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REVIEW

Methodological characteristics of sustainability science: a systematic review

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Abstract Sustainability science has emerged as a research program and a scientific trend that directs all efforts to promote transition of societies toward sustainability. The style of research proposed to tackle unsustainability issues should be characterized by the application of a systems approach, as well as transdisciplinarity, participation, generation of social learning and a problem-solving perspective. However, whether such traits are being actually implemented has not been determined. Furthermore, a mature science is expected to have coherent research typologies, besides a scientific community and shared theoretical assumptions and methodological prescriptions; such types or research on sustainability science is still unknown. This systematic review aimed at analyzing research papers on sustainability carried out in 2013. Three aspects were studied: the scientific community, the theoretical assumptions on the concept of sustainability and the methodological design. Results suggest that the scientific community comes from disciplines different to sustainability, the researchers tend not to define the concept of sustainability and among those who do, and there is a lack of shared assumptions. The present analysis also showed that research on sustainability has not implemented the methodological characteristics mentioned and coherent method typologies were not found. These aspects hinder sustainability science evolution and maturity, given the difficulty to construct theories and consolidate a scientific community that develops coherent methods on such grounds.

Keywords Sustainability science · Methodology · Epistemology · Paradigm · Principles

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1 Introduction

Sustainability science has been described as a research program or a field of knowledge that seeks to understand the fundamental, dynamic and complex character of nature–society interactions (Kates et al. 2001; Clark and Dickson 2003) or as a trend in scientific research programs that direct efforts to promote transition of society toward a sustainable life (Kates et al. 2001). As scientific movement or trend, sustainability science includes all endeavors to understand the relation between human kind and nature in order to attain sustainable societies (Clark and Dickson 2003).[1]

Specific problems tackled by this science, such as poverty, climate change, deforestation or lack of balance in the use of nature (Jiménez 2008), are characterized by their social–ecological character, multi-dimensionality, their expression in different time and space scales, the involvement of diverse types of actors and a behavior hard to predict (Martens 2006; Rapport 2007; Kajikawa 2008). With this in mind, sustainability science has been presented in the methodological field as a style of research that differs from traditional options (Martens 2006; Brown et al. 2015).

Features proper of the way of doing research on sustainability science are its transdisciplinarity (Martens 2006; Rapport 2007; Kajikawa 2008), the participation of other actors besides researchers (Kates et al. 2001; Martens 2006), social learning generation (Kates et al. 2001; Martens 2006), a problem-oriented character, use of both knowledge and decision-making processes and the employment of systems thinking and complex systems approach (Kates et al. 2001; Martens 2006; Sterman 2012). However, these are attributes that sustainability science should have and not necessarily those implemented in research.

The above description originates in both a theoretical construction about the type of research that humans require to solving problems of unsustainability and proposals made by researchers, but it is not the result of an extensive review on its methodological characteristics. These have not been described, and similarly, it is still necessary to analyze the extent to which transdisciplinarity, actors' participation, social learning, problem-solving, decision-making and systems approach have been adopted for research on sustainability.

Potential differences among the characteristics proposed by theorists and those evident in original research make it necessary to perform a systematic review of sustainability research works, in such a way that the description of the real methodological characteristics of primary studies is possible and the sole reference to idealized and theoretical characteristics can be prevented. The importance of addressing this issue in a systematic review is that this method allows to synthetize research on a specific topic, on the basis of previous definition of search and selection criteria, quality assessment and extraction of information from primary studies guided by a question. This minimizes selection bias in original studies (Centro Cochrane Iberoamericano 2012).

A study on the methodological characteristics of sustainability research is needed, somewhat urgently, if it is taken into account that sustainability science is not mature and it is even difficult to label it as 'science' in the commonly accepted meaning of the term (Rapport 2007). This results from the fact that it is not an independent and autonomous

[1] Even though the use of the term '*sustainability science*' is relatively recent, the study of human–nature interactions is not. Human ecology already studied interactions between humans and their environments since 1920s (Hawley 1986).

profession or discipline (Clark and Dickson 2003; Martens 2006), and it does not yet own a set of principles that enable systematic construction of knowledge (Rapport 2007).

In this regard, it should be noted that mature sciences are characterized by a single or various paradigms (Chalmers 1999: 102), defined as the set of general theoretical assumptions, as well as the laws and principles adopted by the members of a scientific community (Chalmers 1999: 101). In other words, the essential characteristics of a mature science include (a) the existence of a scientific community and the (b) set of theoretical assumptions and (c) methodological prescriptions and techniques it shares (Chalmers 1999: 106). This is the reason why, in the prospective context of a mature sustainability science, a systematic review would allow the identification of one or several scientific communities which are nowadays studying problems of unsustainability and its potential relations, the theoretical principles about the concept of sustainability that they share and that lead their research, and the convergence of methodological designs.

The objective of this study is to systematize the research articles related to sustainability, according to its methodological characteristics, conceptualizations, type of journals, institutions and regions involved.

2 Materials and methods

Type of study: systematic review of research articles.

Research protocol in accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement (Urrutia and Bonfill 2010).

2.1 Identification of articles: search strategy

A review of original research articles on sustainability was conducted, starting from the research question 'What are the methodological characteristics of research on sustainability carried out in 2013?'.

Articles were searched in ScienceDirect and EBSCO databases on May 25, 2014. In ScienceDirect, the option 'ALL' from advanced search was employed, entering the term 'sustainability' in the title field and 'methods' OR 'methodology' in the 'FULL TEXT' field. In EBSCO, the 'EBSCOhost Research Databases' service was employed to select databases such as Business Source Complete, Communication and Mass Media Complete, Computers and Applied Sciences Complete, Education Research Complete, Environment Complete, *Fuente Académica Premier*, GreenFILE, Humanities International Complete, Library Information Science and Technology Abstracts and OmniFile Full Text Mega (H.W. Wilson). E-Book Collection (EBSCOhost), Legal Collection and SPORTDiscus with Full Text were not included since they do not offer the 'articles' option. Academic Search Complete, Psychology and Behavioral Sciences Collection, Regional Business News databases do not offer the option 'academic journals,' so these were also not included. Once databases were selected, a combined search was performed in the advanced search section, using the terms '*sustainability*' in the TITLE field and the terms 'methods' OR 'methodology' in 'FULL TEXT'. Some examples of search syntax include: (1) TITLE (sustainability) and (methods OR methodology), (2) TI sustainability AND TX methods OR TX methodology, (3) TI sustainability AND TX method.

2.1.1 Screening or application of inclusion criteria

Articles identified after search were screened using the following inclusion criteria: (a) 'Journal Articles', in ScienceDirect database, and 'academic journal article' in EBSCO. (b) Articles published in 2013. Regarding the definition of the observation window, the decision of taking the year that reported the higher number of scientific publications in sustainability so far as a guide was motivated by the intention of increasing the probability of obtaining more diverse and recent methodological designs for classification. Thus, the selection was restricted to such time period since according to Scopus, this year registered the highest amount of published articles on sustainability. Even on May 5, 2015, Scopus still registered 2013 as the year with the highest number of articles (2929) including the term 'sustainability' in their title. (c) Articles in English. This criterion was established in response to English being the preferred language for publication. After applying the screening criteria, databases automatically reduced the number of articles according to full-text availability, and finally, only (d) original research articles with a clearly defined methods section were considered.

2.1.2 Selection

Resulting articles were compiled in an Excel database, and duplicates were eliminated. Then, two exclusion criteria were applied: (a) articles containing reviews or studies of other studies and (b) research articles without a socio-ecological approach. A research was considered to have a socio-ecological approach when the problem studied entailed social and ecological factors, or when, regardless of the nature of the problem, the researcher tackled its social and ecological aspects.

2.2 Collection of information

The information was extracted from the 'Abstract,' 'Introduction' and 'Materials and methods' sections of each article. Data contained in the abstracts, such as country where research was performed and journal's name, were employed to obtain information on the scientific community. Particularly, information related to journals was also obtained from Ulrichsweb and SCImago databases, as well as from the 'Aims and scope' sections in each journal's Web site. Subject or interest area of each serial publication was also identified here.

In order to identify the concept of sustainability adopted by researchers, the 'Introduction' section of each article was reviewed in the search for fragments in which the authors defined the term explicitly or that allowed it to be inferred. The process led to the identification of authors providing explicit and implicit definitions, as well as of those articles in which the terms 'sustainability' and 'sustainable development' are employed indistinctly.

The section 'Materials and methods' in each article was reviewed to describe the methodological characteristics of each research. In particular, explicit information about the type of study and approach applied was extracted from such fragments.

Evaluation of protocol reproducibility: The whole search and article selection processes, as well as the collection of information, were carried out by two independent reviewers, and disagreement was resolved by consensus or third-party verification.

2.3 Analysis of information

2.3.1 Scientific community

An analysis of the absolute and relative frequencies of the following variables was performed: journals as well as their disciplinary area (on basis of the three information sources: Ulrichsweb, SCImago and 'aims and scope' section of each journal), institution, country of origin of research and country where it was performed.

2.3.2 Sustainability concept

A content analysis of the definitions was carried out, in order to identify emerging types of definitions or categories. Next, definitions were codified according to their type and, afterward, it was performed an analysis of the absolute and relative frequencies of the definition types found. Also, the same analysis of frequencies was performed on the variable 'Does it use the terms sustainability and sustainable development indistinctly?'

Subsequently, the percentage distribution of studies that presented a definition of sustainability was analyzed, according to journal's classification. Regarding methodological characteristics, an analysis of absolute and relative frequencies was performed on approaches and study types identified.

2.4 Scope and limitations

The identification of the articles was carried out by selecting only research articles whose title included the term sustainability. The application of this criterion implies the unavoidable exclusion of sustainability research articles that do not include such term in the search protocol. The identification of this type of research works becomes difficult when considering that there is not a thesaurus specific to sustainability science that would facilitate the filtering of those works that do not belong to this field of knowledge. Another option would be the previous selection of research works with a social–ecological approach and ask the researchers whether they consider that their study can be defined as sustainability research. Nevertheless, the manual character of such a task would hinder the reproducibility of this study.

One more alternative solution to this limitation could be the search of articles containing the term '*sustainability*' in the fields of abstract and keywords. Even though this could improve the identification of articles, this decision could also remarkably rise the number of articles up to a point where the *ex ante* application of inclusion and exclusion criteria might also affect the reproducibility of the research.

In spite of this limitation, the inclusion of articles with the term sustainability in their title, supposed two advantages for this study. First, its combination with the criterion referring to articles with a social–ecological approach guarantees that at least the articles selected correspond to works that intend to be considered as sustainability research. Second, it is only possible to identify assumptions shared by a scientific community when a certain concept is taken as referent, in our case, that of sustainability. This is the most basic concept in sustainability research and not employing it would hinder the possibility of verifying the existence of shared theoretical assumptions. The present study seeks to confirm whether there are shared assumptions solely about the concept of sustainability.

3 Results

After applying search protocol criteria, 253 research articles, published in 2013, were found in both databases (Fig. 1). Therefore, the description of the scientific community, the identification of the assumptions on the concept of sustainability and that of methodological characteristics stemmed from these 253 texts.

3.1 Scientific community

3.1.1 Scientific journal types considering 'aims and scope'

The analysis of the '*aims and scope*' of journals enabled its classification according to publication interests. Two set of journals were identified: (1) A group of journals interested in topics in sustainability, expressed implicitly or explicitly and (2) journals in other areas,

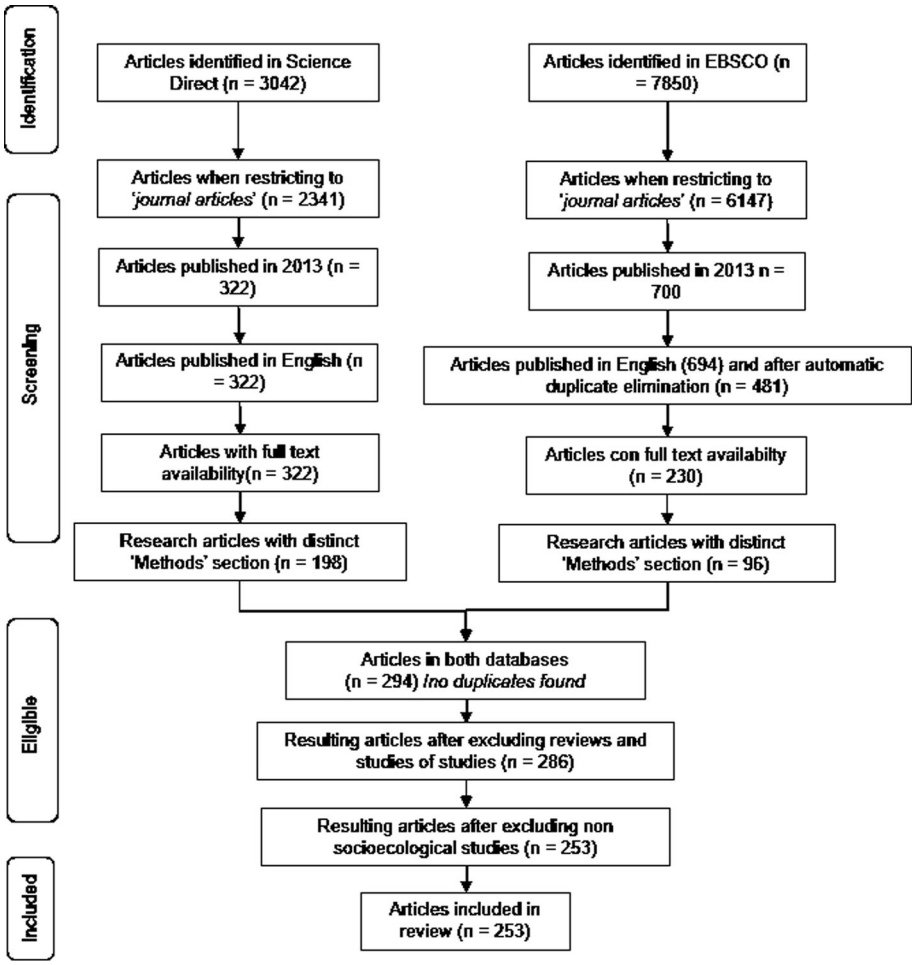

Fig. 1 Article selection process

such as Social and Human Sciences, Exact Sciences and Engineering, Business and Economics and Natural Sciences. Figure 2 depicts the distribution of the number of articles per journal type. Accordingly, 75 % of studies were published in journals in sustainability.

3.1.2 Scientific journals considering Ulrich and SCImago

On the other hand, it was possible to highlight several aspects by considering Ulrich's classification and SCImago Journal Rank database. In first place, none of these indexation systems of journals includes subject areas labeled '*sustainability,*' '*sustainability science,*' '*sustainability studies*', or similar combinations, in which publications in sustainability may be subscribed. In second place, both indexation systems classify journals in relatively similar areas; at any rate, such is the case for journals that published articles on sustainability in 2013, where texts can be found under the Environmental Sciences or Studies, Economics, Engineering, Biology and Social Sciences categories. Nevertheless, some areas differ (Table 1). In third place, journals considered in Ulrich and SCImago as centered in Environmental Sciences or Studies contain the highest number of publications on sustainability research: 42.3 and 30 %, respectively. Table 1 depicts the distribution of articles according to its journal classification in the indexation systems mentioned.

3.1.3 Geographic distribution of studies

Regarding the place where studies were carried out, it was found that 37.5 % ($n = 95$) took place in Europe; 21.7 % ($n = 55$) in the American continent; 20.9 % ($n = 53$) in Asia; 4.3 % in Oceania ($n = 11$); 5.5 % in Africa ($n = 14$); 5.9 % in different countries ($n = 15$), and in 4 % of the cases ($n = 10$), the place was not reported. The most frequent location of studies in Europe were Spain with 12.6 % ($n = 12$); Italy with 12.6 % ($n = 12$); Finland 10.5 % ($n = 10$) and UK 10.5 % ($n = 10$). On the other hand, from the studies in the American continent, 58.2 % was in the USA ($n = 32$); 27.3 % in Brazil

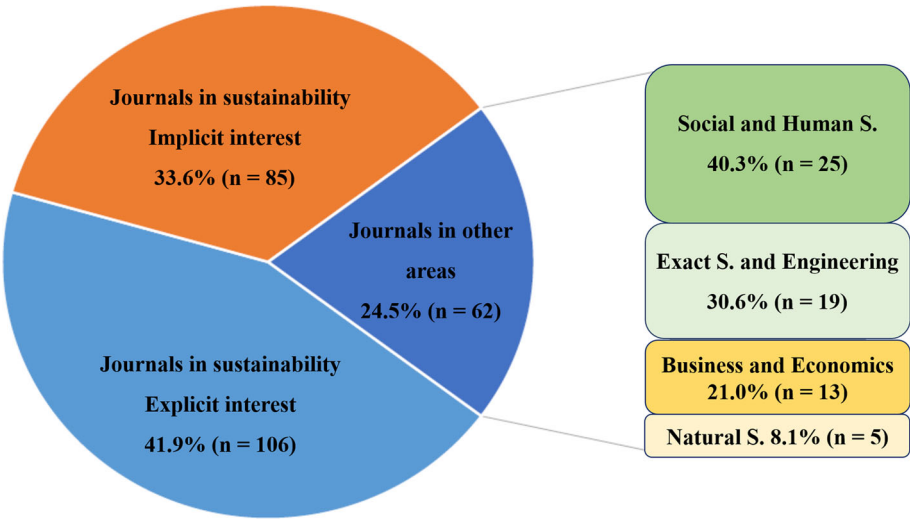

Fig. 2 Percentage distribution of included studies per journal type

Table 1 Distribution of publications included considering Ulrich and SCImago indexation systems

Ulrich classification	% (#)	SCImago classification	% (#)
Environmental Studies	42.3 (107)	Environmental Sciences	30.0 (76)
Engineering	23.3 (59)	Ecology and Biology	21.7 (55)
Economics and Business	13.1 (33)	Economics and Business	11.5 (29)
Social	8.7 (22)	Engineering	9.9 (25)
Agriculture	5.1 (13)	Social Sciences	4.0 (10)
Biology	2.0 (5)	Others	10.3 (26)
Others	5.1 (13)	Without classification	12.6 (32)
Without classification	0.4 (1)		

($n = 15$) and 9.9 % in México ($n = 5$). In Asia, 30 % of studies took place in China ($n = 15$) and 20 % in India ($n = 10$) (Fig. 3).

3.2 The concept of sustainability in research papers

3.2.1 Types and uses of the concept

Even though the 253 articles have the term 'sustainability' in the title, 91.3 % does not include its definition. It was frequently observed that researchers do not define sustainability as an independent concept, although they did define other related terms. For instance, there were papers in which authors did not specify the concept of sustainability taken into account for their research, but included definitions for sustainable agriculture, sustainable building, corporate sustainability, sustainable energy or environmental sustainability as appropriate. On the other hand, among the 22 studies that defined explicitly the concept of sustainability, it was possible to observe three uses or types of definitions:

Fig. 3 Geographic distribution of studies included in the review

72.7 % are teleological definitions (16), 18.2 % (4) are ontological and 9.1 % (2) adopted sustainability as an approach.

Teleological definitions are those in which sustainability is assumed as an aim, purpose or ideal state of society. Their normative character can be argued on such grounds. Considering ontological definitions, sustainability is assumed as a behavior of certain systems. These are centered on the capacity or ability of systems to possess certain characteristics, rather than on the characteristics per se. Hence, these have an empirical character. Similarly, in the case of sustainability as an approach, the term refers to the incorporation of environmental, social and economic variables or criteria in the analysis or design of a given system. It is worth mentioning that in this last context, authors did not define what sustainability was, but did point the means to study or achieve it. Table 2 contains some examples of each type.

Another relevant aspect is the indistinct use of the terms 'sustainability' and 'sustainable development.' Both terms were employed in 156 studies out of 253 selected for our review. Researchers made no difference among these in 93 (59.9 %) of such studies, amount that represent most of the papers reviewed.

3.2.2 Explicit definitions according to classification of journal

Most often, those journals with an interest in sustainability (classification according to 'Aims and Scope') and economics (Ulrich and SCImago) contain explicit definitions of the concept. Table 3 depicts the distribution of the publications per journal's area of interest.

3.3 Methodological characteristics of research papers on sustainability

Considering research approach, only 12.3 % ($n = 31$) of studies specified in the article. Among these, 38.7 % ($n = 12$) were qualitative, 32.3 % ($n = 10$) quantitative, 19.3 %

Table 2 Examples of types and uses of the term 'sustainability'

Type of definition	Example	Author
Teleological	Point of view that guides the structural and social alignment of the organization. Environmental response to this view. Organization that seeks accomplishment of its social and environmental goals	Parisi (2013)
	Sustainability is defined as the capacity of current generations to satisfy their needs without compromising capacity of future ones to satisfy their own (Assuming sustainable development as synonym)	Kataria et al. (2013)
Ontological	Capacity to last in time, which depends on social, economic and environmental relations	Viaggi et al. (2013)
	Capacity of an environmental system to face social development on a long-term basis	Olayide et al. (2013)
Approach	'We adopt the concept of sustainability that is the triple bottom line concept, entailing the dimensions of care for the natural environment, social responsibility and economic result'	Claro et al. (2013)
	All activities aimed at improving the ecological and social development in a company, whilst maintaining its financial basis	Brockhaus et al. (2013)

Table 3 Percentage distribution of studies with an explicit definition of sustainability according to classification of journals

Classification of journals	#	%
A. 'Aims and scope' classification		
Explicit interest in Sustainability	11	10.4
Non-explicit interest in Sustainability	2	2.4
Social and Human S.	6	24.0
Economics, Finance and Business	2	15.4
Exact S. and Engineering	1	5.3
Business and Economics	9	27.3
B. Ulrich classification		
Environmental Studies	8	7.5
Engineering	3	5.1
Social Sciences	1	4.5
Others	1	4.5
C. SCImago classification		
Business and Economics	8	27.6
Social Sciences	1	10.0
Environmental Sciences	4	5.3
Ecology and Biology	1	1.8
Without classification	8	27.6

($n = 5$) mixed holistic approach and 3.2 % ($n = 1$) belonged to the categories of Multidisciplinary Social Constructivism or Sustainability Impact Assessment Tool (SIAT). There was not any research paper containing explicit reference to a systems or transdisciplinary approach.

Regarding the type of study, only 31.6 % ($n = 80$) states it, and even when they do, such types are often assigned another names. The following typologies were identified:

- *Case studies* 30 % ($n = 24$). This category is constituted by diverse studies that were generically considered as 'cases', even if their scopes differed. In such sense, it includes 4 case studies based on computational modeling; 2 longitudinal, 3 exploratory-descriptive and 2 multiple case studies and an institutional one, an analysis of three cases (socio-ecological system in three countries) and another described as simulation based case study.
- *Studies using qualitative tools* 17.5 % ($n = 14$). It includes 4 ethnographic, 3 interpretative-exploratory, 3 grounded theory, 3 action-research (1-IPA) studies and a phenomenological one.
- *Life cycle analysis* 15 % ($n = 12$). Although it must be stated that several authors add to this label by differentiating between descriptive, descriptive multi-attribute or case life cycle analysis.
- *Exploratory-descriptive* 13.8 % ($n = 11$).
- *Modeling* 5 % ($n = 4$). Different types such as economic and sociocultural impact, econometric, mathematical and thermodynamics-based modeling.

Other types of study included system dynamics ($n = 2$) and 2 prospective analyses. One analysis was found in each of the following categories: Emergy analysis, economic and environmental evaluation, multi-criteria hierarchical model, multi-objective decision-making framework, planning-oriented sustainability assessment framework (POSAF),

hierarchical analytic process and sustainability impact assessment tool (SIAT). Application of methodological characteristics proposed for research on sustainability was scarce.

4 Discussion

The results of this systematic review suggest that sustainability science still lacks of a paradigm in which a scientific community can identify itself with certain problems and proposed solutions. Despite the existence of a scientific community, the lack of common theoretical assumptions—or groups of assumptions—about the concept of sustainability and methodological designs seems to evidence that this field of knowledge is still immature.

One indicator of a paradigm configuration is the existence of a scientific community (Kuhn 2006: 304). Scientific communities are groups of professional individual focused on a scientific specialty who generate and validate scientific knowledge. These are thus identifiable at different levels and among different structures such as professional associations, scientific journals, cooperation networks, among others (Kuhn 2006: 307). In our case, the scientific community was observed indirectly, as this work was not aimed at revealing the scientific community structure. However, it does contain aspects that account for it, namely geographic distribution of research and journals that publish studies in sustainability.

Another finding was that countries with the highest number of studies are USA, Brazil, China, Spain, Italy, UK, Finland and India. Such results are consistent with those of Bettencourt and Kaur (2011). These authors did not review the countries in which research was carried out, but the location of institutions behind researchers, and they found that countries with the highest number of publications are the USA, Western European countries and Japan; the authors also highlight production from the UK, Brazil, China and India. Such findings suggest that at least there is a global scientific community, which is stronger in high- and middle-income countries, among which India, China and Brazil outstand as '*emerging economies*'. It should be noted that the study by Bettencourt and Kaur (2011) is considered important, among other reasons, due to its depiction of the scientific community evolution over a period of three decades, in the structure of collaboration among authors.

Journals, on the other hand, are means of communication and validation of knowledge produced by researchers. The identification of areas in which journals are ranked in Ulrich and SCImago databases seems to indicate that sustainability science is not considered an autonomous field of knowledge. Despite journals declaring their interest in research on sustainability and socio-environmental issues as part of their '*aims and scopes*', it is not possible to find a disciplinary field that reflects such interests in their Web sites.

The absence of a category for sustainability in indexation systems such as Ulrich and SCImago may be due to sustainability research being supported by other traditional disciplines. In this regard, works by Kajikawa et al. (2014) and Bettencourt and Kaur (2011) seem to show results consistent with those of this review. Based on the ISI classification, Bettencourt and Kaur (2011) found that articles subject to analysis were published in journals in Biology, Electric Engineering–Computing Sciences, Biotechnology, Chemistry, Medicine, Infectious diseases, Earth, Human, or Social Sciences, Chemical, Civil or Mechanical Engineering, Physics–Mathematics and Brain research. Additionally, considering an academic classification rather than a disciplinary one Kajikawa et al. (2014) finds areas similar to those mentioned in our review, as Environmental systems and Business and

Economics. However, the same author reveals others directly related with some resource such as water, energy and transportation, among others.

One more aspect that characterizes a paradigm is the existence of shared theoretical assumptions and agreement among researchers about what the basics (Chalmers 1999). This aspect was tackled by analyzing how the concept of sustainability was understood among researchers. The results showed that 90 % of authors did not define it; furthermore, it was not possible to observe any potential agreement or shared view among the ones who did. Similarly, there are authors that do not differentiate the terms 'sustainability' and 'sustainable development'.

The term 'sustainability' appears ambiguous and unclear inasmuch as, besides having diverse meanings, these are connected to different objectives and social aims (Kajikawa 2008). Likewise, there are various interrelated terms that, far from being synonyms, researchers employ to refer to sustainability in different systems (Glavič and Lukman 2007).

The multiple meanings given to the term 'sustainability' make it necessary for authors to define this concept, in a way that the theoretical foundation of research can be assessed. This would be at least expected from research with the term on its title. Such omission of the definition may indicate a construct validity problem; nevertheless, proving so would require further review of articles on sustainability of a determined system. This finding also suggests that scientific journals are not demanding researchers to define those terms that provide theoretical support to their work, which is a fundamental aspect of any research (Hernández-Sampieri et al. 2006).

In the same line, the lack of shared theoretical assumptions may entail a setback for theory development. Disagreement and constant debate about foundations obstruct detailed and conscientious work and would lead to the emergence of as many theories as professionals in the field. As these should permanently justify his approach, the development of theories is hindered (Chalmers 1999: 104). The absence of theories about nature–society interactions is a problem yet to be solved in sustainability science (Jerneck et al. 2011).

Another characteristic trait of a paradigm is the existence of a set of methodological and technical prescriptions common to the scientific community (Chalmers 1999). Such aspect was not observable on the papers reviewed; it was just possible to find a record of type of studies that can receive simultaneously different labels, instead of a coherent typology of methodological designs. This is probably indicating that criteria employed to design and evaluate studies derive from other disciplines rather than from sustainability science, which would be logical if it is taken into account that research on sustainability is being published in journals with interests in other areas.

Eventually, a consolidated paradigm would mean a set of established principles owned in sustainability for research design and evaluation. Probably, some criteria may be identified in the methodological characteristics proposed for research in sustainability, such as the complex systems approach, transdisciplinarity, problem-solving perspective, participation and learning generation (Martens 2006; Salas-Zapata and Rios-Osorio 2013). However, studies using systems approach were scarce and transdisciplinary approaches to research were not evidenced. However, it is worth mentioning that the performance of the same study, in 5 or 10 years, might provide a different description of sustainability research.

The explanation to the difference observed between proposed type of research and the type of research carried out in sustainability, may be found in the Kuhnian concept of a transition to maturity (Kuhn 2006: 308). This transition does not mean that a science acquires a paradigm for the first time, but that there is a shift in the nature of an already

existing one. Such transitions frequently show that the same topic may be initially studied by researchers from different communities; scientific change takes place when agreements on these topics are generated. For this reason, transitions entail reconstruction of commitment by the set of researchers. In this regard, we could sustain that, although sustainability science is at a point where proposals are being made by some scientists, the bulk or researchers in the areas belonged to different disciplines that study similar topics, at least until 2013.

Given that both mature sciences and revolutions are activities based on the community, Kuhn (2006: 309) suggests that the study of scientific change should focus on the scientific community, the community structure of sciences, groups and researchers in charge. From such perspective, this study is unable to report on the transition process since its observation window is limited to a specific moment—2013—of research on sustainability. That is why, beyond the bibliometric aspects, the evolution of sustainability science should be studied from an angle that considers the characteristics of the researchers on the field, their disciplinary origins and cooperation dynamics, as well as conceptual construction and its changes over time. Nevertheless, the analysis of the evolution of sustainability science would make part of other research endeavors.

5 Conclusions

Sustainability science is a research program and a scientific trend. In Kuhnian terms, it is not a mature science, and at least until 2013, the identification of a paradigm was not possible. Even though there is a scientific community worldwide studying aspects related with the sustainability of certain human/nature processes, it is not acknowledged as an independent discipline. Such community does not share theoretical assumptions about sustainability and does not share methodological criteria in their studies either. Nevertheless, this does not deny the possibility of a paradigm construction in process.

Research on sustainability seems to be developing under methodological designs and criteria from other disciplines rather than under criteria proposed for research on sustainability. This assertion is supported by the scarce application of methodological characteristics such as systems approach, transdisciplinarity, participation and problem-solving perspective that was observed throughout this review. Moreover, the fact that journals are not classified into an area of knowledge specific to sustainability, but into other disciplines, also leads us to the above conclusion.

It is worth mentioning that these conclusions may differ from those obtained in sustainability studies that do not include the term sustainability; however, such a study will be possible when more precise criteria to identify sustainability research are established.

References

Bettencourt, L., & Kaur, J. (2011). Evolution and structure of sustainability science. *PNAS, 108*(49), 19540–19545.

Brockhaus, S., Kersten, W., & Knemeyer, M. (2013). Where Do We Go From Here? Progressing Sustainability Implementation Efforts Across Supply Chains. *Journal of Business Logistics, 34*(2), 167–182.

Brown, R. R., Deletic, A., & Wong, T. H. F. (2015). How to catalyze collaboration. *Nature, 525*, 315–317.

Centro Cochrane Iberoamericano, t. (2012). *Manual cochrane de revisiones sistemáticas de intervenciones*. http://www.cochrane.es/?q=es/node/269.

Chalmers, A. (1999). *¿Qué es esa cosa llamada ciencia?*. Madrid: Siglo XXI.

Clark, W., & Dickson, N. (2003). Sustainability science: The emerging research program. *PNAS, 100*(14), 8059–8061.

Claro, D. P., Laban Neto, S. A., & de Oliveira Claro, P. B. (2013). Sustainability drivers in food retail. *Journal of Retailing and Consumer Services, 20*(3), 365–371.

Glavič, P., & Lukman, R. (2007). Review of sustainability terms and their definitions. *Journal of Cleaner Production, 15*, 1875–1885.

Hawley, A. H. (1986). *Human ecology: A theoretical essay*. USA: The University of Chicago Press.

Hernández-Sampieri, R., Fernandez-Collado, C., & Baptista-Lucio, P. (2006). *Metodología de la investigación* (4ta ed.). México, DF: McGraw-Hill/Interamericana.

Jerneck, A., Olsson, L., Ness, B., Anderberg, S., Baier, M., Clark, E., et al. (2011). Structuring sustainability science. *Sustainability Science, 6*(1), 69–82.

Jiménez, L. (2008). *Desarrollo sostenible* (2nd ed.). Madrid: Pirámide.

Kajikawa, Y. (2008). Research core and framework of sustainability science. *Sustainability Science, 3*(2), 215–239.

Kajikawa, Y., Tacoa, F., & Yamaguchi, K. (2014). Sustainability science: The changing landscape of sustainability research. *Sustainability Science, 9*, 431–438.

Kataria, A., Kataria, A., & Garg, R. (2013). Effective internal communication: a way Towards Sustainability. *International Journal of Business Insights & Transformation, 6*(2), 46–52.

Kates, R., Clark, W., Corell, R., Hall, J., Jaeger, C., Lowe, I., et al. (2001). Sustainability science. *Science, 292*(5517), 641–642.

Kuhn, T. (2006). *La estructura de las revoluciones científicas*. Mexico DF: Fondo de cultura económica.

Martens, P. (2006). Sustainability: Science or fiction? *Sustainability: Science, Practice, & Policy, 2*(1), 36–41.

Olayide, O. E., Popoola, L., Olaniyan, O., Dapilah, F., & Abudulai Issahaku, R. Y. (2013). Assessing the transition from survival to sustainability: case of wechiau community hippo sanctuary in upper west region of Ghana, West Africa. *Journal of Sustainable Development, 6*(10), 47–56.

Parisi, C. (2013). The Impact of Organisational Alignment on the Effectiveness of Firms Sustainability Strategic Performance Measurement Systems: An Empirical Analysis. *Journal of Management & Governance, 17*(1), 71–97.

Rapport, D. (2007). Sustainability science: an ecohealth perspective. *Sustainability Science, 2*(1), 77–84.

Salas-Zapata, W., & Rios-Osorio, L. (2013). Ciencia de la sostenibilidad, sus características metodológicas y alcances en procesos de toma de decisiones. *Revista de Investigación Agraria y Ambiental, 4*(1), 101–111.

Sterman, J. (2012). Sustaining sustainability: Creating a systems science in a fragmented academy and polarized world. In M. Weinstein & R. E. Turner (Eds.), *Sustainability science: The emerging paradigm and the urban environment* (pp. 21–58). New York: Springer.

Urrutia, G., & Bonfill, X. (2010). Declaración PRISMA: Una propuesta para mejorar la publicación de revisiones sistemáticas y metaanálisis. *Medicina Clinica, 135*, 507–511.

Viaggi, D., Raggi, M., & Gomez y Paloma, S. (2013). Modelling and interpreting the impact of policy and price scenarios on farm-household sustainability: Farming systems vs. result-driven clustering. *Environmental Modelling & Software, 43*, 96–108.