4.1 Field of application: citrus growing in Calabria region

Citriculture is an important resource of Italian economy, representing 3% of national agricultural Gross Saleable Production (GSP) (Scuderi, 2008). According to the last agricultural census by ISTAT (2012), the overall surfaces cultivated with citrus fruits are approx. 128,921.07 hectares in 2010, mostly concentrated in the South, especially Sicily (as first national producer) and

Calabria, that together represent 82% of national citrus production. More in detail, Sicily is the principal producer of oranges and lemons (65% and 89% of national production, respectively), while Calabria is the first producer of clementines (60% of national production) and small citruses (61% of national production, especially bergamot and cedars). In the period between the last two agricultural census (2000-2010), ISTAT (2012) highlighted a general decrease, in Italy, of the surfaces cultivated with citrus fruits (-3%), while the tendency has been the opposite in Calabria, where the regional citriculture surface increased a 10%, with a peak of 24% in the province of Cosenza.

Actually, in Calabria most of agricultural surfaces is occupied by olive growing that, with 55,955 hectares, represents the most cultivated crop and interests 34% of UUA (Utilised Agricultural Area). Among permanent crops, citrus growing is the second most important in terms of surface, accounting for 35,185.3 hectares in 2010 (ISTAT, 2012). Furthermore, 9,005 ha (about 25% of citrus growing areas) are conducted according to standards of organic

Tab. 3. 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: data elaboration according to ISTAT (2012).

farming practices (De Luca *et al.*, 2014). However, in terms of average standard production, expressed in € $farm^{-1}$ $year^{-1}$ and calculated as the total value of standard productions divided per the number of farms, citrus growing shows the best economic performance compared to other agricultural sectors (ISTAT, 2012). The highest value is registered by the farms in the province of Catanzaro, and the lowest by the farms in the province of Reggio Calabria. On the land used for citrus growing, 12,530.8 hectare clementine and hybrids are grown, which represents about 60% of national production (ISTAT, 2012), reaffirming the importance of this product at regional and national level. Citriculture is concentrated in flat areas near the coast, in the provinces of Cosenza and Reggio Calabria, both in terms of hectares and number of farms. In Sibari Plain's citriculture, in the province of Cosenza (CS) about 12,381.35 hectares are dedicated to citrus growing. The area is specialised in the production of clementine: about 70% of the regional production is concentrated there, and most of the clementine productions (795.4 in Calabria) are labelled with the Protected Geographical Indication (PGI), as disciplinated by the Commission Regulation (CE) 2325/97. Gioia Tauro Plain's surface, in the province of Reggio Calabria (RC), is occupied by 11,201.778 hectares of citrus growing; here, citriculture is specialised in oranges, half of which was destined to industrial processing for the production of juices until the last decade (De Blasi and De Boni, 2001). The European reform of the Common Market Organization (COM) of fruit and vegetables (Reg. (EC) 1182/2007) has been suddenly put into force without any transition period. This entailed a reduction of citrus production that have been 2,691.2 thousands of tons in 2008/2009, i.e. 926,000 tons less than the previous year, of which 856,000 tons of oranges (92%) (Source: CLAM data 2014, courtesy of CIRAD Montpellier); moreover, a decrease occurred in the number of Producers Associations (PA) that once gathered the product both for fresh consumption and for processing, thus guaranteeing the existence of an end market.

This led to a further worsening of an already weak Calabrian citriculture and its supply chain. Indeed, according to the study by De Blasi and De Boni (2001), the structure of the citrus-growing already in the early 2000 lacked of profitability and competitiveness of the products, oriented more to quantity than quality (more in Calabria than in Sicily) which was intensified by the low-level of bargaining power available to producers when dealing with the processing industries.

Since decades, there are many well-known social issues linked to the Calabrian agriculture, especially concerning the harvesting task and the involvement of foreign illegal workers. When the economic effectiveness of a productive system decrease, often the solution assumed is cutting the costs, and labour is the first cost item accounted. Seasonal migration is concentrated to the main citrus growing areas, the Plain of Sibari (CS) and the Plain of Gioia Tauro (RC) in particular. Following the report by Osservatorio Placido Rizzotto (2012), the main social issues concerning migrants are working and housing exploitation, irregular labour employment, fraud and deceit for non-paid wages and outstanding labour contracts, illegal recruitment of day labourers, requisition of documents.

According to grey literature on the theme, and interviews to privileged witnesses conducted in 2014, in the only Plain of Gioia Tauro, in the town of Rosarno and surroundings, arrive every year more than 3,000 migrants to be employed in citrus harvest. Not always the supply of work meet the demand. The presence of such a massive number of people that live in poor condition due to low wages (often clandestine and so, without access to many social services) impacts local population and sometimes creates tensions as it has been the case of Rosarno revolt in January 2010, when an increased immigration unfortunately coincided with a decreased citrus production (Paciola, 2012).

4.2 A post-positivist perspective. An impact pathway methodology: psychosocial risk factors

Decent work in agriculture has been the first goal of international organizations such as ILO (International Labor Organization); indeed, many conditions can threaten the safety of agricultural workers, in terms of ergonomics, exposure to hazardous products, diseases, and psychosocial risks. Concerning these last, one of the most diffused definitions describes psychosocial risks factors (PRF) as "those aspects of work planning and management – and their relative social and environmental contexts – that can potentially lead to physical or psychological damages" (Cox and Griffiths, 1995: 69). The methodology here applied is based on the works by Silveri *et al.* (2014) and Gasnier (2012). Their studies proposed a new methodology to predict damage to health of workers (involved in the life cycle) caused by psychosocial risk factors at work.

The paradigmatic stances underlying this first application are post-positivist. Indeed, the methodology is based on cause-effects relationships validated by previous empirical studies available in literature that provided an explanation of causes by their effect (induction), and whose results are verifiable, confirmable and refutable. These statistical relationships are expressed in odds ratios, and allow explaining the impact pathway that link the product life cycle to possible health risks in a quantifiable and probabilistic way.

The present impact pathway methodology is applied to two citrus growing scenarios: the agricultural life cycle phases (i.e. from cradle to gate) of oranges for industries and clementines for fresh consumption in two fictitious farms of Gioia Tauro Plain (province of Reggio Calabria), with the same agricultural surface (3 ha), duration (40 years), and farming management (conventional).

The methodology is divided into the following four steps:

- an inventory analysis of working hours needs for each task (e.g. tillages, pruning, harvesting, phytoyatric treatments) and for each agricultural phases;
- a literature review about the association between particular working conditions and psychosocial risk factors expressed in odds ratio, a statistical measure of the intensity of association. Odds ratios have been classified in classes of association intensity in weak (1< OR <1.3), moderate (1.3< OR <1.7), strong (1.7< OR <8) (Iofrida, 2016).
- the construction of a PRF Matrix (Appendix Tab. A.3), where every working condition occurring in the scenarios is linked to a physical or psychosocial disease.
- the assessment of social impact through the quantification of working hours that potentially expose workers to one or more diseases.

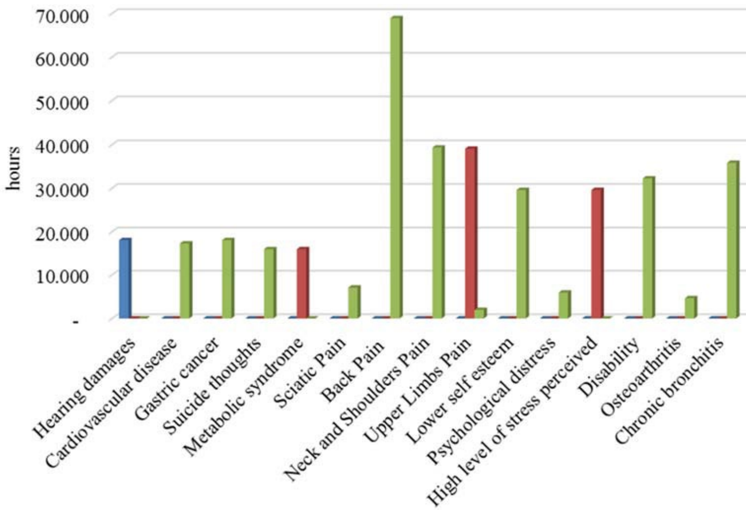
Results (Fig. 1) showed that the agricultural phases of industrial oranges life cycle entails 58,120 hours of work with exposure to the risk of chronic bronchitis (strong association), 42,510 hours of work exposing to risk of back pain (strong association), and 28,562 hours of work exposing to risk of upper limbs pain (moderate association). The agricultural phase of clementines life cycle entails 68,916 hours of working tasks exposing to the risk of back pain (strong association), and the risk of neck and shoulders pain (39,334 hours with strong association) and upper limbs pain (39,060 hours with moderate association).

4.3 An interpretivist perspective. A local based, multicriterial and participative proposal

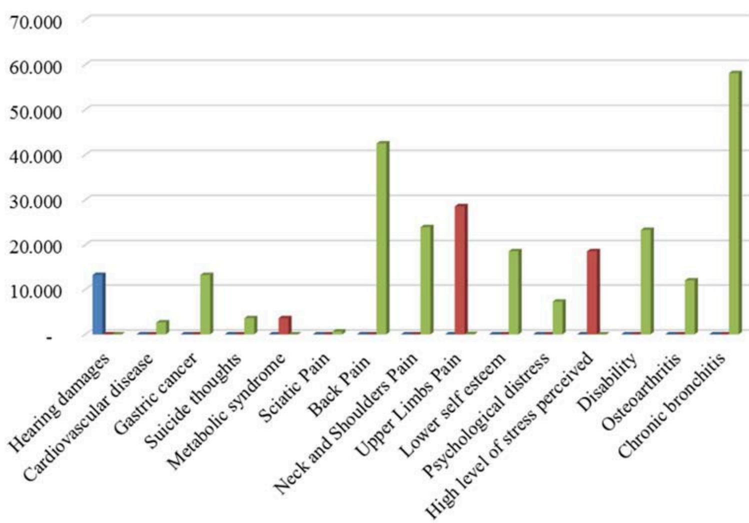
The paradigmatic stances of this second methodological proposal are interpretivist, so it is assumed that subject (researcher) and object (research) are dependent and that knowledge is interpreted through the participation of relevant actors. Many procedural choices have been at discretion of the researcher or those actors whose perception were considered important.

Nine scenarios of clementine production are compared, deriving from three main agricultural areas (Sibari Plain in the province of Cosenza, Lamezia Terme Plain in the province of Catanzaro, and Gioia Tauro Plain in the province of Reggio Calabria), and from three techniques of cultivation: organic (O), integrated (I) and conventional (C). The methodological frame-

Fig. 1. PRFs of clementine (a) and orange (b) growing scenarios



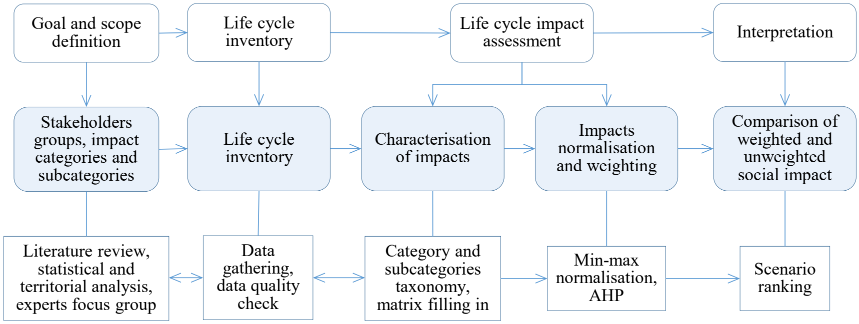
a)



b)

Source: Iofrida (2016).

Fig. 2. Interpretivist methodological framework

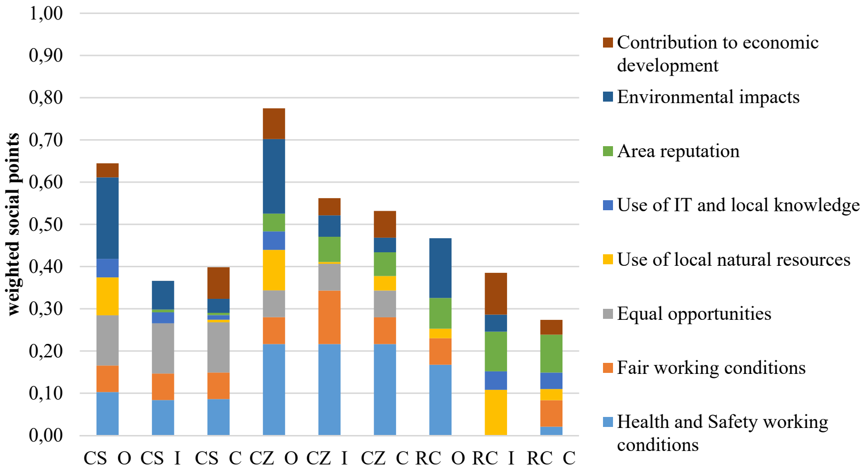


Source: De Luca *et al.* (2015b: 385).

work follows the work by De Luca *et al.* (2015a) and is graphically represented in Figure 2.

The first step of the methodological framework consisted in territorial analyses and a literature review on the main issues of the areas analysed; focus groups with local experts were implemented to choose impact categories, subcategories, and indicators. The second step concerned the inventory analysis: indicators have been calculated to complete the Social Impact Matrix (SIM) (De Luca *et al.*, 2015b). Data were collected from both primary (interviews) and secondary sources (on line databases); most of the environmental and economic data were taken from the results of previous LCA and LCC analyses of the same case study (Strano *et al.*, 2013). The third step - the life cycle impact assessment – consisted in the homogenisation of inventory data (in a positive direction) and the normalisation. The Analytic Hierarchy Process (AHP) (Saaty, 1990) was applied as a multicriterial tool to involve three groups of affected actors (workers, local communities, society from the three areas under study) in the evaluation of the relative importance of each impact category and subcategory. The forth step consisted in the application of the set of weights and the interpretation of results. Participation played a key role to make the assessment legitimate and adherent to reality. Normalisation allowed the comparison between indicators of different nature, thus offering a first ranking among scenarios in terms of (unweighted) social performances. Impacts dimensions, expressed in "unweighted social points", are the result of minimised negative data and maximised positive data, and, therefore a higher score represents a more socially sustainable performance. Results (Fig. 3) show that the organic production of Lamezia Terme Plain ("CZ_O") is the best scenario, followed by that of Sibari Plain ("CS_O") and the integrated production of Gioia T. Plain ("RC_I").

Fig. 3. Scenarios ranking with the application of local weights



Source: De Luca *et al*. (2015b: 393); Iofrida (2016).

Considering the three sets of local weights obtained from the application of the AHP, few differences result in terms of ranking among scenarios; indeed, once again the "CZ_O" and "CS_O" are the best scenarios (Fig. 3), but followed by "CZ_I". A further overall ranking elaborated from a unique set of weights (regional preferences) showed that organic growing is the most socially sustainable.

5. Discussion

The two methodologies have been very different in terms of research procedures, epistemological assumptions, and methodological choices. They furnished different typologies of results that can have different usefulness according to the context they are applied.

The first methodology applied in this study, i.e. the PRF impact pathway, was framed in the realm of post-positivism paradigms, and allowed to quantify the cause-effect relationship between citrus life cycle and psychosocial impacts on affected workers. It allowed assessing objectively the differences between two productive scenarios, and the methodology resulted to be generalizable and applicable to other contexts. It was limited to only a group of affected actors (workers), but it would be possible to extend the study to other stakeholders. Furthermore, extending the methodology to a whole sector, it would possible to predict the social consequences also in terms of social welfare, public health and the socio-economic repercussions for a wider group of stakeholders. The principal strength stayed in the possibility of predicting the consequences of managerial or structural changes in the life cycle. Decision makers can find, in the PRF matrix, a valuable instrument to support decision, both at farm level and in the context of policy making. Furthermore, this methodology is in line with the current state of the art of environmental Life Cycle Assessment, based on cause-effect relationships between inventories of matter and energy flows and impact categories. Many scholars advocated for the development and improvement of Life Cycle Sustainability Assessment, intended as the harmonisation of eLCA, LCC and SLCA. The impact pathway methodologies well serve this aim of unification, being framed in the same paradigmatic perspective.

The interpretivism-oriented SLCA methodology (participative SIM) applied in this study mixed quali-quantitative techniques and multicriteria analysis tools allowing the recognition of local specificities by involving local experts and affected stakeholders. The practice of combinig multicriterial methods with life cycle tools has being adopted since a long time, allowing to manage subjectivity in a scientifically way (De Luca *et al.*, 2015c; De Luca *et al.*, 2017). Despite its local character, the entire methodological framework can be adapted to other agricultural processes and to further supply chain phases, but system boundaries and the choice of impact categories should be revised and adapted to the new context. The value added of this methodology stays in the legitimacy given by stakeholder participation and their opinions that have been used to assess impacts. Furthermore, negative and positive impacts have been taken into account, and assessment practices that have been poorly applied until now in SLCA studies. The paradigmatic perspective underpinning the methodology is in line with the state of the art of SLCA literature, as demonstrated in the critical review of scientific literature.

Concerning the research phases, Table 4 compares the two methodological proposals. As it shows, points of difference can be outlined since the beginning of the research processes, i.e. in the formulation of research question: the first one looks for explanation (*Erklären*, typical of nomothetic sciences), the second for comprehension (*Verstehen*, typical of idiographic sciences[1]) of social impacts; the same dichotomy can be found between the two main families of paradigm of sociology and management science.

The choice of case studies are similar in some terms, because based on available information and knowledge about the actual situation of Calabria ci-

[1] The terms *Erklären* and *Verstehen* comes from the discussions inside the German historicism, but have been used in many sociological debate contexts (Iofrida, 2016).

Tab. 4. Comparison of research processes of the two methodologies

PRF impact pathway	Research phases	Participative SLCA
Post-positivism. Realist and objective posture.	1. Paradigm choice	Interpretivism. Relativist and subjective posture.
Which are the real social impacts caused by the functioning of citrus life cycle? Which changes should be made to improve it?	2. Formulation of research question	How assessing social impacts on a wide range of actors affected (positively and negatively) by citrus growing? What is worthwhile protecting and for who? Who is responsible for what? Which typology of farming practice is more socially sustainable?
A transformation is occurring in Calabria citriculture: oranges for industry are disappearing in favour of quality products, e.g. clementine.	3. Choice of case study and planning	Clementine is the most renowned citricultural product from Calabria. Three main areas of production (CS, RC, CZ) and three typologies of farming practices (O, I, C).
Review of scientific literature. Data triangulation with few interviews to privileged actors.	4. Data collection	Review of grey and scientific literature, databases consultation, direct surveys and interviews.
Data gathering, classification and calculation.	5. Data analysis and impact assessment	Data gathering, normalization, and weighting according to stakeholder preferences, calculation.
The risk of Back Pain is stronger in clementine growing, but chronic bronchitis is weaker. Management changes would improve working conditions and reduce the exposure to risk of health troubles.	6. Interpretation and use of results	Organic farming practices are socially preferable. Environmental impacts and working conditions are the greatest concern among local actors.

Source: Iofrida (2016)

triculture; the same sources have been used, i.e. literature and statistics (e.g. ISTAT, 1012; INAIL, 2013).

Data collection, at the contrary, has been very different. In the first case, it was limited to literature review among medical journals, and triangulation served to select and verify the pertinence of the PRF chosen to the case study. In the second methodology, it has been a long and costly process in terms of time and costs. Many displacements were necessary for interviews that also took time according to the typology of actor interviewed: for example, foreigners (and relative problems of communication), or actors that have no information about citriculture issues. In addition, data gathering from available database was a quite long task, due to the differences of levels among them and relative adjustments needed (e.g. local vs regional data). This entailed also the construction of proxy indicators to adapt data to the case study.

Data analysis and impact assessment took the same efforts in terms of time, just a little longer in the second case due to the calculation and application of stakeholders' preferences.

In these two last points of research process (phase 4 and 5 in Tab. 4), the posture of the researcher was different. In the second methodology, the intervention of researcher into the analysis and the assessment was stronger and the personal expertise on the field of application was necessarily involved. On the other side, it was a personally enriching experience, and it showed how it is necessary to inform actors about research topics and findings and to cooperate and listen to them: at the end, they are the final addressees of research, not only academics.

The interpretation of results served different aims, as different were the starting questions. The first methodology focused only on a typology of actor, i.e. workers, but allowed to predict the effects of life cycle changes, such as the disappearing of industrial oranges citriculture in favour of clementine citrus growing. The second methodology furnished a wide description of different typologies of social impacts (or rather "performances" according to Parent *et al.*, 2010) and different actors. Furthermore, results from previous available LCA and LCC studies have been used for some indicators in the same methodological framework. However, it is not totally possible to predict which effects would occur by means of life cycle changes.

According to the analysis of paradigms in SLCA, in Table 5 the characteristics of each impact assessment are checked. By comparing them, and according to what discussed until now, it is possible to find the same strength and weaknesses of each family of paradigm in the two methodological proposals.

In both methodologies, the choice of impact categories (or health diseases in the first methodology) influenced the results. Maybe results would be different if considering more categories or different issues. As already said, there is many place for further developments and improvements.

Tab. 5. Comparison of the two impact assessment methodologies

PRF matrix	Yes ✓ No ✗	Participative SIM	Yes ✓ No ✗
Dynamic indexes/indicators to assess a status change	✗	Static indexes/indicators compared to international standards or national laws	✓
Cause-effect relationships and causal chain	✓	Participation, stakeholders involvement through qualitative methods	✓
Direct relation between process flows and impact pathways	✓	Choice of impact category according to the claims of interest groups, public acceptability, actors opinions	✓
Social impacts are intended in the same way as environmental ones in eLCA	✓	Companies behaviour regarding international norms on social issues	✗
The researcher do not need to have a direct contact with affected actors, research process is not influenced by personal opinions	✓	The researcher is directly involved in the research process, as the principal responsible of procedural and category assessment choice	✓
Access to national and international databases and statistical hypothesis testing	✗	Direct contact with affected actors (interviews, surveys)	✓
Deterministic account of life cycle causal variables	✗	Social values, actor meanings and companies behaviours	✓
Effects prediction, modelling, quantification as priority task to be assumed	✓	Qualitative scoring, social acceptance	✓
The study can be based on the same inventory data used for LCA and LCC	✓	Qualitative and quali-quantitative indicators are preferred	✓
All impacts can be quantitatively linked to a functional unit	✓	Company performances and behaviors are considered the principal source of impacts	✗
Social consequences on people lives due to a life cycle change	✗	The context specificities have strong repercussions on the assessment results	✓
The importance of generalizations and universal laws is emphasized	✓	Findings can assume a different meaning according to the context	✓
Results allow to predict a future situation	✓	Results allow to describe a current state or based on historical data	✓
Long term consequences are accounted	✓	Short term assessments	✓

Source: Iofrida (2016); Iofrida *et al*. (2016).

6. Conclusion

The aim of the study was not just to compare results, but to compare the research processes that led to the development of each methodology. The first aim of the study was to demonstrate that the methodological diversity that characterised SLCA literature is due to the influences of the scientific and cultural heritage of the disciplines assumed to be linked to SLCA, i.e. social sciences. Secondly, the study tried to answer the question if different paradigms can coexist in SLCA. Finally, the general aim was to push the academic debate from a methodological level towards an epistemological one, which has been lacking until now in SLCA. The disciplinary roots of SLCA have been tracked down into sociology and management science, and the multiparadigmatic characteristics of both have been outlined, describing the main difference of the two opposite possible paradigmatic positions (post-positivism and interpretivism). SLCA has been critically reviewed in search of which family of paradigms were mostly applied. Results provided an interesting information: the 78% of selected studies applied an interpretivist perspective. However, many scholars affirmed that SLCA should address social impacts evalutation in the same way eLCA does for environmental ones (that would mean in a post-positivism perspective).

Two methodologies have been proposed starting from opposite paradigmatic perspectives. Both provided interesting results and have been compared in terms of validity and usability.

Coming back to the main research question, the methodological diversity of SLCA literature can find a justification in the multiparadigmatic characteristics of sociology and management science, in which SLCA is rooted. That there is place in SLCA for different paradigms, it is an empirical evidence, as showed in the critical review and in the case study.

The scientific goodness of the SLCA methodology is of utmost importance when the purpose of the analysis is for economic or political decision-making processes. Both families of paradigms are scientifically valid, but the objectives can be different and therefore can serve different purposes. If cause-effects relationship and quantification can be required, for example, in formulating national or international economic and political decisions, predicting the consequences. In other cases, as it could be at local level, for governance purposes or entrepreneurial management decision-making processes, an interpretivist stance would be prefereable, in favour of dialogue, consensus and stakeholders participation.

What remains to be discussed in SLCA academia, is about the awareness that the paradigmatic stance matters when social impacts are assessed. The present study wants to be a contribution to this.

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Appendix

Tab. A.1 Criteria for the critical review of sLCA literature

Criteria (examples)
Typology of indicators applied/proposed
Typology of impact assessment method
Main purpose of the assessment
Conception of social impacts
Theory underlying the assessment
Typology of data gathering process
Statistical validity Importance given to dialogue and consensus
Participative processes
Quantification method
Importance of context
Generalizability of results

Tab. A.2 Critical review results

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
1	Albrecht S, Brandstetter P, Beck T, Fullana-i-Palmer P, Grönman K, Baitz M, Deimling S, Sandilands J, Fischer M	2013	An extended life cycle analysis of packaging systems for fruit and vegetable transport in Europe	Int J LCA 18(8):1549-1567	JA	Packaging	LCA + LCC + Life Cycle Working Environment	GaBi software and database	i
2	Andrews E, Lesage P, Benoît C, Parent J, Norris G, Revéret JP	2009	Life Cycle Attribute Assessment. Case Study of Quebec Greenhouse Tomatoes	Journal of Industrial Ecology 13(4):565-578	JA	Greenhouse tomatoes	Life Cycle Attribute Assessment	Attribute LCA; labour hour satellite matrix	i
3	Aparcana S, Salhofer S	2013a	Development of a social impact assessment methodology for recycling systems in low-income countries.	Int J LCA 18(5):1106-1115	JA	Waste: recycling systems	SLCA	UNEP-SETAC guidelines + interviews + score system	i
4	Aparcana S, Salhofer S	2013b	Application of a methodology for the social life cycle assessment of recycling systems in low income countries: three Peruvian case studies	Int J LCA 18(5):1116-1128	JA	Waste: recycling systems	SLCA	UNEP-SETAC guidelines + stakeholders interview + score system	i

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
5	Arcese G, Di Pietro L, Guglielmetti Mugion R	2015	Social Life Cycle Assessment Application: Stakeholder Implication in the Cultural Heritage Sector	In: Muthu SS (eds), Social Life Cycle Assessment, Springer Singapore, pp 115-146	BC	Cultural heritage sector	SLCA	UNEP-SETAC guidelines, SAM + consistency scoring	i
6	Arcese G, Lucchetti MC, Martucci O	2015	Social Life Cycle Assessment in a Managerial Perspective: An Integrative Approach for Business Strategy	In: Muthu SS (eds), Social Life Cycle Assessment, Springer Singapore, pp 227-252	BC	Business management	SLCA	UNEP-SETAC guidelines	i
7	Arcese G, Lucchetti MC, Merli R	2013	Social Life Cycle Assessment as a Management Tool: Methodology for Application in Tourism	Sustainability 5:3275-3287	JA	Tourism services	SLCA	UNEP-SETAC guidelines	i
8	Arvidsson R, Baumann H, Hildenbrand J	2015	On the scientific justification of the use of working hours, child labour and property rights in social life cycle assessment: three topical reviews	Int J LCA 20(2):161-173	JA	SLCA development	SLCA	Pathway	pp

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
9	Baumann H, Arvidsson R, Tong H, Wang Y	2013	Does the Production of an Airbag Injure more People than the Airbag Saves in Traffic? Opting for an Empirically Based Approach to Social Life Cycle Assessment	Journal of Industrial Ecology 17(4):517-527	JA	Airbags	SLCA	Disability-adjusted life years (DALY)	pp
10	Benoît C, Norris GA, Valdivia S, Ciroth A, Moberg A, Bos U, Prakash S, Ugaya C, Beck T	2010	The guidelines for social life cycle assessment of products: just in time!	Int J LCA 15(2):156-163	JA	SLCA development	SLCA	UNEP-SETAC guidelines	i
11	Benoît Norris C	2012	Social Life Cycle Assessment: A Technique Providing a New Wealth of Information to Inform Sustainability-Related Decision Making	In: Curran M.A. (Ed), Life Cycle Assessment Handbook, Wiley, pp.433-450.	BC	SLCA development	SLCA	UNEP-SETAC guidelines	i
12	Benoît Norris C	2014	Data for social LCA	Int J LCA 19(2):261-265	JA	SLCA development	SLCA	UNEP-SETAC guidelines	i
13	Benoît Norris C, Aulisio D, Norris GA, Hallisey-Kepka C, Overakker S, Vickery Niederman G	2011	A social Hotspot Database for Acquiring Greater Visibility in Product Supply Chains: Overview and Application to Orange Juice	In: Finkbeiner M (ed) Towards Life Cycle Sustainability Management, pp. 53-62, Springer	BC	Orange juice	SLCA	SHDB	i

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
14	Benoît Norris C, Aulisio Cavan D, Norris GA	2012a	Identifying Social Impacts in Product Supply Chains: Overview and Application of the Social Hotspot Database	Sustainability 4(9):1946-1965	JA	Strawberry yogurt	SLCA	Social Hotspot Database	i
15	Benoît Norris C, Aulisio Cavan D, Norris GA	2012b	Working with the Social Hotspots Database - Methodology and Findings from 7 Social Scoping Assessments	In: Dornfeld DA, Linke BS (Eds) Leveraging Technology for a Sustainable World. Proceedings of the 19th CIRP Conference on Life Cycle Engineering, Berkeley, USA, May 23-25 (pp. 581-586). Springer.	CP	Shampoo supply chain	SLCA	Social Hotspot Database	i
16	Benoît Norris C, Norris GA, Aulisio D	2014	Efficient Assessment of Social Hotspots in the Supply Chains of 100 Product Categories Using the Social Hotspots Database	Sustainability 6(10):6973-6984	JA	100 product categories	SLCA	Social Hotspot Database	i

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
17	Benoît Norris C, Revéret JP	2015	Partial Organization and Social LCA Development: The Creation and Expansion of an Epistemic Community	In: Muthu SS (eds), Social Life Cycle Assessment, Springer Singapore, pp 199-226	BC	SLCA development	SLCA	UNEP-SETAC guidelines, Social Hotspot Database	i
18	Benoît Norris C, Vickery-Niederman G, Valdivia S, Franze J, Traverso M, Ciroth A, Mazijn B	2011	Introducing the UNEP/SETAC methodological sheets for subcategories of social LCA	Int J LCA 16(7):682-690	JA	SLCA development	SLCA	UNEP-SETAC guidelines	i
19	Bocoum I, Macombe C, Revéret JP	2015	Anticipating impacts on health based on changes in income inequality caused by life cycles	Int J LCA 20(3):405-417	JA	Income inequality and health	SLCA	Wilkinson Pathway	pp
20	Bork CAS, Junior DJDB, Gomez JDO	2015	Social Life Cycle Assessment of three Companies of the furniture sector.	Procedia CIRP 29: 150-155	CP	Furniture for buildings construction	SLCA	UNEP-SETAC guidelines	i
21	Bouzid A, Padilla M	2014	Analysis of social performance of the industrial tomatoes food chain in Algeria	NEW MEDIT N. 1/2014, pp. 60-65	JA	Tomatoes	SLCA	UNEP-SETAC guidelines	i
22	Chang Y-J, Sproesser G, Neugebauer S, Wolf K, Scheumann R, Pittner A, Rethmeier M, Finkbeiner M	2015	Environmental and Social Life Cycle Assessment of Welding Technologies	Procedia CIRP 26:293-298	CP	Welding technology	LCA + SLCA	Fair salary and health risks	pp

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
23	De Luca AI, Iofrida N, Strano A, Falcone G, Gulisano G	2015b	Social Life Cycle Assessment and participatory approaches: a methodological proposal applied to citrus farming in Southern Italy	Int Env Assesst and Manag 11(3):383396	JA	Clementine	SLCA	UNEP-SETAC guidelines + participatory approach	i
24	Dong YH, Ng ST	2015	A social life cycle assessment model for building construction in Hong Kong	Int J LCA 20(8):1166-1180	JA	Buildings	SLCA	UNEP-SETAC guidelines	i
25	Dreyer LC, Hauschild MZ, Schierbeck J	2006	A Framework for Social Life Cycle Impact Assessment	Int J LCA 11(2):88-97	JA	SLCA development	SLCA	Scorecard multicriteria indicator model	i
26	Dreyer LC, Hauschild MZ, Schierbeck J	2010a	Characterisation of social impacts in LCA Part 1: Development of indicators for labour rights	Int J LCA 15(3):247-259	JA	SLCA development	SLCA	social risk assessment	i
27	Dreyer LC, Hauschild MZ, Schierbeck J	2010b	Characterisation of social impacts in LCA. Part 2: implementation in six company case studies	Int J LCA 15(4):385-402	JA	Industry	SLCA	social risk assessment	i
28	Ekener-Petersen E, Finnveden G	2013	Potential hotspots identified by social LCA—part 1: a case study of a laptop computer	Int J LCA 18(1):127-143	JA	Laptop computer	SLCA	UNEP-SETAC guidelines, Social Hotspot Database	i

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
29	Ekener-Petersen E, Höglund J, Finnveden G	2014	Screening potential social impacts of fossil fuels and biofuels for vehicles	Energy Policy 73:416-426	JA	Fossil and biological fuels	SLCA	UNEP-SETAC guidelines, Social Hotspot Database	i
30	Ekener-Petersen E, Moberg Å	2013	Potential hotspots identified by social LCA-Part 2: Reflections on a study of a complex product	Int J LCA 18(1):144-154	JA	Laptop computer	SLCA	UNEP-SETAC guidelines, Social Hotspot Database	i
31	Feschet P, Macombe C, Garrabé M, Loeillet D, Rolo Saez A, Benhmad F	2013	Social impact assessment in LCA using the Preston pathway. The case of banana industry in Cameroon	Int J LCA 18(2):490-503	JA	Bananas	SLCA	Preston Pathway	pp
32	Foolmaun RK, Ramjeeawon T	2013a	Life cycle sustainability assessments (LCSA) of four disposal scenarios for used polyethylene terephthalate (PET) bottles in Mauritius	Environment, Development and Sustainability 15(3):783-806	JA	Waste	LCSA	UNEP-SETAC guidelines	i
33	Foolmaun RK, Ramjeeawon T	2013b	Comparative life cycle assessment and social life cycle assessment of used polyethylene terephthalate (PET) bottles in Mauritius	Int J LCA 18(1):155-171	JA	Waste	LCA + SLCA	UNEP-SETAC guidelines	i
34	Franze J, Ciroth A	2011	A comparison of cut roses from Ecuador and the Netherlands	Int J LCA 16(4):366-379	JA	Roses	SLCA	UNEP-SETAC guidelines	i

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
35	Gauthier C	2005	Measuring Corporate Social and Environmental Performance: The Extended Life-Cycle Assessment	Journal of Business Ethics 59(1): 199-206	JA	Business strategy and management	“Extended” LCA	Systematic assessment of social criteria in extended LCA	i
36	Hauschild MZ, Dreyer LC, Jørgensen A	2008	Assessing social impacts in a life cycle perspective - Lessons learned	CIRP Annals - Manufacturing Technology 57(1):21-24	JA	SLCA development	SLCA	Companies behavior	i
37	Heller MC, Keoleian GA	2003	Assessing the sustainability of the US food system: a life cycle perspective	Agricultural Systems 76(3):1007-1041	JA	Food systems	LCSA	Attibutive assessment through static indicators	i
38	Hosseinijou SA, Mansour S, Shirazi MA	2014	Social life cycle assessment for material selection: a case study of building materials	Int J LCA 19(3):620-645	JA	Building materials	SLCA	UNEP-SETAC guidelines	i

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
39	Hsu C-W, Wang S-W, Hu A	2013	Development of a New Methodology for Impact Assessment of SLCA	In: Nee AYC, Song B, Ong S-K, (Eds) Re-engineering Manufacturing for Sustainability. Proceedings of the 20th CIRP International Conference on Life Cycle Engineering, Singapore 17-19 April, 2013. pp. 469-473	CP	SLCA development	SLCA	UNEP-SETAC guidelines and Performance Reference points	i
40	Hu M, Kleijn R, Bozhilova-Kisheva KP, Di Maio F	2013	An approach to LCSA: the case of concrete recycling	Int J LCA 18(9):1793-1803	JA	Recycling	LCSA	UNEP-SETAC guidelines	i
41	Hunkeler D	2006	Societal LCA methodology and case study.	Int J LCA 11(6):371-382	JA	Detergents	SLCA	Geographically specific midpoint based	pp
42	Jørgensen A	2013	Social LCA - a way ahead?	Int J LCA 18(2):296-299	JA	SLCA development	SLCA	Pathway	pp
43	Jørgensen A, Finkbeiner M, Jørgensen MS, Hauschild MZ	2010	Defining the baseline in social life cycle assessment	Int J LCA 15(4):376-384	JA	SLCA development	SLCA	Pathway	pp

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
44	Jørgensen A, Hauschild MZ, Jørgensen MS, Wangel A	2009	Relevance and feasibility of social life cycle assessment from a company perspective	Int J LCA 14(3):204-214	JA	Company	SLCA	interviews	i
45	Jørgensen A, Lai LC, Hauschild MZ	2010	Assessing the validity of impact pathways for child labour and well-being in social life cycle assessment	Int J LCA 15(1):5-16	JA	Child labour	SLCA	Pathway	pp
46	Kruse SA, Flysjö A, Kasperczyk N, Scholz AJ	2009	Socioeconomic indicators as a complement to life cycle assessment—an application to salmon production systems.	Int J LCA 14(1):8-18	JA	Salmon	Socio-economic LCA	Attributive and descriptive assessment	i
47	Lagarde V, Macombe C	2012	Designing the social life cycle of products from the systematic competitive model	Int J LCA 18(1):172-184	JA	System boundaries definition	SLCA	Systematic Competitive Model	pp
48	Lehmann A, Russi D, Bala A, Finkbeiner M, Fullana-i-Palmer P	2011	Integration of Social Aspects in Decision Support, Based on Life Cycle Thinking	Sustainability 3(4):562-577	JA	Water management and packaging waste	SLCA	UNEP-SETAC guidelines + literature	i
49	Lehmann A, Zschieschang E, Traverso M, Finkbeiner M, Schebek	2013	Social aspects for sustainability assessment of technologies - challenges for social life cycle assessment (SLCA)	Int J LCA 18(8):1581-1592	JA	Technologies	SLCA	UNEP-SETAC guidelines	i

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
50	Macombe C, Leskinen P, Feschet P, Antikainen R	2013	Social life cycle assessment of biodiesel production at three levels: a literature review and development needs	Journal of Cleaner Production 52(1):205-216	JA	Energy	SLCA	Pathway	pp
51	Manik Y, Leahy J, Halog A	2013	Social life cycle assessment of palm oil biodiesel: a case study in Jambi Province of Indonesia	Int J LCA 18(7):1386-1392	JA	Energy	SLCA	UNEP-SETAC guidelines	i
52	Martínez-Blanco J, Lehman A, Munoz P, Antòn A, Traverso M, Rieradevall J, Finkbeiner M	2014	Application challenges for the social Life Cycle Assessment of fertilizers within life cycle sustainability assessment	Journal of Cleaner Production 69 34-48	JA	Fertilizers	LCSA	UNEP-SETAC guidelines	i
53	Mathé S	2014	Integrating participatory approaches into social life cycle assessment: the SLCA participatory approach	Int J LCA 19(8):1506-1514	JA	Fisheries	Participatory SLCA	Participatory approach	i
54	Musaazi MK, Mechtenberg AR, Nakibuule J, Sensenig R, Miyingo E, Makanda JV, Hakimian A, Eckelman MJ	2015	Quantification of social equity in life cycle assessment for increased sustainable production of sanitary products in Uganda	Journal of Cleaner Production 96 569-579	JA	Sanitary pads	LCA + SLCA	Pathway	pp

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
55	Nemarumane TM, Mbohwa C	2015	Social Life Cycle Assessment in the South African Sugar Industry: Issues and Views	In: Muthu SS (eds), Social Life Cycle Assessment, Springer Singapore, pp 71-113	BC	Sugar cane	SLCA	UNEP-SETAC guidelines	i
56	Neugebauer S, Martinez-Blanco J, Scheumann R, Finkbeiner M	2015	Enhancing the practical implementation of life cycle sustainability assessment. Proposal of a Tiered approach	Journal of Cleaner Production 102:165-176	JA	SLCA development	LCSA	UNEP-SETAC guidelines + Tiered approach	i
57	Neugebauer S, Traverso M, Scheumann R, Chang Y-J, Wolf K, Finkbeiner M	2014	Impact Pathways to Address Social Well-Being and Social Justice in SLCA-Fair Wage and Level of Education	Sustainability 6(8):4839-4857	JA	SLCA development	SLCA	Pathway	pp
58	Norris GA	2006	Social Impacts in Product Life Cycles - Towards Life Cycle Attribute Assessment.	Int J LCA 11: 97-104	JA	SLCA development	SLCA	Pathway + Life Cycle Attribute Assessment	pp + i
59	Ramirez SPK, Petti L, Haberland NT, Ugaya CML	2014	Subcategory assessment method for social life cycle assessment. Part 1: methodological framework	Int J LCA 19(8):1515-1523	JA	SLCA development	SLCA	SAM	i

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
60	Ramirez SPK, Petti L, Ugaya CML	2014	Subcategory assessment method for social LCA: A first application on the wine sector	In: Salomone R, Saija G (eds):Pathways to environmental sustainability: Methodologies and experiences. Springer	BC	Wine	SLCA	SAM	i
61	Reitinger C, Dumke M, Barosevcic M, Hillerbrand R	2011	A conceptual framework for impact assessment within SLCA	Int J LCA 16(4):380-388	JA	SLCA development	SLCA	Capabilities approach	i
62	Revéret JP, Couture JM, Parent J	2015	Socioeconomic LCA of Milk Production in Canada	In: Muthu SS (eds), Social Life Cycle Assessment, Springer Singapore, pp 25-69	BC	Milk	SLCA	UNEP-SETAC guidelines + SHDB	i
63	Rugani B., Benedetto E, Igos E, Quinti G, Declich A, Feudo F	2014	Towards prospective life cycle sustainability analysis: exploring complementarities between social and environmental life cycle assessments for the case of Luxembourg's energy system	Materiaux & Techniques 102, 605 (2014)	JA	Energy	LCA + SLCA	SHDB	i

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
64	Sandin G, Peters G, Pilgård A, Svanström M, Westin M	2011	Integrating Sustainability Considerations into Product Development: A Practical Tool for Prioritising Social Sustainability Indicators and Experiences from Real Case Application	In: Finkbeiner M (ed) Towards Life Cycle Sustainability Management, pp. 3-14, Springer	BC	SLCA development	SLCA	UNEP-SETAC guidelines	i
65	Santoyo-Castelazo E, Azapagic A	2014	Sustainability assessment of energy systems: integrating environmental, economic and social aspects	Journal of Cleaner Production 80:119-138	JA	Energy	Sustainability assessment	Social interpretation LCA indicators	i
66	Schmidt I, Meurer M, Saling P, Reuter W, Kicherer A, Gensch C-O	2004	Managing Sustainability of Products and Processes with the Socio-Eco-Efficiency Analysis by BASF	Greener Management International 45:79-94	JA	Energy	Socio-eco-efficiency	SEEBalance	i
67	Smith J, Barling D	2014	Social impacts and life cycle assessment: proposals for methodological development for SMEs in the European food and drink sector	Int J LCA 19(4):944-949	JA	Food and drink	SLCA	Qualitative bottom-up and top down approach	i
68	Traverso M, Asdrubali F, Francia A, Finkbeiner M	2012	Towards Life Cycle Sustainability assessment: an implementation to photovoltaic modules	Int J LCA 17(8):1068-1079	JA	Energy	LCSA	UNEP-SETAC guidelines + LCSA dashboard	i

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
69	Traverso M, Finkbeiner M	2012	Life Cycle Sustainability Dashboard	Journal of Industrial Ecology 16(5):680-688	JA	Natural hard floor coverings	LCSA	UNEP-SETAC guidelines	i
70	Umair S, Björklund A, Ekener-Petersen E	2015	Social Life Cycle Inventory and Impact Assessment of Informal Recycling of Electronic ICT Waste in Pakistan	Resources, Conservation and Recycling 95 46-57	JA	Waste	SLCA	UNEP-SETAC guidelines	i
71	Valdivia S, Ugaya CML, Hildenbrand J, Traverso M, Mazijn B, Sonnemann G	2013	A UNEP/SETAC approach towards a life cycle sustainability assessment - our contribution to Rio+20	Int J LCA 18(9):1673-1685	JA	Marble	LCSA	UNEP-SETAC guidelines	i
72	Vavra J, Munzarova S, Bednarikova M	2015	Assessment of Social Impacts of Chemical and Food Products in the Czech Republic	In: Muthu SS (eds), Social Life Cycle Assessment, Springer Singapore, pp 147-197	BC	Chemical and food products	SLCA	UNEP-SETAC guidelines and qualitative weighting	i
73	Vinyes E, Oliver-Solà J, Ugaya C, Rieradevall J, Gasol CM	2013	Application of LCSA to used cooking oil waste management.	Int J LCA 18(2):445-455.	JA	Waste	LCSA	general indicators	i
74	Weidema BP	2005	ISO 14044 also Applies to Social LCA	Int J LCA 10(6):381-381	JA	SLCA development	SLCA	Two-layer SLCA method	pp

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
75	Weidema BP	2006	The integration of Economic and Social Aspects in Life Cycle Impact Assessment	Int J LCA 11:89-96	JA	SLCA development	SLCA	Pathway	pp
76	Weldegiorgis FS, Franks DM	2014	Social dimensions of energy supply alternatives in steelmaking: comparison of biomass and coal production scenarios in Australia	Journal of Cleaner Production 84:281-288	JA	Energy	SLCA	UNEP-SETAC guidelines	i
77	Wilhelm M, Hutchins, Mars C, Benoit Norris C	2015	An overview of social impacts and their corresponding improvement implications: a mobile phone case study	Journal of Cleaner Production 102:302-315	JA	Mobile phones	SLCA	SHDB	i
78	Wu SR, Chen J, Apul D, Fan P, Yan Y, Fan Y, Zhou P	2015	Causality in social life cycle impact assessment (SLCIA)	Int J LCA 20(9):1312-1323	JA	SLCA development	SLCA	Pathway	pp

Legend: JA (Journal Article); CP (Conference Proceedings); BC (Book Chapter); pp (post-positivism); i (interpretivism).

Tab. A.3 PRF Matrix

Risk Factors (working conditions)	Hearing damages	Cardiovascular disease	Gastric cancer	Suicide thoughts	Metabolic syndrome	MSDs				Lower self esteem	Psychological distress	High level of stress perceived	Disability	Osteoarthritis	Chronic bronchitis
						Sciatic Pain	Back Pain	Neck and Shoulders	Upper Limbs						
Noise									1,58 (Stock *et al.* 2006)						
Total Boby Vibrations (tractor driving)						3,9 (Bovenzi and Betta)	1,83 (Bovenzi and Betta, 1994)	2,07 (Stock *et al.* 2006)							
Vibration manual tools(chain saw)									2,44 (Stock *et al.* 2006)						
High physical demand							4,4 (Raeisi *et al.* 2014)	2,1 (Stock *et al.* 2006)	1,66 men (Stock *et al.*)				2,02 (Lahelma, 2012)		
Temporary employment							2,00 (Domenighetti *et al.* 1999)			2,9 (Domenighetti *et al.* 1999)		1,6 (Domenighetti *et al.* 1999)			
Outdoor working environment															1,77 (Kotaniemi *et al.* 2003)
Heavy manual labour														2,8 in agriculture (Rossignol *et al.* 2005)	
Citrus chemicals exposure	1,19 (Crawford *et al.* 2008)		2,88 (Mills and Yang 2007)												
Long working hours >8 to 9 hours/ day				1,38 (Yoon *et al.* 2015)	1,66 (Kobayashi *et al.* 2012)										
Long working hours >9 to 10 hours/day				2,01 (Yoon *et al.* 2015)	1,48; (Kobayashi *et al*, 2012)										

Risk Factors (working conditions)	Hearing damages	Cardiovascular disease	Gastric cancer	Suicide thoughts	Metabolic syndrome	MSDs				Lower self esteem	Psychological distress	High level of stress perceived	Disability	Osteoarthritis	Chronic bronchitis
						Sciatic Pain	Back Pain	Neck and Shoulders	Upper Limbs						
Long working hours >10 hours/day				2,01 (Yoon *et al.* 2015)	(Kobayashi *et al.* 2012)										
Work pressure		3,45 (Siegrist 1996)													
Effort-reward imbalance		6,15 (Siegrist 1996)													
High psychological demand											2,04 (Bourbonnais, 1996)				

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Keywords: quality of life, capability approach, non-compensatory method, rural/inland areas, rural development programs

Jel Code: C43, I31, R58

Well-being and rurality: a spatial tool for rural development programs evaluation

Improving the quality of life of populations is one of the priorities of rural development policies. Based on the *capability* approach, the aim is to realise a *Quality of Life* (*QoL*) index measuring territorial disparities. The *QoL* index, aggregated by a non-compensatory method, is compared with rural and inland areas of the study area, Basilicata region. The analysis shows a clear relationship between features of *QoL* and rurality/peripherality degree and a global *QoL* below the regional average for 61% of municipalities. In these areas, as expected, the high level of environmental protection is offset by lower socio-economic opportunities but, the possibility to evaluate them through an index over time can help policymakers to address rural policies and evaluate their effects.

1. Introduction

There is currently a great interest in the studies and research that assess well-being going beyond economic growth-based analyses. Many authors (Frey and Stutzer; 2002; Boarini *et al.*, 2006; Giovannini *et al.*, 2007) argue that conventional measures based on income, wealth and consumption, are not sufficient to assess human well-being, as they exclude a wide range of key factors, such as environment, state of health, social inclusion, etc. In particular, Stiglitz report (2009) has laid the bases for a multi-dimensional approach to the estimate of well-being vs quality of life. The *Quality of Life* (*QoL*) is similar to the concept of well-being (in the broadest sense). Some authors (Daly and Cobb, 1989; Gigliarano *et al.*, 2014; Kubiszewski *et al.*, 2015) mean the *QoL* as the economic well-being measured by traditional indicators of economic performance, such as the adjusted GDP, but they include non-marketable societal and environmental goods and services. Other authors (Dasgupta, 2001; Stiglitz *et al.*, 2009) emphasise that the *QoL* can be maintained only if the whole of resources are used in a sustainable manner. Different studies are being conducted to calculate – following different routes – a quality of life index based on the potential of the area concerned (Nuvolati, 2003; Buettner

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and Ebertz, 2009; Brereton *et al.*, 2011) with a growing interest to compiling composite indicators of well-being on the local scale (Costanza *et al.*, 2004; Pulselli *et al.*, 2006; Bleys, 2013; Gigliarano *et al.*, 2014; Chelli *et al.*, 2015). In this context, it could be very interesting and useful evaluate a *QoL* index in areas with a high level of vulnerability, such as rural areas and inland areas (characterized by a predominantly rural connotation). The lack of economic opportunities, social isolation, and the difficulties in delivering services typical of such areas, could generate a process of self-reinforcement called "downward spiral", which is difficult to reverse without a sufficient population density or in the absence of factors and specific resources (Cagliero *et al.*, 2011). These issues are of growing weight for the European Union which has decided to include the theme of quality of life among the priorities of the new rural development policy 2014-2020 (reg. 1305/13 art. 20 *Basic services and village renewal in rural areas*).

In the light of the above considerations, the present research is aimed at implementing a spatial decision support tool able to define the geography of the *QoL* on the micro-territorial scale and to identify the endogenous disparities linked to the quality of life in rural areas. The knowledge and integration of data in building information is an essential tool for policymakers. The ability to synthesise complex information is important to compare the state of various geographical contexts and their evolution over time.

To test the significance of the model, it was applied to the Basilicata region, a rural lagging region in southern Italy, comparing the different degrees of *QoL* obtained whit the rural degree of region.

However, since the entire region is classified as rural region according both to European and national classification, without any distinction at local level, we have decided to correlate the *QoL* index with the rural degree obtained by the method developed by Romano *et al.* This method allows to calculate a rural index on a local scale based on the socio-economic and environmental characteristics of a given territory.

The degree of peripherality of inland areas is also considered, based on the definition provided by the National Strategy for Inland Areas (SNAI), a strategy born in 2012 with the aim of supporting the economic and employment growth of these areas and, in cascade, reversing the negative demographic trend (IFEL, 2015).

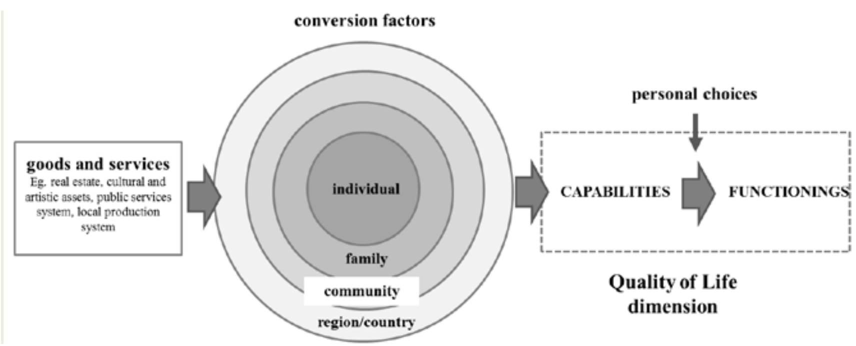
2. Concept of quality life and theoretical approach for measuring

The concept quality of life in literature is strongly rooted in the thinking about health. There are several models which refer to health as an indicator of livability, while in other models quality of life is treated as the determinant of health (Van Kamp *et al.*, 2003). In a schematic model formulated by RIVM (2000) health and livability are, instead, paralleled as two separate dimensions of quality of life.

Mitchell *et al.* (2001) assert «there is no agreement yet on quality of life, in terminology nor in construction methods or the criteria that comprise quality of life». In spite of this Mitchell *et al.* (2001) did try to use its different components. In his approach quality of life consists of health, physical environment, natural resources, personal development and security. In this model the domain of economy is lacking, while others view this as one of the three major pillars (or dimensions) of quality of life with society and environment (Stiglitz, 2009).

According to Sen (1985) the central idea to assess the quality of life is that a process of improvement is not only understood in economic terms but as an extension of the opportunities. In other words, in the language that characterizes the capability approach, material well-being, limited in the standard economic vision to the simple availability of resources, is replaced by the idea of "well-being", understood as a condition that includes "what the individual can or can do" from the resources and means available and in relation to individual conditions (sex, age, natural predisposition, level of education), but also depends on the place where they live (family, social and territorial conditions) (Biggeri and Chiappero, 2010). The set of these potentially achievable (capability set) or actually accomplished (functioning) goals contributes, overall, to determine the individual quality of life. With equal resources, people may have different chances of transforming these resources to achieve certain results. In particular, we want to focus the attention on the territorial factor at community level (Fig. 1).

Fig. 1. Capability approach for measuring quality of life



3. Materials and methods

3.1 Model setting and analysis of set of indicators

The assumed model is based on the relationship between the level of quality of life of the individuals living in the *i-th* municipality (QoL_i) and the level of existing opportunities in a given area (t_r), including the services s_r provided in the *i-th* area.

The basic assumption is that the individual well-being may be expressed as:

$$QoL_i = f(\bar{y}, t_r) \tag{1}$$

where: $t_r = f(s_r)$

$\bar{y}$ is the vector of individual conditions (employment, gender, etc.) that result to be exogenous to the model.

The indicators that most contribute to defining varying levels of *QoL* are important to emphasise the territorial disparities in well-being (Boncinelli *et al.*, 2015), depending on the availability of data at the level of detail required, which is quite high in the present analysis. Essential factors, such as criminality or social exclusion, are missing.

The dataset applied to develop the model includes a set of basic indicators derived from different sources (ISTAT, property market Observatory, regional technical map, ISPRA, river basin authority, etc..) that have been grouped in thematic areas and further categorised based on the relevant dimensions (economic, social and environmental) (Appendix Tab. A.1).

The indicators relating the economic dimension concern the number of bank branches and the average estate prices as *proxy* of the economic well-being and of the economic opportunity of an area. Indeed the assumption is that the number of bank branches in a municipality is proportionate to the population and to the amount of operating volumes (loans and deposits). The average estate prices of the last five years reflect the economic dynamism of an area and depend, for instance, on population trends and on the level of the "services and quality" provided (Rosen, 1974).

As for the social dimension, the study included the spread and proximity to services/structures/activities that exercise a decisive influence not only on the everyday life organisation of a community, but also on its mobility and degree of external dependence. The presence of healthcare settings is an essential condition influencing citizens' security, or their possibility to receive preventive care services and appropriate treatment. These services are widespread, although access to them may vary for the citizens of different municipalities.

Other factors were included, such as the spread and proximity of education services, recreational facilities (camping sites, sports structures, playgrounds) and cultural activities (libraries, cinema, museums, theatres, etc.), non-decentralised departments (courts, chambers of commerce, etc.). To take into account proximity, the travel time to reach different services was calculated by the isochrones method, via the Network Analysis, using the GIS (Wang *et al.*, 2012). Among daily trips that influence the organisation of everyday life, those related to work or study were shown to be prevailing, so they were used to derive the home-work mobility rate and the mean journey time.

In relation to the environmental dimension, which is meant as the ability to supply essential goods and services for human well-being, the analysis included population equivalents (ISTAT, 2016) that reflect the estimated pollutant load produced by domestic and economic activities; the proximity to waste dumps and industrial areas that may affect the environmental health; the availability and extent of areas characterised by high ecological-nature value; and the presence of factors of environmental risk (hydro-geological and seismic risks).

To capture accurately the relationships among the basic indicators and to identify if the indicators are able to discriminate disparities in quality of life within rural and/or inland areas, a Pearson correlation test was applied. This comparison has been made possible using the Rural Areas classification (RAc) of the region into eight areas characterised by a different rurality level proposed by Romano *et al.* (2016) and the Inland Areas classification (IAc) of the region into five areas proposed by Agency for territorial cohesion (2014).

3.2 Aggregation of indicators by a non-compensatory method

Quality of Life measurement is an ambitious and complex objective that poses many problems of theoretical, empirical and methodological nature. It is a multidimensional phenomenon that is not directly measurable, the evaluation of which depends largely on arbitrary choices of the researcher: selection of elementary indicators, standardization, weight allocation, choice of aggregation function, presentation of results, etc. In fact, the idea of summarizing complex phenomena into single numbers is not straightforward, with a series of pros and cons (Zhou and Ang, 2008); in particular, it involves the risk of losing valuable information that is evidently characterizing the geographic areas. It involves both methodological assumptions that need to be assessed carefully to avoid producing results of dubious analytic rigour (Saisana *et al.*, 2005).

Despite methodological limits, synthetic indexes are widely used by many international bodies to measure economic, environmental and social phenomena (UNDP, 2001; OECD, 2008 UNDP, 2010; Annoni and Kozovska, 2010) and for this they are a very modern and evolving tool.

The literature on synthetic indicators offers a wide variety of aggregation methods (Bandura, 2008; Wu and Barnes, 2011; Cozzi *et al.*, 2014; Cozzi *et al.*, 2015b, Cozzi *et al.*, 2015c). The possible choices to reach a synthetic index are numerous and range from descriptive statistics tools to multivariate analysis techniques, as Principal Component Analysis[1] (automatic weighting) (Dunteman, 1989), from the adoption of distance measurements (taxonomic method of Wroclaw) to the application of linear and non-linear functions. The most used are additive methods that range from summing up unit ranking in each indicator (equal weighting) to aggregating weighted transformations of the original indicators (expert weighting). In particular, additive methods that give explicit weights to each indicator and sum the product of each indicator and its weight, assume a full compensability among the different dimensions (eg. a good standard of living can compensate for any educational deficit and vice versa), but it is often not de-sirable to compensate for the main components of the phenomenon. To overcome these difficulties, some authors have proposed multiplicative aggregation methods, such as the geometric mean; for example, in 2010, the Human Development Index - HDI formula has changed from an arithmetic average to a geometric mean (UNDP, 2010). However, the geometric mean assumes that the syn-thesis sum is of multi-plicative nature, rather than additive, and assigns a higher weight to the lower values and cannot be calculated in the presence of negative or null values, eg. in our case the number of bank branches.

For this reason, an alternative synthetic index is proposed which, starting from a linear aggregation, introduces a penalty for municipalities with "unbalanced" values of the indicators compared to the average.

The method of the coefficient of variation penalty (Mazziotta and Pareto, 2015) was applied in order to develop the composite indicator. This method enables building of a synthetic measure of quality of life for each territorial unit x_i, assuming that each component of the *QoL* is non substitutable or is only partially substitutable. This approach requires a balanced supply of all basic components.

The method involves standardising indicators using a transformation criterion to release them from their units of measurement and variability (Delvec-

[1] The PCA is a multivariate statistical method of synthesis that follows a compensatory approach, starting from a large number of individual indicators, allows us to identify a small number of composite indices (factors or components) that explain most of the variance observed. The composite indicex so obtained are a linear combination of the individual indicators with weights that maximize the variation in the aggregated index values, over all possible choices of weights.

chio, 1995). Therefore, basic indicators have been corrected so as to be ranged within the same scale, by transforming each indicator in a standardised variable with an average of 100 and a mean square deviation of 10; the values obtained will be approximately comprised within a range 70-130.

Thus, once the matrix of n rows (territorial units) and m columns (basic indicators) was constructed, the next step was the matrix $Z = \{z_{ij}\}$:

$$z_{ij} = 100 \pm \frac{\left(x_{ij} - M_{x_j}\right)}{S_{x_j}} 10 \tag{2}$$

where $M_{x_j} = \frac{\sum_{i=1}^{n} x_{ij}}{n}$ is the average and $S = \sqrt{\frac{\sum_{i=1}^{n}\left(x_{ij} - M_{x_j}\right)^2}{n}}$ is the mean square deviation.

Then the aggregation function, Mazziotta-Pareto Index (MPI) was "corrected" by a penalty coefficient that depends, for each territorial unit, on the degree of variability of indicators from the mean value ("horizontal variability").

$$MPI_i^{+/-} = M_{z_i} \pm S_{z_i} cv_i \tag{3}$$

The arithmetic mean (M_{zi})of standardised indicators is corrected by subtracting an amount (the product $S_{zi}cv_i$) proportional to the mean square deviation, and is direct function of the coefficient of variation.

This variability, measured by the coefficient of variation (cv_i), penalises the scoring of the units with the highest imbalance between the values of indicators and, hence, an imbalanced supply. The use of standardised deviations (S_{zi}) enables a robust measure that is not influenced by the elimination of a single basic indicator (Mazziotta and Pareto, 2015). The main disadvantage lies in the possibility of making only 'relative' comparisons of the values of units over time, with respect to the average.

The method has been applied to calculate the *QoL* for each dimension, economic dimension (*EcQoL*), social dimension (*SocQoL*), environmental dimension (*EnvQoL*) and then to calculate a global *QoL* (*TotQoL*) that takes into account all basic indicators.

4. Results and discussion

The study has provided an initial response to the following questions: Is there a relationship between indicators of quality of life? How do the rural and inland areas differ relative to indicators, such as education, healthcare, work-life balance, etc.? Is it useful the use of a composite indicator to evaluate disparities in quality of life within these areas?

The Pearson's r data analysis revealed for $-0.7<P_{XY}<-0.3$: a negative correlation of PPR with TTH (r=-0.32) and TTS (r=-0.30), a negative correlation for BBN with TTH (r=-0.48), TTS (r=-0.37) and TTA (r=-0.31); a negative between IET and AHE (r=-0.31).

The Pearson's r data analysis revealed for $0.3<P_{XY}<0.7$: a positive correlation of PPR with PSp (r=0.38), PFT (r=0.34). and a positive correlation of BBN with PEd (r=0.58), PSp (r=0.53), PFT (r=0.50) and LR[2] (r=0.35); a positively correlation of PEd with PSp (r=0.45) and PFT (r=0.51); IET and LR (r=-0.37).

The Pearson's r data analysis revealed for $P_{XY}>0.7$: a positive correlation between BBN and IET (r=0.82), for IET with PSp (r=0.78) and PFT (r=0.71), between Psp and PFT (r=0.94).

The other indicators: MDWS, PDWS, TTC, TTG, PAI, DI, DL and SR are weakly correlated (Appendix Tab. A.2).

The correlation analysis shows a relevant aspect: economic opportunities are positively correlated with increased presence and accessibility of basic services, but also sporting services and free time. It means that if one of the QoL features decreases tend to decrease other features as well, but where more features are significantly scarce, it is easy to verify the risk of social and economic marginalization (par. 1). This highlights the need to aggregate these factors and therefore supports the proposal to use composite indicators.

The Pearson correlation test shows that indicators have a similar correlation between rural e inland areas classifications, but never strong: PPR (r_{RAc}=-0.32; r_{IAc} =-0.15) and BBN (r_{RAc}=-0.50; r_{IAc}=-0.70) have a negative correlation, which are then characterized by more limited economic opportunities; longer travel times to reach health and educational facilities (TTH – r_{RAc}=-0.43; r_{IAc}=-0.31), (TTS – r_{RAc}=-0.36; r_{IAc}=-0.14) and less school infrastructures[3] (Ped – r_{RAc}=-0.11; r_{IAc}=-0.30); also for cultural and sports-recreational opportunities there are longer travel (TTC – r_{RAc}=0.19; r_{IAc}=-0.21, TTG – r_{RAc}=0.13; r_{IAc}=0.06) times and less widespread facilities (PSp, r_{RAc}=-0.32; r_{IAc}=-0.35 , PFT – r_{RAc}=0.21; r_{IAc}=-0.29).

As to the environmental dimension, there is a significant difference in terms of pollutant load produced by domestic and economic activities (IET - r_{RAc}=-0.57; r_{IAc}=-0.58), and higher environmental health, mainly due to re-

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2 The positive correlation of LR with BBN and PEd is influenced by the municipality of Potenza characterised by a high risk of landslides and high percentage of Bank Branches Number and Education services.

3 89% of these infrastructures are nurseries and secondary schools.

moteness of industrial areas and waste dumps ((DI - r_{RAc}=0.19; r_{IAc}=0.21; DL - r_{RAc}=0.31; r_{IAc}=-0.18) in rural and inland areas. Additionally, there are more areas with a high ecological and conservation value (AHE – r_{RAc}=0.56; r_{IAc}=0.28). On the other hand, it would cause possible major risks for landslides (LR[4] – r_{RAc}=0.18; r_{IAc}=-0.24) and earthquakes (SR - r_{RAc}=0.16; r_{IAc}=0.14), which also affect the quality of road infrastructures. MDWS and PAI are unrelated (0.0_) (Tab. 1).

The analysis has made it possible to deepen the knowledge about the endogenous dynamics within rural/inland areas, which are affected by the same issues in relation to indicators such as education, healthcare, work-life balance, etc., and has validated the consistency in identifying the indicators (chosen on a bibliographic basis) to the study area and respect to the target.

From a methodological point of view, mapping data has also enabled the identification of macro-areas characterized by similar conditions relative to some indicators, revealing marginalized contexts, some distinctive examples of which are mentioned below. As to the percentage distribution of school facilities (0-43% range), there is a macro-area North-West of the region's chief town, where the rate is <7%. On the other hand, there are 45 municipalities mostly concentrated in the inland part of the region, with an average population density of 29 inhab./km^2, where there are no bank branches.

The model, applied to the Basilicata region, assumes a *TotQoL* variable in a range of values comprised between 93 and 105 (Tab. 2), with 61% of municipalities characterized by a *TotQoL* below the average (=100). At the regional level, there is a low percentage (39%) of municipalities with a *TotQoL* above the regional average (=100) (Fig.2; Graph 1a); moreover, there is a significant difference between the municipalities in the province of Potenza (PZ) and those in the province of Matera (MT), with values of respectively 31% and 65% above the regional average.

The *EcQoL* (91–130) is characterized by a wide variation range (St. Dev. = 5.9) with a max value that is considerably spaced from the average (Tab. 2), but with 53% of municipalities characterized by a value of EcQoL below the average (Fig. 2). This means that these values, although high, affect very few municipalities in relation to the general condition that appears to be below the regional average or otherwise around the mean. The SocQoL (88–113) is characterized by a less wide variation range (St. Dev. = 4.1) with min and max that are almost equally distanced (Tab. 2), with 60% of municipalities characterized by a SocQoL below the average (Fig. 3). The EnvQoL (73–109) is charac-

4 LR reveals a different correlation between RAc and IAc, respectively weakly positive and negative, probably beacause RAc classification includes the average altitude.

Tab. 1. Comparison of basic indicators with rural areas and internal areas classification with Pearson correlation test

Elementary indicators	Acronym	Pearson r	
		RAc*	IAc**
Average Purchase Prices of Real estate	PPR	-0.319817	-0.149603
Bank Branches Number	BBN	-0.497384	-0.690117
Mobility rate Domicile-Work/Study	MDWS	0.043947	0.089247
Proximity rate Domicile-Work/Study	PDWS	-0.108996	-0.137296
Travel Time to reach Hospital structures	TTH	0.427522	0.314290
Travel Time to reach Secondary schools	TTS	0.356735	0.142477
Percentage of Education services	PEd	-0.109025	-0.301323
Travel Time to reach Administrative offices	TTA	0.055945	0.395281
Travel Time to reach Cultural activities	TTC	0.193830	0.211334
Travel Time to reach Green spaces	TTG	0.133139	0.057621
Percentage of Sport facilities	PSp	-0.324291	-0.348279
Percentage of Free Time facilities	PFT	-0.211271	-0.290176
Percentage of Population coverage with Access to Internet between 2 Mbps e 20 Mbps	PAI	-0.087996	0.019062
Inhabitant Equivalent Total	IET	-0.568086	-0.579699
Distance from Industrial areas	DI	0.192221	0.214515
Distance from Landfills	DL	0.307542	0.178390
Areas percentage with High Ecological-naturalistic value	AHE	0.559761	0.281918
Landslide risk	LR	0.180781	-0.238521
Seismic risk	SR	0.158237	0.136672

Note: * Rural Areas classification; ** Inland Areas classification
With: $P_{XY}>0$ positive correlation; $P_{XY}=0$ no correlation; $P_{XY}<0$ negative correlation; $0<|P_{XY}|<0.3$ weak correlation; $0.3<|P_{XY}|<0.7$ moderate correlation; $|P_{XY}|>0.7$ strong correlation.
Source: our processing.

terized by a slightly wider variation range than the SocQoL (St. Dev. = 4.5), but with a min that is considerably spaced from the average (Tab. 2); 56% of municipalities are characterized by an EnvQoL below the average (Graph 1a).

The analysis of the data reveals a significant difference between the two provinces, partly related to the morphological diversity of the territory: the province of Potenza is characterized by a mainly mountainous (Apennines)

Tab. 3. Descriptive statistics on *EcQoL*, *SocQoL*, *EnvQoL* and *TotQoL*

Statistics	*EcQoL*	*SocQoL*	*EnvQoL*	*TotQoL*
Min	91	88	73	93
Max	130	113	109	105
Average	100	100	100	100
St Dev	2.5	4.1	4.5	2.5

Source: our processing.

Fig. 2. Spatial distribution of TotQoL

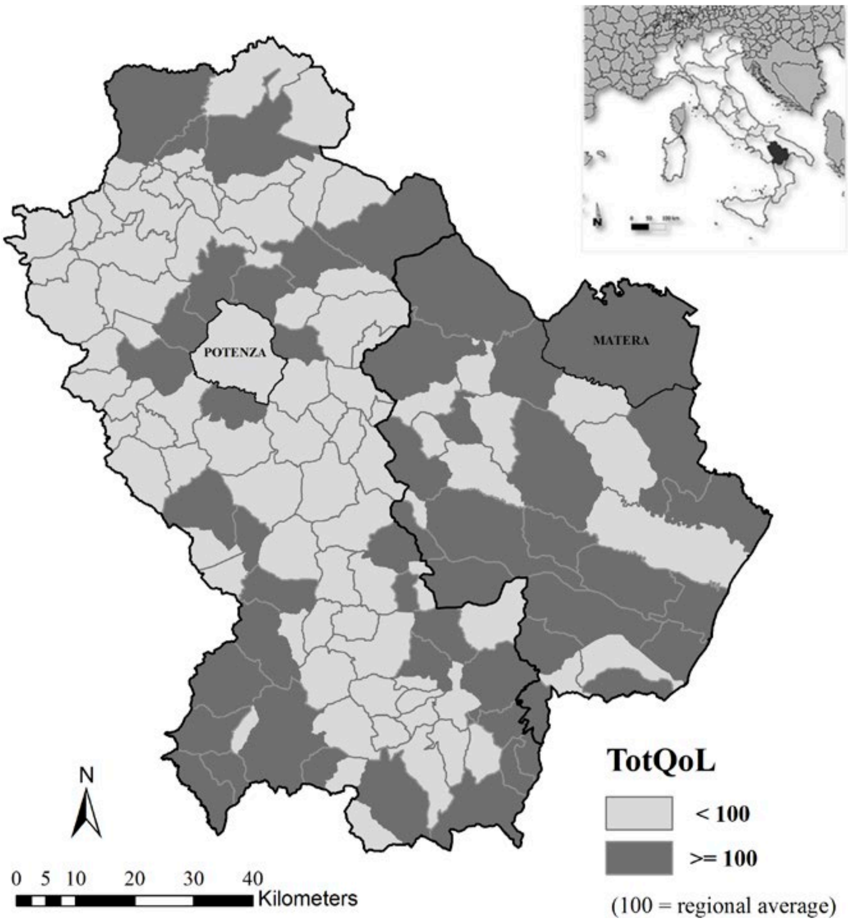
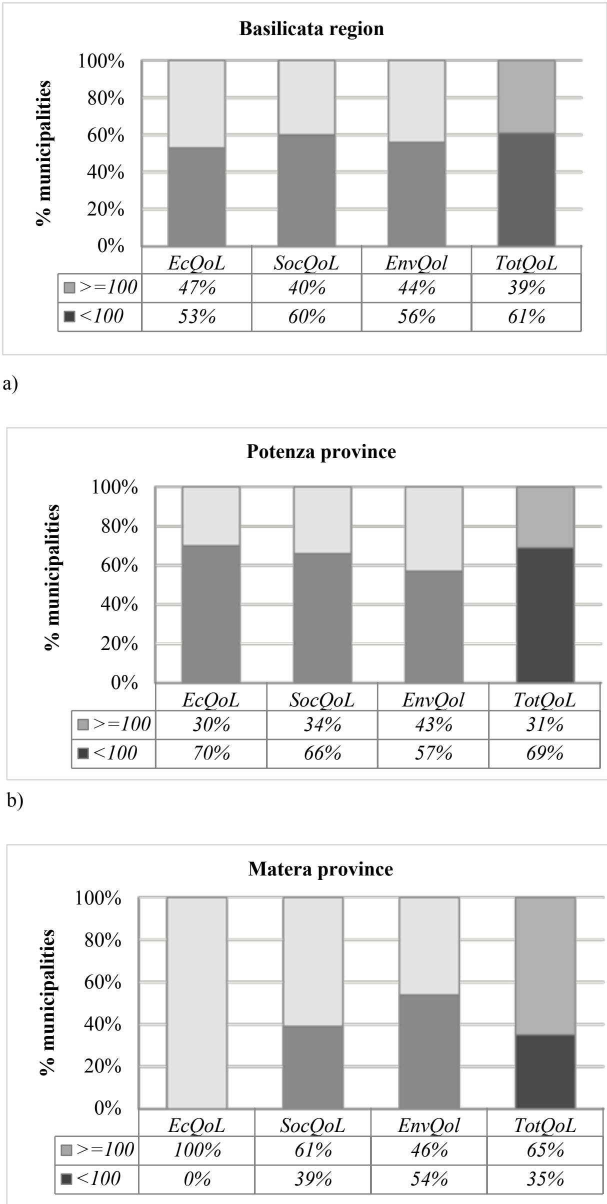


Fig. 3. QoL at regional level (a) and provincial level (b, c)



c)

and hilly territory (clay soils in 45.13% of the region, subject to erosion resulting in landslides), while the flat part (8% of the region) is concentrated in the province of Matera along the Ionian coast.

Considering that the regional population is mostly concentrated in large centres, the distribution in percentage is the following: 56% live in the 12 largest towns in the region, 27% live in medium-sized centres, namely those between 5,000 and 9,999 inhabitants, and the remaining 17% live in small towns, which are mostly concentrated in the province of Potenza (82 municipalities out of 100 are below 5,000 inhabitants, 52 of which below 2,000 inhabitants).

By comparing the national classification of Inland Areas based on their peripherality from essential services, the variables identified for calculating the *QoL* allow a more complete and accurate reading of the sub-regional territory. Different areas can actually have a positive or negative connotation in relation to the general context, depending on the dimension concerned. The factors considered, in fact, allow to discriminate in a more precise manner the imbalances on the territory, highlighting, for example, the areas that have developed autonomously, in terms of many important services, even though – or maybe simply because – they are distant from the hubs. Moreover, it includes not only weaknesses, but also territories that may be less "attractive" in relation to the level of services offered; they also involve strengths, related to their still unexploited potentials (this is the case of the areas of great natural value that could offer important opportunities for tourism, recreation and gastronomy) (Prete *et al.*, 2017).

5. Conclusions

Currently, the Common Framework for Monitoring and Evaluation (European Commission, 2016) does not provide a definition of the concept of quality nor the size to be investigated to determine the impacts produced by rural development programs. So, the proposed methodology offers the possibility to use a series of appropriately aggregated indicators that allow to define for an overall picture compared to the overall objective (improving the quality of life within rural areas) in order to identify the situations of marginality.

From a metrological point of you the paper proposes a model to determine multidimensional levels (economic, social and environmental) of quality of life linked to the territory, adopting capability approach.

Innovative element is the use of a non-compensatory synthetic indicator which lies in the possibility of "awarding" the territorial units characterized by a balancing of all indicators. Moreover is important to highlight that this work, overcoming the classical urban-rural comparison, proposes a tool that offers a new reading key capable of grasping endogenous disparities within rural/inland areas.

Results show that there are areas with different levels in quality of life indicating marginalized situations. In addition to the physical and demographic characteristics of the territory, the provision of basic but also of leisure services results to be differentiated. On average, to have access to different services provided at the local level, the populations of most rural and inland municipalities use more time (and resources) as compared to less rural and inland municipalities, where those services are more common for a higher concentration of resident population.

The *policy makers* should thus pay special attention to the problems related to the accessibility of these services, and should try to maintain them locally. The possibility of ensuring ubiquity of services would help reduce the abandonment of these areas, starting from marginal ones. Within the framework of rural development policy, the abandonment of these areas would jeopardise the "maintenance" of the territory by reducing "non-market" services (ecosystem services). The smallest municipalities are the most sensitive, so they would need greater attention. For example, forms of association between municipalities could be encouraged (d.gls 267/2000), also envisaged in the SNAI.

Although the methodology is applied successfully, it would be useful to make more detailed evaluations in spatial terms, taking into account the time factor in order to determine increasing/decreasing trends. In this sense a limitation could be the availability of data, although national and international statistical offices provide more and more helpful information to improve and derive realistic indicators.

In conclusion, the proposed framework, applied to the Basilicata region and repeatable in other territorial contexts, can present a useful tool in the current political context in the implementation of actions aimed at gradually reducing regional disparities in terms of quality of life, that follow these goals:

- address of interventions, which should take into account balanced growth of the (economic, social and environmental) dimensions of quality of life: the observation of the constituent components of the index makes it possible to define more specific addresses on which to focus the attention and resources available, the latter being made up of Community funds managed by the Regions (for market intervention) and resources specifically intended from Laws of Stability 2014 and 2015 (for action on citizenship). In addition, all Rural Development Programs have taken into consideration the objective of the National Strategy for Domestic Areas to a different extent from Region to Region;
- ex-ante and ex-post effects evaluation of the carried out interventions, as a synthetic "measure" of achievements in terms of improving the quality of

life; global *QoL* provides an overall idea, a "meter" to measure delta compared to the regional average and hence the endogenous disparities in the quality of life of rural and inland areas;
- finally identification and, if necessary, redistribution of the areas that need priority interventions and resources.

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Appendix

Tab. A.1 List of indicators included in the model

Dimensions	Thematic areas	Correlation with QoL	Indicators	Calculation method	Unit of measure	Data source	Reporting year
Economic dimension	Economic opportunities of the territory	+	Average Purchase Prices of Real estate (PPR)	-	€	Italian Real estate market monitor	2010-2014
		+	Bank Branches Number (BBN)	-	number	Bank of Italy	2015
Social dimension	Proximity to places of work/study	-	Mobility rate Domicile-Work/Study (MDWS)	(Individuals number who move to onother town/ residents number)*100	%	Elaboration on ISTAT data – Census population 2011	2011
		+	Proximity rate Domicile-Work/Study (PDWS)	(Individuals number who emply <15 minutes to reach work/study/ residents number)*100	%	Elaboration on ISTAT data – Census population 2011	2011
	Spread and proximity to health and educational facilities	-	Travel Time to reach Hospital structures (TTH)	-	minutes	Our GIS processing - CTR	2015
		-	Travel Time to reach Secondary schools (TTS)	-		Our GIS processing - CTR	2015
		+	Percentage of Education services (PEd)	(School number/ population density)*100	%	Our GIS processing - CTR	2015
	Proximity to non-decentralized services	-	Travel Time to reach Administrative offices (TTA)	-	minutes	Our GIS processing - CTR	2015

Dimensions	Thematic areas	Correlation with QoL	Indicators	Calculation method	Unit of measure	Data source	Reporting year
Social dimension	Cultural and recreational facilities	-	Travel Time to reach Cultural activities (TTC)	-	minutes	Our GIS processing - CTR	2015
		-	Travel Time to reach Green spaces (TTG)	-	minutes	Our GIS processing - CTR	2015
		+	Percentage of Sport facilities (PSp)	-	%	Our GIS processing - CTR	2015
		+	Percentage of Free Time facilities (PFT)	-	%	Our GIS processing - CTR	2015
	Broadband access	+	Percentage of Population coverage with Access to Internet between 2 Mbps e 20 Mbps (PAI)	Individual number coverage with access to internet between 2 Mbps e 20 Mbps/resident number)*100	%	www.Infratelitalia.it	2015
Environmental dimension	Environmental health	-	Inhabitant Equivalent Total (IET)	1 inhabitant equivalent = 60 grams od Bod5	inhabitants	ISTAT	2009
		+	Distance from Industrial areas (DI)	-	meters	Our GIS processing - CTR	2015
		+	Distance from Landfills (DL)	-	meters	Our GIS processing – CTR	2015
	Nature conservancy	+	Areas percentage with High Ecological-naturalistic value (AHE)	(High ecological-naturalistic areas/ municipal areas)*100	%	ISPRA	2010
	Risk factors	-	Landslide risk (LR)	Landslide risk areas (R1, R2, R3, R4)/municipal areas)*100	%	Basin Authority	2015
		-	Seismic risk (SR)	-	Classes	www.utsbasilicata.it	2012

Source: our processing

Tab. A.2 Pearson correlation matrix for basic indicators

COR. MATRIX	PPR	BBN	MDWS	PDWS	TTH	TTS	PEd	TTA	TTC	TTG	PSp	PFT	PAI	IET	DI	DL	AHE	LR	SR
PPR	1																		
BBN	0.16161	1																	
MDWS	0.02954	-0.00331	1																
PDWS	-0.05372	-0.03696	0.063943	1															
TTH	-0.32465	-0.47543	0.02215	-0.03079	1														
TTS	-0.30185	-0.37313	0.00317	-0.01856	0.29910	1													
PEd	0.17527	0.57604	0.13254	0.014802	-0.19636	-0.21209	1												
TTA	-0.10105	-0.31176	0.02818	-0.10887	0.07829	0.19447	-0.25692	1											
TTC	-0.01868	-0.17004	0.052824	-0.18155	0.04160	0.16431	-0.03308	0.00504	1										
TTG	-0.08548	-0.13941	-0.07657	-0.04841	0.14483	0.21487	-0.06980	0.18121	0.06749	1									
PSp	0.38396	0.52941	0.06676	-0.20904	-0.27917	-0.25605	0.45015	-0.01651	0.08565	-0.07971	1								
PFT	0.34418	0.49739	0.06748	-0.23846	-0.20820	-0.19657	0.50607	-0.02759	0.04757	-0.13992	0.94495	1							
PAI	0.07049	0.13058	-0.00686	0.08241	-0.03365	-0.04777	0.170819	0.00994	-0.15398	0.03190	0.11936	0.13308	1						
IET	0.24285	0.81826	0.09317	-0.11917	-0.45248	-0.39506	0.43476	-0.1035	0.01019	-0.14400	0.77814	0.70703	0.12417	1					
DI	-0.11166	-0.08467	0.02357	0.00954	-0.18135	-0.02897	-0.01589	-0.14438	-0.00103	-0.04958	-0.15464	-0.11358	0.05919	-0.15018	1				
DL	-0.22580	-0.22313	0.00019	-0.02495	0.19262	0.38681	-0.24776	0.16635	0.03837	0.02880	-0.16253	-0.09739	0.00748	-0.20646	0.04787	1			
AHE	-0.05304	-0.20116	-0.03411	-0.10259	0.12367	0.06287	-0.16868	-0.17757	0.19019	0.05768	-0.17498	-0.14149	-0.06701	-0.30819	0.29632	0.20316	1		
LR	0.00294	0.35309	0.00149	0.09054	0.05063	-0.05026	0.37098	-0.35296	0.03544	0.03074	0.00144	0.04036	-0.10109	0.10761	-0.04193	-0.07027	0.14403	1	
SR	0.26158	0.12356	-0.05058	-0.06514	-0.05607	-0.11851	0.15833	-0.29504	0.08572	-0.01829	0.23269	0.23829	0.02159	0.18461	-0.05812	-0.23138	-0.13577	0.08048	1

Note: $P_{XY} > 0$ positive correlation; $P_{XY} = 0$ no correlation; $P_{XY} < 0$ negative correlation; $0 < |P_{XY}| < 0.3$ weak correlation; $0.3 < |P_{XY}| < 0.7$ moderate correlation; $|P_{XY}| > 0.7$ strong correlation.

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The "REDUCE" project: definition of a methodology for quantifying food waste by means of targeted waste composition analysis

"REDUCE" (Research, Education, Communication: an integrated approach for food waste prevention) is a biennial project on food waste funded by the Italian Ministry of the Environment and managed by the DISTAL Department at the University of Bologna, with four partners. This paper focuses on a specific research activity related to the definition of a methodology for the quantification of food waste by means of waste composition analysis. This methodology implies the physical separation, weighing, and classification of food waste found in representative samples of municipal waste entering the treatment facilities. The objectives of the research activity, the main steps of the methodology, and some preliminary results are presented in the paper.

1. Introduction

Every year, at the global level, roughly one-third of food suitable for human consumption is unnecessarily wasted or lost, leading to an inefficient use of natural resources, economic costs, and social implications (FAO, 2011; Koivupuro *et al.,* 2012). In the European context (EU-28), the amount of food waste, including the inedible fraction, was estimated equal to 88 million tons in 2012, with around 50% occurring in the household sector (Stenmarck *et al.,* 2016). Due to this massive generation, there is an urgent need to prevent and reduce food waste. The European Commission has set the target to halve the disposal of edible food by 2020 in its Roadmap to a Resource Efficient Europe (European Commission, 2011). In addition, in the revision of the European Waste Framework Directive 2008/98/EC (European Commission, 2015), Member States are required to establish prevention measures specifically related to food waste, in line with the goal 12.3 of the 2030 Agenda for Sustainable Development adopted by the United Nations (by 2030, halve per capita global food waste at the retail and consumer levels).

According to this framework, the Italian Ministry of the Environment has recently funded "REDUCE", a biennial project of Research, Education, and

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Communication on food waste managed by the Department DISTAL at the University of Bologna with the collaboration of four research partners. Among its specific objectives, the project aims at improving the knowledge related to the amount, composition, and causes of food waste at the household level. In the existing literature, different methodological approaches have been used to quantify and classify the domestic food waste. These approaches can be divided into three main categories: measuring and reporting by the consumer (questionnaires, interviews, and kitchen diaries), food waste composition analysis, and estimates from statistical data. Each methodology shows advantages and disadvantages (Tab. 1) and for this reason a combination of the three methods is recommended (Koivupuro *et al.,* 2012; Jörissen *et al.,* 2015).

This paper focuses on the methodology of waste composition analysis, used to physically separate, weigh and categorize the food waste. In the recent literature on the topic, a number of authors have applied this methodology in different European countries by analyzing the content of waste bins of a number of representative households. All these authors found large potentials for food waste minimization among the European households, since the avoidable fraction ranges from 35% to 60% by weight of the overall food waste and it is mainly composed of perishable products (Tab. 2).

2. Objectives of the research activity

This paper is related to the specific research activity consisting in the definition of a standard methodology for the quantification of food waste by means of waste composition analysis at the treatment facilities. This methodology is based on physical separation, weighing, and classification of food waste contained in two municipal waste fractions: the residual waste and the organic waste from separated collection. The ultimate goal of the research is to incorporate the methodology into the periodical waste analyses carried out by local authorities and environmental protection agencies, in order to provide historical series of data specifically related to food waste at the national level. Food waste statistics may contribute to raise awareness among citizens as well as to support the definition and the monitoring of specific prevention measures.

The following sections of the paper are dedicated to the description of the methodology with specific reference to the municipal residual waste. The methodology for the residual waste was defined in cooperation with Conai (the Italian National Consortium for Packaging waste), which performs periodical analyses on the waste delivered to incineration plants.

Tab. 1. Main methodological approaches for the quantification and classification of food waste at the household level: definition, advantages and disadvantages (Lebersorger and Schneider, 2011; Koivupuro *et al.*, 2012; Møller *et al.*, 2014; Jörissen *et al.*, 2015; World Resources Institute, 2016)

Methodological approach	Definition	Advantages	Disadvantages
Interviews and questionnaires	Gathering of information on food waste (attitudes, beliefs, and behaviours) from a large number of individuals through a set of structured questions	- Methodically simple approach to collect qualitative information about food waste	- Possible will of the respondents to present themselves in a positive light (respondents tend to underestimate their losses when self-reporting or they tend to give “socially accepted answers”)
Kitchen diaries	Participants measure their own food waste and record its quantity and other information (type, reason of disposal) on a regular basis	- Collection of detailed data about the composition and the reason of each single disposal - The influence of socio-demographical, behavioural and attitudinal factors can be investigated	- Possible underestimation of food waste due to: 1. participants may forget to record or decide not to record part of food waste due to the significant effort required by the activity 2. changes in the handling of foodstuff during the test
Waste composition analysis	Physical separation, weighing, and classification of food waste from representative samples of municipal waste. The analysis is performed by a third party	- More objective and accurate analysis compared to consumer self-measurement methods - Possibility to apply the methodology to the traditional analyses of the municipal waste	- Lack of a standard methodology and inconsistency in the definitions reported in the existing literature - High degradation of the waste that can affect the separation and the identification of single items - No information about the reasons behind the disposal - Poor representativeness of the analysed sample
Estimates from statistical data	- Estimate based on the difference between the supply of food and what was eaten (nutrition data) for a specific geographical area - Estimate from municipal waste statistics	No involvement of consumers	Estimates may be prone to uncertainties mainly due to the used assumptions and models

Tab. 2. Structure of food waste in different European countries acquired through household waste composition analysis (literature review)

Source	Country	Type of analysed municipal waste	Food waste	Avoidable food waste	Composition of the avoidable food waste
Edjabou M.E. et al. (2016)	Denmark (1474 households)	Residual Waste [1]	85 kg/inhabitant/year	*56%* of food waste	Mainly vegetable products (*71%*) [2]
Lebersorger S. and Schneider F. (2011)	Austria (137 sample units)	Residual Waste	33 kg/inhabitant/year	*56%* of food waste	Mainly vegetables (*18%*), bread (*15%*), confectionery/desserts (12%), meat (11%)
Schott A.B.S. et al. (2013)	Sweden (2590 households)	Residual waste and separately-collected food waste	175 kg/household/year	*34%* of food waste	Not reported
Ventour L. (2008)	United Kingdom (2138 households)	Residual waste and separately-collected food waste	96 kg/inhabitant/year	*61%* of food waste	Potatoes, slices of bread and apples resulted the most wasted products

[1] In the studied area, food waste was neither source-segregated nor accepted at recycling stations.
[2] Vegetable products include non-animal derived food like fresh vegetables and salads, fruit, bakery, drinks and confectionery, canned food.

3. Materials and methods

The development of the methodology has included:

- the assumption of a reference definition for food waste;
- the evaluation of possible classifications of food waste into subcategories;
- the definition of a standard procedure for the analysis at waste treatment facilities in cooperation with Conai.

3.1 Food waste definition

In this study, the definition of food waste proposed in the context of the European Project “FUSIONS” was considered (Östergren *et al.,* 2014). According to this definition, food waste includes all food products and beverages intended for human consumption and discarded, with the associated inedible elements. Pet food, medicines, cigarettes, and food packaging are thus excluded.

3.2 Possible classifications of food waste

The defined methodology also includes a classification of food waste into subcategories. According to the FUSIONS Project guidelines, which recommend including the inedible elements in the estimation, food waste is classified into three main categories (Quested and Johnson, 2009):

- *avoidable food waste*, composed of edible material, at some point prior to disposal, which was discarded regardless of the reason (the category includes edible, stale, mouldy or out-of-date food products and beverages);
- *possibly avoidable food waste*, composed of edible parts of food, which some people eat and others not (e.g., apple skin), or that can be eaten when prepared in one way but not in another (e.g., potato skins);
- *unavoidable food waste*, i.e. parts of food which are inedible under normal circumstances (for example meat bones, used tea bags, and apple cores).

In order not to leave room for subjective interpretations, each element is classified among the three categories according to the characteristics of edibility defined in the context of the FUSIONS Project (Tostivint *et al.,* 2016). This source provides a complete list of edible, technically edible, and inedible parts of food (Tab. 3). Whole products including different components (for example a banana composed by the flesh intended for human consumption and by the inedible peel) are considered avoidable in this methodology, following the

Tab. 3. Examples of edible, technically edible, and inedible parts of food for some fruit and vegetable products. The complete list is available in Tostivint *et al*. (2016)

Product	Classification		
	Edible	Technically edible	Inedible
Apple	Flesh	Skin	Core/stem
Orange and other citrus fruits	Flesh	Skin	Stem
Stone fruits	Flesh	Plum and peach peel	Stone/mango and avocado skin
Banana	Flesh	-	Skin
Carrot/cucumber/courgette	Flesh	Peel	Top/end/stalks
Onion	Flesh	-	Sprouts/peel
Peas	Peas	-	Pea pods

example of other studies related to food waste analysis (Quested and Johnson, 2009; Edjabou *et al.*, 2016).

After this first classification, a further characterisation of avoidable food waste is proposed in order to collect more indications about its composition and thus to support the definition of specific prevention measures. In particular, two classifications of the avoidable waste were selected for the methodology:

- a classification by product type (for example, fruit and vegetable products, dairy products, meat, and fish);
- a classification based on packaging: food waste inside an unopened sale packaging, food waste inside an opened sale packaging, and loose food waste (Schott *et al.*, 2013).

The state of waste degradation and the lack of information about the reasons behind the disposal prevented the application of other classifications, like that by life cycle stage proposed by Salhofer S. *et al.* in the year 2008 (food in its original condition, only partially consumed food, residues in course of food preparation, and leftovers from plates).

3.3 Definition of a standard procedure for the analysis at waste treatment facilities

Every year, Conai performs composition analyses of the residual waste delivered to Italian incineration plants. The objective is to evaluate the amount of packaging waste made of aluminium, paper, plastic, and wood sent to energy recovery as required by the Directive 2004/12/EC on packaging and packaging waste (European Parliament and Council, 2004).

The first step of the Conai analysis consists in the preparation of a sample representative of the residual waste processed by the plant (about 150-200 kg). The sample is directly taken from the storage pit where the waste is mixed before the combustion or, alternatively, it is composed with garbage bags associated to different catchment areas and unloaded from collection vehicles entering the plant. The sample is then manually sorted into 16 main waste categories (including the organic fraction) and the percentage by weight of each category is calculated. For each incineration plant, the described procedure is repeated three times in the same day (ANPA, 2000).

Starting from such standard procedure, a further detailed analysis on food waste (a subcategory of the organic fraction) was defined for the research activity of the REDUCE Project. The FUSIONS food waste quantification manual (Tostivint *et al.,* 2016), the Food Loss and Waste Accounting and Reporting Protocol of the World Resources Institute (2016), and the paper by Lebersorger and Schneider (2011) served as a reference during the design of the analysis.

The analytical procedure includes the following steps:

- weighing of the overall food waste;
- separation of each identifiable element from the sample of food waste;
- weighing of each identified element with a scale of 1 gram of accuracy and note of the relevant information for the classification: product type (e.g. a slice of bread, bones, banana peel), weight, and other characteristics (Tab. 4). For packaged products, a standard process of identification was defined. First, the current level of filling is noted (unopened packaging with the whole product inside or opened packaging with food partially consumed inside). Then, the packaging is removed and weighed separately from the contained food. If the separation is not feasible (e.g. the removal of the jam from a jar), an estimate of the packaging weight is derived from the net weight imprinted on the pack (only for unopened items), from the mass of an identical empty packaging or, in the absence of these alternatives, from a visual estimate of the food waste amount;
- weighing of the unclassifiable remaining fraction, i.e. elements of food waste whose level of degradation makes them inseparable and not further classifiable.

The described procedure can be applied each time the delivered waste comes directly from the collection, without intermediate pre-treatment. In fact, the pre-treatment of the residual waste, which might take place before the waste is delivered to the final treatment plant, implies some disadvantages for the analysis on food waste. First of all, the material is typically shredded, making the identification of the single items very difficult. Moreover, when a bio-

Tab. 4. Example of table used for the characterisation of elements of food waste

Identified element	Inside sale packaging?	Other characteristics	Product weight (g)	Packaging weight (g)
Apple	no	Whole	200	-
Meat	no	Some raw steaks	300	-
Banana peel	no	-	900	-
Bones	no	-	400	-
Pasta	yes (unopened)	1 kg bag	1000	10
Water	yes (opened)	Bottle of 0.5 L	240	15

logical stage is included during pre-treatment, the organic fraction is inevitably affected by moisture reduction and degradation of the biodegradable carbon.

A first campaign of analysis on the residual waste was performed during the spring of year 2016 (Tab. 5). The residual waste delivered to eight incineration plants was selected based on the following criteria:

- considering different Italian regions (Emilia-Romagna, Lombardy, and Piedmont) in order to take into account the geographical variability of the waste composition;
- locations where previous analyses of Conai showed a non-negligible amount of food waste in the residual waste (higher than 10% by weight);
- high catchment basin, in terms of generated waste.

At each site, Conai performed 3 traditional analyses on the residual waste (24 analyses in total). 14 out of 24 samples were then subjected to a further composition analysis of food waste.

4. Preliminary results and discussion

For the analysed waste samples, in the year 2016, 15% by weight of the residual waste was classified as food waste on the average (Tab. 6). Compared to the previous year, a 4% reduction by weight was observed, as a result of the continuous increase of the separated collection of the organic waste in Italy during the recent years (from 13% of the total municipal waste in 2010 to 21% in 2015; ISPRA 2013 and ISPRA 2016).

As regards the composition of food waste, the first aspect is related to the unclassifiable fraction, whose contribution by weight ranged from 29% to 74% of the sample of food waste (48% on the average), confirming that the degradation of the waste really limits the analysis (Fig. 1). Packaged food waste or

Tab. 5. Main characteristics of the incineration plants where the residual waste was sampled. The amount of treated waste is related to the year 2015 and it is reported in ISPRA (2016) while the average percentage of food waste in the residual waste was provided by Conai for the year 2015

Incineration plant	Treated waste (t/year)	Food waste (% by weight)	Date of analysis	Number of composition analysis on food waste
A	126,643	*11%*	26/04/2016	1
B	61,644	*15%*	27/04/2016	2
C	113,162	*30%*	28/04/2016	3
D	151,555	*16%*	5/05/2016	2
E	213,821	*20%*	27/05/2016	1
F	472,754	*27%*	22/06/2016	2
G	505,680	*15%*	29/06/2016	2
H	686,575	*21%*	30/06/2016	1

Tab. 6. Amount of food waste (percentage by weight) in the three samples of residual waste analysed at each incineration plant, with the corresponding average value for the year 2016. The average amount of food waste related to the year 2015 in the same plants is also reported for comparison purpose. Note: samples in grey were subjected to a further composition analysis of the food waste

Incineration plant	Sample 1 (2016)	Sample 2 (2016)	Sample 3 (2016)	Average (2016)	Average (2015)
A	*9%*	*7%*	*8%*	*8%*	*11%*
B	*13%*	*13%*	*13%*	*13%*	*15%*
C	*9%*	*12%*	*6%*	*9%*	*30%*
D	*22%*	*13%*	*11%*	*15%*	*16%*
E	*12%*	*11%*	*8%*	*10%*	*20%*
F	*13%*	*30%*	*20%*	*21%*	*27%*
G	*22%*	*19%*	*23%*	*21%*	*15%*
H	*30%*	*24%*	*9%*	*21%*	*21%*
Average amount of food waste for the eight incinerators (24 analyses)				*15%*	*19%*

whole loose items (for example an apple or a whole loaf) were typically identified, while food preparation residues or leftovers from plates could not always be separated and classified precisely. Most important factors responsible for the presence of the unclassifiable fraction include: the biological degradation happening between the disposal of the waste and its sorting (the organic waste is highly putrescible compared to other waste fractions) and the process of mixing and compaction of the waste in the collection vehicles and in the storage pit of the plant (where the material is mixed with buckets).

Despite such limitations, interesting data were collected about the characteristics of food waste. The avoidable fraction represented 28% of the total food waste on the average (Fig. 1). This value is lower if compared to other European studies (which found from 35% to 60% of the overall food waste), but it is a preliminary indication only related to the residual waste. In terms of product composition, the avoidable category resulted mainly composed of perishable food items (fruit, vegetables, and bread, above all; Fig. 2), while the classification based on packaging showed that more than 10% by weight of the avoidable products was discarded still in its unopened packaging in 6 out of 14 analyses (Fig. 3). In relation to this aspect, a similar indication was reported by Lebersorger *et al.* (2011) for the residual waste in the Austrian context (11% by mass of the avoidable food waste was classified as unused and originally packaged).

Fig. 1. Classification of food waste into different categories: avoidable food waste, possibly avoidable food waste, unavoidable food waste, extraneous fraction (packaging separated from food during the identification, pet food, medicines, and contaminations from other waste categories) and unclassifiable remaining fraction. * S stands for SAMPLE

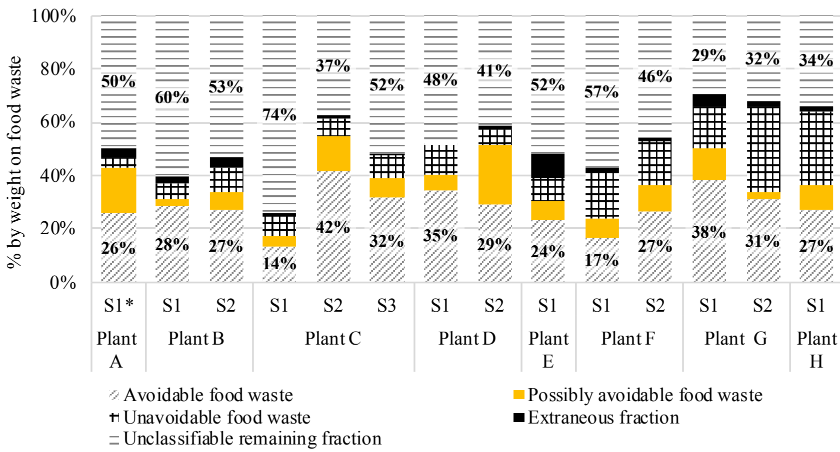


Fig. 2. Classification of the avoidable food waste by product type

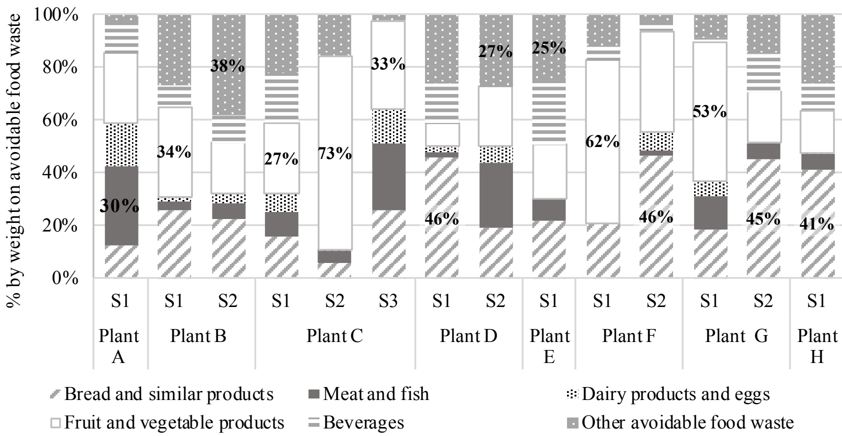
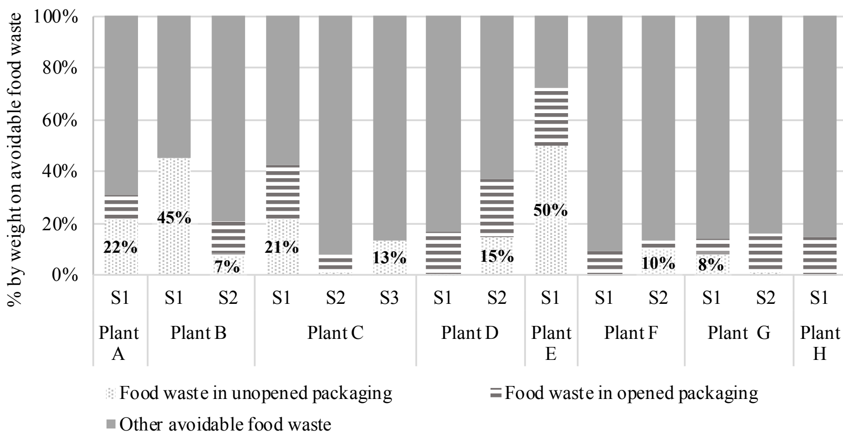


Fig. 3. Classification of the avoidable food waste into: food waste in its unopened sale packaging, food waste in its opened sale packaging, and other avoidable food waste



Possibly avoidable and unavoidable food waste revealed a lower average percentage by weight (9% and 13% of the total food waste, respectively). However, the unavoidable food waste showed a clear seasonal variability, with a higher contribution (more than 15%) for the last five samples (Fig. 1), which were analysed during the early summer, with a significant presence of watermelon rinds.

5. Conclusions and future steps of the research

The minimisation and prevention of food waste require a good understanding of its amount and composition. The defined methodology, if integrated within the routine waste composition analysis performed by the environmental protection agencies in Italy, can be a valid tool for monitoring the characteristics of food waste at national/regional level, at regular intervals (on an annual or biennial basis), and at an affordable cost. In relation to this last aspect, the additional charges to a traditional waste analysis are mainly related to the increase of the personnel due to the more time-consuming procedure.

The following step of the research activity will be focused on the organic waste from separated collection, where the authors expect to find appreciable amounts of avoidable food waste.

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Preliminary results of a methodology for determining food waste in primary school canteens

Reducing food waste (FW) is seen as a way to improve sustainability of food systems, both in itself and as a way to improve the efficiency of resource use. A first step is to improve data collection of FW.
The paper presents the results of a test conducted in a primary school located in the Bologna province. The aim of this study is to define a new methodology to assess FW in school canteens that can be applied in large-scale studies involving all stakeholders.
The results show that a methodology for data gathering on FW in school canteens involving all the concerned actors can be implemented. However for the success of the monitoring it is necessary the involvement of teachers that remain the key to success, but also it is necessary to adapt the methodology to the capabilities of pupils.

1. Introduction

Numerous studies (Monier *et al.*, 2010; HLPE, 2014; FUSIONS, 2014) have stressed the need to improve data collection and analysis of main causes of food waste (FW) in the last parts of the food chain.

REDUCE (Research, Education, Communication) is a national project supported by the Italian Ministry of Environment (REDUCE, 2016) that aims at collecting data on FW in the last stages of the food chain and at providing innovative solutions to prevent and reduce it. It builds upon the progresses realized these last years including through the approval of the National Waste Prevention Programme (MATTM, 2013), the implementation of the National Food Waste Prevention Plan (Segrè, Azzurro and Giordano, 2014) and the Bologna Charter against food waste (MATTM, 2014).

The project faces the issue of FW with an integrated approach, through three main intervention strategies: (a) research activities to prevent and reduce FW at the last stages of the food supply chain; (b) technical support and advice for decision-makers; and (c) awareness raising and education oriented to prevention and reduction of FW.

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One of the main research activities is focused on FW in school canteens, with the aim to collect data about food waste quantities and causes. Italian data on FW at this stage of the food chain is scarce and does not enable to have a correct assessment of the situation, as are only available qualitative data conducted on large samples (ORICON, 2015) or quantitative data but obtained from a limited number of schools (Vezzosi *et al.*, 2014; Falasconi *et al.*, 2015). The experiment consists in the collection of data on food waste in a sample of approximately 100 school canteens, located in three Italian Regions (Emilia-Romagna, Friuli Venezia-Giulia, Lazio).

The paper presents the preliminary results of a test conducted as part of REDUCE project, conducted in a primary school located in the Bologna province and monitored during a period of two weeks. The aim of this study is to define a new methodology for quantifying food waste in school canteens that can be applied in large-scale studies involving all stakeholders: kitchen employees and teachers, as well as the students themselves, so that monitoring becomes an instrument of active learning. At the same time the new methodology must however be accurate, easy to transpose, does not require external support, provides the comparable data on quantity and nutritional quality of food waste.

2. Material and methods

2.1 Involved actors

The concerned actors were directly involved in the quantification of food waste and in the data collection.

The kitchen employees were responsible for the quantification of the food prepared in the kitchen, whereas pupils, under the supervision of teachers, conducted the quantification of the non-consumed food left in the refectory after the lunchtime. The idea of involving pupils in the quantification phases of school wastes partially comes from the Waste Wise Schools Program promoted by the Department of Environment and Conservation of Government of Western Australia (Ralph, 2015).

To avoid potential bias due to pupils' desire to show a better behaviour with respect to everyday life, they were not aware of the real reason of the experiment. Although teachers and janitors were aware of the objectives of the study, it was asked to them to do not modify their habits.

2.2 Data collection

The classification of monitored food waste is inspired by Comstock *et al.* (1979): aggregate selective food waste measurement involves collecting tray from all, or a sample, of the students in a lunchroom and separately scraping the waste from each food item. The monitored food can be divided into three stages: 1) prepared food, which is the food that has been prepared for a determined meal and is ready to be served; 2) non-served food, which is the amount of food not distributed to diners and remaining in the serving bowls; 3) and served but not consumed food (plate waste), which is the amount of food rejected by diners and left on their plates. At each stage, food is quantified at aggregated level, separated by dish type. The dish type classification for food waste collection reflects the typical structure of the Italian meal: first course, generally composed of pasta or rice, second course, consisting mainly of animal products, side dish of vegetables, bread and fruit, as already used in previous studies on food waste in Italy (Iapello *et al.*, 2011; Vezzosi *et al.*, 2014; Falasconi *et al.*, 2015). Each dish type was quantified separately, for a total of five weight measurements per stage. The quantification was realized with a precision scale, except for bread and fruit of the prepared and non-served stages, for which average weight of individual portions were used and multiplied by the number of untouched portions. The average weights for bread items were established in the catering contract, while the average weight of the fruits has been empirically calculated from a sample of fruits served at school.

Data are adjusted to account for non-avoidable[1] food waste (WRAP, 2011; FUSIONS, 2014). To estimate the proportion of unavoidable food waste, a sample of non-edible parts was weighted, multiplied by the number of portion served and then subtracted from the overall weight of the waste collected.

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[1] 'avoidable' refers to any food waste item typically intended for consumption. Food that is not edible because it has gone off or been damaged is still classified as avoidable because it was, at some point prior to disposal, edible. Examples include half-eaten sandwiches, part-eaten dinners, uneaten fruit, unopened or partially eaten yoghurts, dinners that have not been served etc.

'possibly avoidable' refers to items that are eaten by some people but not by others for reasons of personal taste, and to waste items that are the result of particular method of preparation. Examples of possibly avoidable food waste areedible vegetable peelings, potato skins, apple skins, bread crusts etc.

'unavoidable or non-avoidable' refers to all waste from food that one would not expect people to eat; it is mostly composed of food preparation waste. Examples include egg shells, meat and fish bones, orange and banana skins, tea bags, coffee grounds etc. Food that is inedible because it has gone off is not classified as unavoidable, because the waste could have been avoided by using the product before this time. (WRAP, 2011, p.19)

2.3 Quantification phases

Before the field observation, four moderator focus groups (two with teachers and two with kitchen employees) were performed. They enabled to collect key information, such as on non-edible parts generally found and on the final destination of non-served bread and fruit. For this last type, since they are untouched portions sometimes they are left in the refectory, otherwise teachers brought them in classroom to be eaten by the pupils during the afternoon.

The kitchen employees were responsible for the quantification of prepared food, whereas pupils and teachers were involved in the plate waste separation and in the quantification of non-served and non-consumed food. The kitchen provided the precision scale, while the Department of Agricultural and Food Sciences of the University of Bologna provided the garbage bags and the garbage bins for the disposal of food waste. Kitchen employees weighed the cooked dishes (first course, second course and side dish) and counted the portions of bread and fruit. After lunch, the pupils and the teachers separated their plate waste in the five bins, corresponding to each dish type. In order to facilitate the separation, a label marked the bins indicating each dish type with the help of pictures.

After the separation phase the pupils of each class counted the non-served portions of bread and fruit. In order to record the final destination of non-served bread and fruit, the register distinguishes between portions left in the refectory and portions brought in classroom, generally to be eaten by the pupils during the afternoon.

One single class per day performed the quantification of remaining non-served food (first course, second course and side dish) and of plate waste dishes collected in the five bins, in order to do it in a less crowded environment and to limit the risk of errors.

3. Results

The school has 174 pupils, 167 of whom normally eat at school every day. It has an internal kitchen managed by a private catering company. During the period of the study, 1626 meals were prepared, with an average of 162.6 meals per day. Percentages of food waste stages are calculated as ratio of the total amount of prepared food. Data are reported as percentage of waste per single food stage (non-served and non-consumed food) and as total percentage of wasted food, intended as the sum of non-served and non-consumed food. Food waste data of non-served bread and fruit are related only to the portions left in the refectory since those brought in the classroom are assumed to be eaten.

Tab. 1. Percentage of total food waste

First Course	Second course	Side dish	Bread	Fruit
29.6%	*38.3%*	*57.7%*	*13.1%*	*13.4%*

Source: Authors' elaboration.

Tab. 2. Percentage of non-consumed food

First Course	Second course	Side dish	Bread	Fruit
22.4%	*31%*	*43.6%*	*6.6%*	*8.2%*

Source: Authors' elaboration.

Tab. 3. Percentage of non-served food

First course	Second course	Side dish	Bread		Fruit	
			Non-served	Refectory	Non-served	Refectory
7.2%	*8.0%*	*14.1%*	*57.1%*	*6.5%*	*62.1%*	*5.2%*

Source: Authors' elaboration.

During the period of investigation the total amount of wasted food represented an average of 29.4%. The percentage of wasted food amounted to 29.6% for the first course, 38.3% for the second course and 57.7% for the side dish, while for both bread and fruit portions it amounted approximately to 13.0% (13.1% bread and 13.4% fruit).

The percentage of non-consumed food had the highest percentage of food waste, corrisponding to 22,36%. Plate waste amounted to 22.4% for the first course (25.1% during the first week, 19.7% during the second week), to 31% for the second course (31.5% during the first week, 30.5% during the second week), 43.6% for the side dish (40.0% during the first week, 47.2% during the second week). The percentages of bread and fruit plate waste remain lower: 5.3% for bread and 5.8% for fruit during the first week, 7.9% for bread and 10.6% for fruit during the second week.

During the period of investigation the non-served food represented an average of 7.0%. The percentage of non-served food amounted to 7.2% for the first, 8.0% for the second course and 14.1% for the side dish, with an average of 10.2% considering all cooked dishes. The percentage of bread and fruit portions left in the refectory amounted respectively to 6.5% and 5.2%. However, the total amount of non-served portions amounted to 62.1% for fruit and to 57.1% for bread: this occurred since pupils generally do not consume entire portions, but cut them and share slices with schoolmates.

4. Discussion

The aim of this study was to define a new methodology for quantifying food waste in school canteens, that can be applied in large-scale studies, cost-effective and time-saving, able to provide reliable and comparable data, and able to involve all stakeholders.

The test results underline how the various actors were able to do what they were requested to. The quantification phases conducted by the kitchen employees have been well performed, with no specific difficulty reported.

The phases conducted by teachers and pupils were also well performed. The teachers were generally committed (however some of them were not interested, which could jeopardize the success of the project) even if the plate waste separation phase was partially overlapping with other duties; indeed, one of them has to stay close to the bins during the lunch preventing it for accomplishing other duties. During this test emerged that the arrival of a substitute teacher unaware of the ongoing experiment could be another potential source of errors. In fact, the lack of an adequate training might be a cause of mistakes. The plate waste separation phase conducted by pupils needs to be monitored by an adult when effectuated by pupils of less than 8 years to avoid errors, as the youngest children showed uncertainties in the plate waste separation phase. Finally, another critical aspect is related to some foods that stick to the plate, like rice used for risotto, which can result in underestimation of its non-consumed part.

The aim of the present study was not to provide quantitative results and data summarily reported do not intend to be statistically significant. However the results of this test are in the broad range of results of previous studies. The total wasted food amounted to 29.4%, while Vezzosi *et al.* (2015) found 40% and ORICON (2015) 13%.

It is necessary to clarify that ORICON detected its data through questionnaires based on visual estimates of canteens staff, which could justify the smaller quantities, whereas Vezzosi *et al.* detected their data through the support of their researchers, which can lead to greater accuracy but an impossibility to replicate large-scale detection.

The amount of non-consumed food represented an amount of approximately 22.4%, in line with the 20% found by Vezzosi *et al.* (2015). The amount of non-served food represented an average of 7.0% in line with the 8.48%

found by Falasconi *et al.* (2015), but lower than Vezzosi *et al.* (2015), whose results were approximately around 20%. Finally, as in previous Italian studies the side dish represented the most wasted, both as non-served and/or non-consumed food (Vezzosi *et al.*, 2014; Falasconi *et al.*, 2015; ORICON, 2015).

5. Conclusions

Results from the test phase do not intend to be statistically significant since they were obtained from a single case study. However, the percentage of both non-served and non-consumed food per dish type remained comparable during the two monitored weeks. Referring to cooked dishes (intended for first course, second course and side dish) of non-served food, the average of 10.2% is quite low and in line with what was declared by kitchen employees during the focus groups: in order to be able to address unexpected events (e.g. a tray that get burned during preparation or spilled out during transportation), chefs generally prepare 10% more food than needed. On the contrary, the percentage of non-served bread and fruit are really high, linked to the obligations of the catering contract, which stipulates that one portion of bread and fruit per person must be served at every meal.

However the test highlights how this new methodology don't allows to detect in detail the drivers of food waste in school canteens. In any case it is necessary to underline that this methodology was designed to fill a gap in the detection of quantitative aspects of the phenomenon in school canteens. For detection of qualitative aspects we suggest to set up focus groups among the stakeholders, as proposed by Falasconi *et al.* (2015).

The test has shown that a methodology for data gathering on food waste in school canteens involving all the concerned actors can be implemented. However, even if they were interested in the experiment and willing to participate, the monitoring requires a very well designed methodology, adapted to the needs and capabilities of children, with appropriate support and monitoring for the youngest, as well as paying attention to time constraints and other duties of teachers during and after meals. The involvement of teachers remains key to success; in order to improve their collaboration, a teacher for each school will be designated as supervisor responsible for the project and trained. Finally, even if it can be implemented in different countries, it has shown the importance of taking into account and using national specificities such as the meal structure for the collection of food waste, as well as for what can be considered as edible.

In order to definitely test the methodology and the capability of involved actors to perform what is requested to them, a pilot study will be conducted during October 2016 over a sample of three schools.

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The role of Poland's primary sector in the development of the country's bioeconomy

The main objective is to assess the role of the primary sector in the Polish economy as a prerequisite for development of the bioeconomy. Based on the data on the main suppliers of biomass, it can be clearly noticed that agriculture with its share of 76% plays an important role in biomass supply of the entire country. The share of the primary sector in GVA was used for spatial analyses for the period 2004-2012. Analyses conducted with the use of the global Moran *I* and local Moran statistics show that biomass production in Poland differs considerably by subregion – there are clusters of subregions where the primary sector plays an important role, and others where it has only a marginal character. These clusters cross regional administrative boundaries, justifying an interregional approach in strategic and policy planning, facilitating development of the bioeconomy in Poland.

1. Introduction

The bioeconomy has been defined and discussed by various authors. For example Staffas, Gustavsson and McCormick in 2013 distinguished the terms bioeconomy (BE) and bio-based economy (BBE). According to their comparative analysis of selected national strategies and policies in these fields, BE refers to the biotechnological and life science part of an existing economy, whereas BBE is applied for describing an economy which is predominantly based on biomass for food, feed, energy and other purposes, rather than fossil-based resources. They concluded that these two terms can also be used interchangeably. Maciejczak and Hofreiter (2013) reviewed a number of definitions of the bioeconomy and found that the core of this concept lies in the sustainable transformation of renewable biological resources based on innovation in the life sciences and turned into products and processes that aim at meeting both private and public expectations. Generally, the production of biomass — that is, all raw materials and products of biological origin, which are renewable and produced in agriculture, forestry, fishing and waste management — is the base of the value chain in the bioeconomy (Gołębiewski 2013). Lewandowski (2015) uses a general defi-

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nition of biomass referring to all organic material originating from plants, animals or microorganisms.

The concept of the bioeconomy was introduced and approved at the level of the European Union as for example within the European Strategy for building a sustainable bioeconomy, which is supposed to support a solution to many social challenges (European Commission, 2012). Furthermore, some EU Member States have developed their own national bioeconomy strategies. Germany, can be an example of advanced programming (National Research Strategy BioEconomy 2030) and implementation of different initiatives in this field, some of which come from Bioökonomierat - the Bioeconomy Council an independant advisory body to the German Federal Government.

In Poland, no special strategy or other document has addressed the issues attending the bioeconomy. Some aspects can be found in three integrated strategies, which are included in the implementation of the Medium-Term Strategy for the Development of the Country defining development goals for Poland until 2020 (Strategia Rozwoju Kraju 2020). In spite of a lack of a comprehensive strategy, the bioeconomy and organic food are both important parts of Poland's national smart specialisations (Gołębiewski, 2014). For their part, regional authorities also see the bioeconomy playing a role in the development of their territories. Research shows that the majority of Polish regions base their future development on natural resources. Poland's regional self-authorities have introduced topics related to the bioeconomy in their smart specialisations. However, regions traditionally associated with primary production frequently lack innovation, so support in building competitive advantage is important for them (Drejerska, 2013b).

2. Measuring the importance of the primary sector and the bioeconomy

It is not easy to transform the state of affairs or the policy approach into measurable indicators in order to gain scientific insight into development of the bioeconomy. One reason is that there are many traditional industries which not only produce biomass, but also process raw materials of biological origin. Efken and co-authors assume that the primary sector belongs entirely to the bioeconomy, as it produces biological resources, which are the bioeconomic inputs for downstream industries. However, it is difficult to valuate and separate the non-biobased and bio-based activities in this sector (Efken *et al.* 2016). Efken and co-authors did not limit their measuring of the importance of the bioeconomy to the primary sector only, but also included, to take one example, the monetary weight of power generation from biological resources based on different sources of information. However, they admitted that because bioenergy is a relatively new area of economic activity, there is no well-established foundation in the official statistics. Poland faces similar problems in measuring its bioeconomy – the lack of reliable data make it difficult to measure it. Another barrier is the territorial unit analysed in this paper – the subregion (NUTS 3). There are results of bioeconomy measuring, which include other sectors that use inputs from the primary sectors, but they are provided for a single country (a national level), as for example the Netherlands (Heijman, 2016). Characterizing and measuring bioeconomy for NUTS 3 regions is a complex issue, as we can observe it for example in collaboration of research and private partners in the BERST project (BioEconomy Regional Strategy Toolkit for benchmarking and developing strategies, 2016).

At fora and consortia of organisations working for the European Union, basic indicators concerning Gross Domestic Product (GDP) or employment in activities included in the bioeconomy are used (The European Bioeconomy in 2030). Distinguishing the bioeconomy into four types of sectoral bio-based activities according to their nomenclature in the Statistical Classification of Economic Activities in the European Community (NACE) is also applied, which leads to the use of comparable statistical data on economic activities in both EU and world regions on: primary sector activities (natural resource-based activities that directly exploit the bio-resources to be used as input for the bioeconomy), secondary sector activities (conventional/direct users of raw agricultural products), tertiary sector activities (new users of renewable raw materials) and ecosystem or non-market services (conventional users of green resources, such as sea, parks and forest) (Van Leeuwen, *et al.* 2013). Recently, a systematic approach to understanding and quantifying the EU's bioeconomy was provided for example by Ronzon and others (Ronzon, *et al.* 2017). They used some Eurostat databases and designed a methodology to provide bioeconomy monitoring indicators. Furthermore, they also identified three main types of bioeconomy across the EU Member States. It resulted in qualification of Poland in a group with labour productivity in the bioeconomy below EU average and average employment share in biomass-producing sectors above EU.

3. Material and methods

The main objective of the study is to assess the role of the primary sector in the Polish economy as a prerequisite for development of the bioeconomy. Specific objectives include an attempt to verify if Polish subregions (66 territories according to the NUTS 3 level) can be grouped into clusters by similarity of primary sector development and determine if these clusters fit into administrative regional boundaries. If such clusters extend beyond the borders, it is reasonable to undertake a specific interregional policy to support activities which can contribute to developing the bioeconomy.

As biomass is central to the bioeconomy, and the primary sector is the basic one supplying it, data on agriculture, forestry and fisheries (the primary sector) were used. General data about biomass supply in Poland come from data portal of agro-economics modelling – DataM of the Joint Research Centre of the European Commission. Its use illustrates biomass supply from the quantity perspective. However, this kind of data are not available for a more detailed (e.g. subregional) level of territorial division. Then, the structure of the Gross Value Added (GVA) by sector was taken into account and the share of the primary sector in GVA was the basic indicator used for the spatial analyses. The data used were from the Central Statistical Office of Poland (CSOP). The study covers the average values for the periods 2004-2006 and 2010-2012, so from Poland's accession to the European Union to the most recent data available on this level of the territorial division. Principles of spatial autocorrelation (the Moran's statistics) were used to facilitate the investigation of these interactions.

Analysis of the spatial autocorrelation is based on the values attributed to spatial objects. Spatial autocorrelation means that objects that are geographically close are more similar to each other than those far away from each other. This phenomenon usually causes the formation of spatial clusters of similar values. W.R. Tobler, a precursor of spatial econometricians, invoked the first law of geography with the simple statement: "everything is related to everything else, but near things are more related than distant things" (Tobler, 1970). Following these words with suitable mathematic equations, he justified why spatial relations should be taken into account in any means all. Some examples of this measures' use referring to the primary sector can be found in the work of Bartova and Konyova (2015) and Motamed, Florax and Masters (2014). Methodological aspects of its use are discussed by Schabenberger and Gotway (2005), among others. Generally, an issue of clustering of agricultural activities including a spatial dimension was investigated for example by Davidova and others (2009), D'Amico and others (2013) as well as Toma and Dobre (2016).

The value of Moran's statistic generally falls into the interval [-1, 1] and three different situations may occur:

- $I = 0$ - no autocorrelation
- $I < 0$ - negative autocorrelation (objects that are located next to each other at a specified distance have different values)
- $I > 0$ - positive autocorrelation (objects located next to each other, at a specified distance, have similar values).

The Global Moran's statistic is described by the formula (1):

$$I_i = \frac{n}{W} \frac{{}^2\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \tag{1}$$

w_{ij} – weight of the connections between units i and j (1st order matrix standardised according to rows),
x_i x_j – value of the variables in spatial units i and j (1st order matrix standardised according to rows),
$\bar{x}$ – arithmetic mean value of the analysed variable for all spatial units.

The local Moran's statistic is also widely used to examine how the value of one region is formed in comparison with neighbouring regions, as compared to a random distribution of values in the tested area. The local Moran's statistic is expressed by the formula (2):

$$I_i = \frac{(x_i - \bar{x})^2 \sum_{i=1}^{n} w_{ij}(x_j - \bar{x})}{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n}} \tag{2}$$

Description as previously.

The results of the global Moran I and local Moran statistics for the share of the primary sector in GVA are presented in the maps and graphs. Then results are interpreted.

4. Results

This significant role of agriculture in the Polish economy allows to consider it also as a substantial prerequisite for the bioeconomy's sector. According to the classification used by the European Commission[1], bioeconomy can be divided into sectors producing biomass (agriculture, forestry, fishing and fisheries), sectors wholly based on raw materials of biological origin (food industry, production of beverage and tobacco, wood industry, paper industry, pro-

[1] https://biobs.jrc.ec.europa.eu/research/private-investment (Accessed 20.09.2015).

duction of leather goods) and sectors partially using raw materials of biological origin (the chemical, pharmaceutical, furniture, production of rubber and plastics, and construction industries). Important branches of the bioeconomy are also sectors of the production of bioenergy and biofuels as parts of the fuel and energy sectors. As the agriculture, forestry, fisheries, aquaculture and algae sectors are the main suppliers of biomass (Ronzon *et al.*, 2017), a structure of their contribution to biomass production in Poland is presented in the Table 1. It can be clearly noticed that agriculture with its share of 76% plays an important role in biomass supply of the entire country.

Table 2 presents the basic characteristics of Poland's biomass production sector. Despite a decreasing tendency in agricultural employment it is still one of the highest indicator in Europe. Although, a phenomenon referred to desagrarisation of rural areas occurs (Wilkin, 2016) this sector still plays and important role in providing workplaces.

Given the above, it can be stated that the share of the primary sector (agriculture, forestry and fisheries) in Gross Value Added (GVA) is one of the basic values characterising the scale of biomass production. In Poland, this indicator had values ranging from 2.77% to 3.62% (Fig. 1) in the 2004-2012 period. It should also be stressed here that despite the fact that sectors of material pro-

Tab. 1. Biomass supply in Poland (last data available)

Sector	Commodity	1000 T of dry matter	%	%
Agriculture	Crop harvested residues	11188	*14.38*	*75.90*
	Crops	42091	*54.10*	
	Grazed biomass	5771	*7.42*	
Fishery	Capture Fisheries	50	*0.06*	*0.21*
	Aquaculture	7	*0.01*	
	Fish and seafood	66	*0.09*	
	Fishmeal and oil	39	*0.05*	
Forestry	Wood pulp	1376	*1.77*	*23.89*
	Post-consumer wood	452	*0.58*	
	By- & co- products (incl. wood pellets)	3919	*5.04*	
	Primary woody biomass	12843	*16.51*	
Total		77802	*100.00*	*100.00*

Source: the authors' calculations based on https://datam.jrc.ec.europa.eu/datam/mashup/BIOMASS_FLOWS/index.html (Accessed 25.10.2017)

Tab. 2. Basic characteristics of the biomass' production sector in Poland

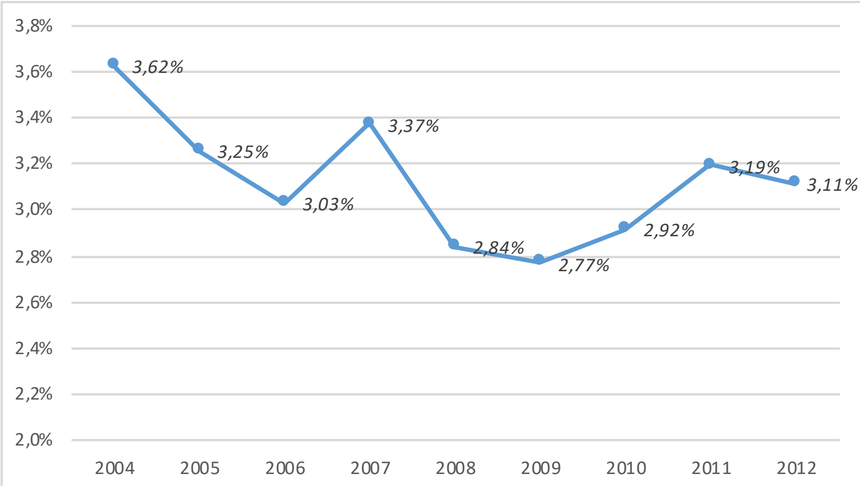
Specification	Average for 2010-2013
Employed in agriculture, forestry, fishing and fisheries (thousands of persons)	2382.3
Proportion employed in agriculture, forestry, fishing and fisheries in the total number employed in the Polish economy (%)	17
Gross Value Added of agriculture, forestry, fishing and fisheries (million zł)	42077
Proportion of Gross Value Added of agriculture, forestry, fishing and fisheries in total GVA (%)	3
Gross Value Added per one employee (thousand zł)	19.5
Ratio of Gross Value Added in agriculture, forestry, fishing and fisheries to GVA per employee in the national economy	0.21
Average farm area (ha)	9
Total number of farms (thousand)	1518.2
Agricultural land area (thousand ha)	14541.8
Total cereal crops (thousand tonnes)	27748.6
Oilseed rape and turnip rape crops (thousand tonnes)	2158.4
Milk production (thousand tonnes)	12519.75
Production of animals for slaughter (thousand tonnes)	5243.6
Total forest area (thousand ha)	9151.6
Timber harvesting (thousand m3)	36909.1

Source: the authors' calculations based on CSOP data.

duction (industry, construction and agriculture) contribute only to one third of the value added of the entire Polish economy, they are its pillars determining real driving forces and considerably influence on the GDP growth rate (Matkowski *et al.,* 2016).

As Poland is a relatively large country (the 6^{th} largest in the EU by surface area), the role of the primary sector differs across the country. There are some territories, particularly urban ones, where the share of the primary sector in GVA is close to zero, but there are also subregions (NUTS 3 level) where it reaches nearly 14%. Analysing the spatial patterns of the primary sector's development in Poland is no simple task. The global Moran's *I* statistic was calculated as the first step to verifying if neighbouring subregions affected the share of the primary sector in the GVA in the period investigated. Figure 2 presents the Moran scatter plots, which make it possible to divide objects according to specific spatial regimes: High-High (upper right part), Low-Low

Fig. 1. Share of the biomass production in the GVA in Poland



Source: the authors' calculations based on CSOP data.

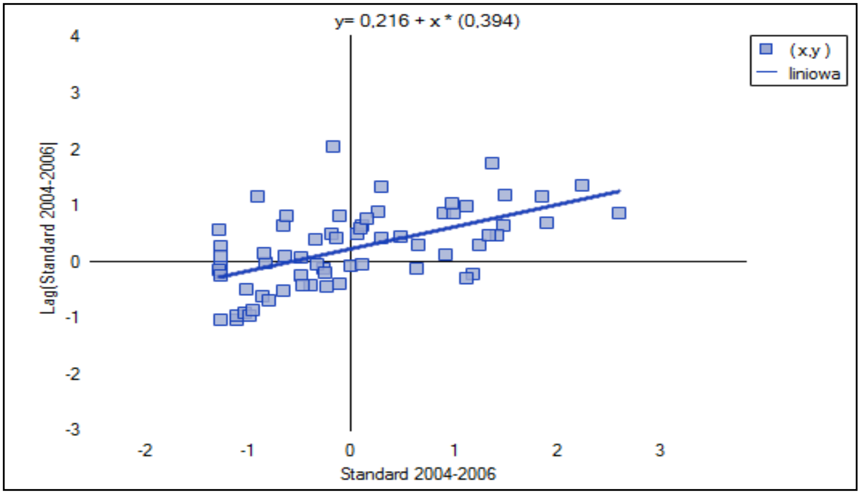
(bottom left part), Low-High (bottom right part), High-Low (upper left part). Positions of points in the lower left and upper right quadrants indicate spatial clustering of similar values: low values (that is, less than the mean) in the lower left and high values in the upper right (Anselin, 1995). The slope of the regression line represents the Moran's *I* statistic (Pietrzykowski, 2011) and proves the autocorrelation for the analysed data is positive. For 2004-2006 it was 0.39 while for 2010-2012 it was 0.74.

Values of the local Moran's statistic are presented in Figure 3. The following clusters of regions can be found: regions characterised by the low (statistically significant) local Moran's statistic value and surrounded by regions with the low value of the local Moran's statistic (Low-Low; areas marked in blue); as well as regions characterised by the high (statistically significant) local Moran's statistic value and surrounded by regions with the high value of the local Moran's statistic (High-High; areas in red). A similar way of interpreting the local Moran's statistic can be found in Chrzanowska (2016) and her analyses of agricultural land prices by region in Poland.

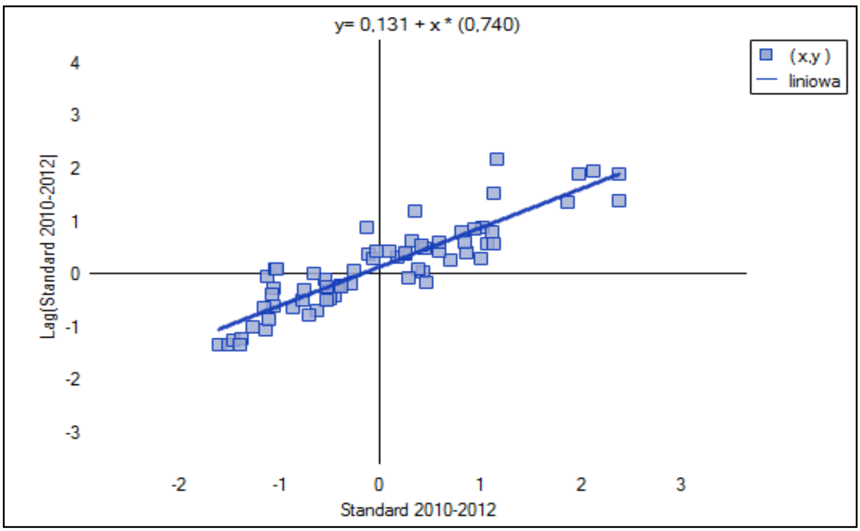
As it can be seen on the maps and in the Table 3, the primary sector does not play a significant role in the group of subregions in the southwest part of Poland. This is a traditional industrial area, where subregions whose primary sectors contribute little to GVA (Low-Low, marked blue) are surrounded by

Fig. 2. Moran scatter plots for share of the primary sector in GVA in Polish subregions

2004-2006

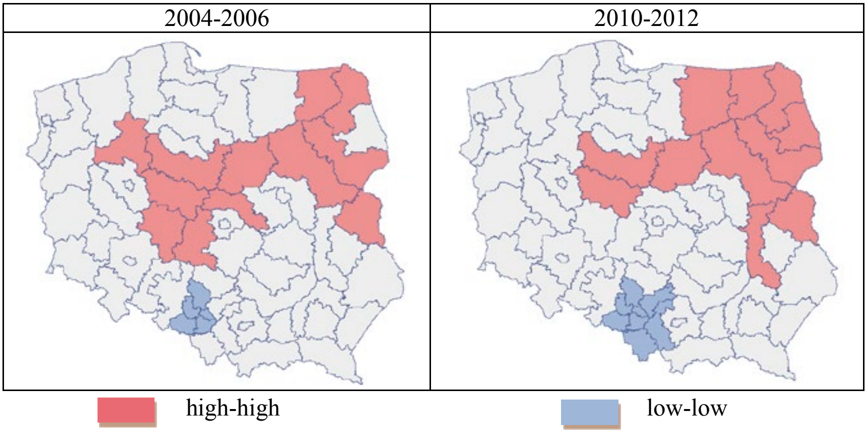


2010-2012



Source: the authors' calculations.

Fig. 3. Location of statistically significant local Moran values for the share of the primary sector accounts for in GVA by Polish subregions



Source: the authors' calculations.

Tab. 3. Types of statistically significant spatial relationships for determining the share of the primary sector in GVA by Polish subregions

Spatial relationship	Subregions
	2004-2006
High-High	ostrołęcko-siedlecki, ciechanowsko-płocki, bialski, skierniewicki, sieradzki, pilski, kaliski, suwalski, łomżyński, koniński, ełcki, włocławski
Low-low	katowicki, tyski, gliwicki, rybnicki, bytomski
	2010-2012
High-High	ostrołęcko-siedlecki, ciechanowsko-płocki, bialski, puławski, suwalski, łomżyński, koniński, białostocki, ełcki, olsztyński, włocławski
Low-low	oświęcimski, katowicki, tyski, gliwicki, rybnicki, bielski, sosnowiecki, bytomski

Source: the authors' calculation.

similar ones. On the other hand, there is a quite stable cluster of subregions in the country's northeast and centre where biomass production figures prominently in GVA (High-High, marked with red colour). They are surrounded by similar subregions that play a similar role in the bioeconomy.

5. Discussion

About 60% of the Polish territory is used by the agricultural sector and further 30% by the forestry. The agri-food (agribusiness) is the largest subsystem of the Polish economy (Baer-Nawrocka, Poczta, 2014). Polish rural areas significantly depend on agriculture and are still in need of restructuring and modernisation. Despite the decreasing share of farmers living in rural areas, they highly depend on agriculture-oriented policies (Kozak, 2014). During the last decade more dynamic structural changes were observable in the Polish agriculture, food and rural areas. The following are indicated as ones of the most important (Wigier, 2014):

1. reduction in the number of farms, while increasing the share of the largest holdings, which has a direct impact on the increase in the average farm area;
2. decline in employment in agriculture;
3. progressive concentration and specialisation of production.

From the international perspective, it can be stated that Polish agriculture is a significant component of the agricultural production sector in the European Union (EU). The basic effects of integration with the EU in this regard include changes in legislation of safety and quality of food, the changing environmental standards, legislation concerning foreign investments and international trade. Accession to the EU resulted in a possibility to take advantage of the phenomenon of globalization, allowing the Polish entrepreneurs to enter the internal market of the Community (Gołebiewski 2013). Since 2004, export growth rate in Polish agri-food products has been faster than the import one and Poland turned from an agricultural net importer to a net exporter (Grzelak, Roszko-Wójtowicz 2015). These processes are visible and reported even in the headlines of the international press, as for example the Economist referring to a golden age for Polish farming and Poland as a country surpassing China as the world's biggest exporter of apples in 2013 (The Economist, 2014).

General processes in the agricultural sector indicated above as well as 76% of contribution of this sector to biomass supply in Poland allow to state that it plays a significant role as a prerequisite for development of the bioeconomy. Results characterizing its spatial patterns are not surprising as a significant regional differentiation of the Polish agriculture is traditionally noted by researchers (Poczta, Bartkowiak, 2012) as well as the central authorities (Ministry of Agriculture and Rural Development, 2015) or international organizations (OECD, 2008). However, all mentioned studies and a lot of others investigate the differences determined by a number of factors, both agri-climatic and socio-economic, at the regional level (NUTS 2) whereas this study, realized for NUTS3 (subregions), proved that there is a necessity of interregional approach to bioeconomy – clusters of subregions exceed borders of administrative regions (NUTS2) were identified. It is important because as it was mentioned before, some regional authorities included the bioeconomy or some of its aspects into their development strategies. They can also use some parts of Rural Development Programme 2014-2020 (as the second pillar of the Common Agricultural Policy), so they have instruments to support this part of the economy. Finally, regional authorities can also apply some funds of regional policy, which programmed at the European level is conducted as cohesion policy (Drejerska, 2013a), to support for example entrepreneurship or technological progress of companies in the field of bioeconomy. All these activities programmed and implemented from an interregional perspective are reasonable as biomasses, due to their extreme diversification (by sector of origin of the raw material) and their strong link with the territory may generate positive impacts at the local level, in terms of employment, land care and maintenance and optimal use of agro-forestry resources (Romano, *et al.* 2013).

Identification of a necessity to interregional approach to bioeconomy is a strength of this study. It can lead to more efficient addressing of this sector by agricultural policy, including the regional government selection criteria to distribute European funds referred for example by Di Vita and others (2014) from a perspective of wine sector. Although it should be noticed that the applied methodology concerns only the primary sector. Such an approach can be perceived as a limitation of this study from the perspective of the entire bioeconomy sector. Other scientists indicate for example localization of bio-clusters and bio-parks as well as companies of pharmaceutical biotechnology in the largest Polish cities (Wozniak, Twardowski, 2017b). These localizations are not covered by the clusters identified within this study. However, the refereed researchers in their other work claim that the structure of the Polish bioeconomy is dominated by traditional sectors, such as agriculture and agro-food industries (Wozniak, Twardowski, 2017a). This statement together with clear objectives of the study referring to the primary sector and bioeconomy provide background for the research performed. Similar research can also be provided as example for subregions of other EU countries in order to facilitate understanding of functional regions with considerable biomass production, which create clusters crossing administrational regional or even national borders.

6. Conclusions

The spatial differentiation of the bioeconomy undoubtedly requires further research. A particular challenge remains quantifying the bioeconomy on a lower level of territorial analysis as the majority of data has been compiled for the national level. However, studies on the role of the primary sector in subregional economies can illustrate where the biomass production sector (agriculture, forestry and fisheries) is important; and, as a consequence of its significant role for the bioeconomy, where the bioeconomy can be supported as an important part of the overall economy.

The analyses conducted for the purpose of this study with the use of Moran's statistics proved that the role the primary sector plays in Poland varies considerably across regions. There exist clusters of similar subregions (NUTS 3) that play a significant role in the economy's biomass production sector. These results not only have cognitive value, but can also provide some background for regional and local policy-making as they confirm that the bioeconomy is worth our concern, as is a system policy approach in the Polish subregions indicated. Moreover, the subregional clusters that play a relatively significant role in biomass production exceed administrative regional borders, so it is reasonable to undertake a specific interregional policy to support activities which can further the development of the bioeconomy.

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