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Collective innovation and management of common agricultural resources: A bibliometric analysis

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Abstract
In a context of perpetual change and global competition, the study of collective innovation in resource management has given rise to original literature in recent years. The main aim of this study is to present a synthesis of global research on collective innovation in the management of common agricultural resources over the past 20 years. A bibliometric analysis was developed on the Scopus database to identify relevant articles evaluated. The questions were made successively with the words: collective innovation, management and agriculture respectively in French and English. The consultation concerned the title, abstract and keywords of the articles, for a period from 1998 to 2019. After a check by reading all the abstracts, a base of 146 articles was selected. The variables analyzed are: articles by year, category, journal, country, institution, key authors, affiliations and keywords. The results indicate that the number of articles published per year is growing remarkably. The main category is agricultural science, social science, and environment. The countries with the most numerous articles are: France (n = 92), USA (n = 11), for African countries, Benin (n = 5), Burkina-Faso (n = 5). Institutions like INRA, CIRAD, AgroParis tech are the most productive. Three main clusters have been identified: "innovation", "system" and "development". The most frequently used keywords are: collective innovation, learning, natural resources, commons, sustainability. The results of this study provide an overview of global research in this area.

Keywords: Author, Bibliometric Analysis, Innovation, Management, Scopus

1. Introduction
The art organizations, both private and public, are largely affected by the uncertainties of their environments (Suire *et al.*, 2018) [16]. In a context of global competition based on innovation, the activity sectors and the companies that compose them evolve under the set of contradictory forces (Uzunidis, 2018) [17]. To face this complex and constantly changing environment, any organization must ensure its development and guarantee its sustainability (Rakotondranaivo, 2006) [14]. More and more, a company to ensure its survival in an environment in perpetual movement, must then continually seek to propose new products, processes and services. It must constantly face changes in its environment by adapting its processes and internal organization to external developments, social, political, environmental, technological and economic constraints or opportunities (Rakotondranaivo, 2006) [14]. Faced with intensifying competition and the rapid renewal of economic data (products, processes, services, markets, technologies, knowledge and know-how, etc.), innovation is becoming an imperative for organizations or companies. Innovation is thus seen as an introduction of a certain novelty into a certain way of doing things (Faure *et al.*, 2018) [8]. The innovation can be applied to all dimensions of the production of goods and services (Fontan *et al.*, 2004) [9]. Innovation is an important factor that can lead to better results on farms (De Romemont, 2014) [4]. In addition, the complex interrelationships between players, both between individuals and between organizations, lead to the concept of "innovation system" being proposed to better understand the dynamics of innovation. It can be defined as a network of organizations, companies and individuals producing new products, new processes, or new forms of organization implemented in economic activities, and including institutions and policies. That affect their behavior and performance (Rajalahti *et al.*, 2008) [13]. Thus for Uzunidis, (2018) [17], innovation is itself a collective, cumulative and historical process defined by seven major characteristics: a) the impacts of innovation are difficult to predict; b) the scale of diffusion of innovation is difficult to calculate; c) innovative activities are asymmetric and lagged in time; d) the time of learning, execution and dissemination plays a major role in the act of innovating; e) the business climate conditions the time, scale, nature and impacts of innovation; f) the space of realization, in other words the geographical and communication distances, favors or, on the contrary, hinders access to information and to strategic knowledge of the innovation process; g) innovations are interdependent; the risk linked to costs and time means that innovation is sometimes or both a collective act and sometimes the result of the collectivization of its inputs.

This line of research has reached an important level of development; therefore, the analysis of the evolution of research on collective innovation is necessary. The objective of this work is to present a review of global research on collective innovation. To achieve this objective, a systematic and quantitative study was carried out using the bibliometric method.

The article is organized as follows. After this introduction, the methodology used in the development of this article, the main results as well as their discussion are presented and finally the conclusion of this research.

2. Materials and methods

A bibliometric analysis was developed on the Scopus database to identify relevant articles evaluated. The analytical grid allows us to explore scientific production using the concept of collective innovation in work on agriculture. We therefore carried out a bibliometric study using the Scopus search engine. This database was chosen because it covers most of the international literature on agriculture and refers to a variety of scientific disciplines.

The questions were made successively with the words "innovation" AND "collective" AND "agriculture" AND "management" respectively in French and English. The consultation concerned the title, the abstract and the keywords of the articles, for a period going from 1999 to 2019. After a control by reading all the abstracts, a base of 146 articles was retained including the articles concerning directly agriculture, social sciences, environment, management as well as part of the articles on biotechnologies and engineering when they appear to be related to agriculture or agrifood. The variables analyzed are articles by year, number of citations, subject category, journal, country, institution, key authors, their affiliations and key words.

Among other things, bibliometric analysis software (VOS viewer) was used to complete the analysis and generate a map that visualizes the citation models of 146 articles containing different terms.

Using the bibliometric tool, we identified three clusters on the basis of which future research axes are developed. It is: innovation, system, and development.

3. Results of the bibliometric study and discussion

3.1 Evolution of scientific productions

Table 1 shows the evolution of the main characteristics of research works on collective innovation published from 1998 to 2019, divided by articles, authors, references, citations, journals and countries.

Table 1: Evolution of research on collective innovation by article, authors, citation and country

Year	Item number	Author number	Author number/article number	Number of citation	Number of citations per article	Number of countries
2019	13	71	5.5	219	16.8	12
2018	15	58	3.9	231	15.4	11
2017	15	47	3.1	163	10.9	12
2016	16	41	2.6	141	8.8	10
2015	10	36	3.6	140	14.0	13
2014	14	53	3.8	94	6.7	4
2013	10	26	2.6	87	8.7	6
2012	6	48	8	93	15.5	23
2011	7	15	2.1	73	10.4	2
2010	2	2	1	57	28.5	2
2009	5	16	3.2	49	9.8	5
2008	3	4	1.3	34	11.3	3
2007	5	17	3.4	24	4.8	6
2006	6	16	2.7	28	4.7	4
2005	3	6	2	21	7.0	3
2004	2	7	3.5	11	5.5	4
2003	4	8	2	10	2.5	5
2002	4	5	1.2	6	1.5	3
2001	2	2	1	4	2.0	2
2000	0	-	-	-	-	-
1999	2	7	3.5	3	1.5	5
1998	1	3	3	3	3.0	2

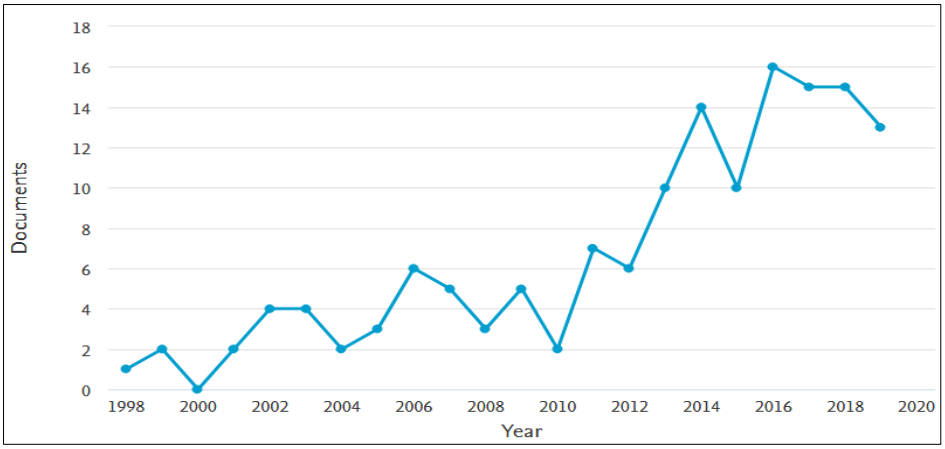
During the first two decades of the analyzed period (1998-2008), only 26 % of the total number of published works were published, while between 2009 and 2019, 74% of total works of the period were been published. Regarding the number of authors, a total of 488 authors participated in the creation of 488 articles analyzed. The annual calculation verifies that the number of authors has steadily increased from 1 article in 1998 to 16 in 2016, 15 in 2017, 2018. The average number of authors per article has increased significantly throughout the period, from 1 to 5. The number of citation has also increased significantly. Compared to the number of citations are items published on collective innovation throughout the period, 145 products analyzed accumulated a total of 1491 citations in 137 countries, an average of 10,3 citations per article. This variable increased exponentially from 3 citations in 1998 to 231 citations in 2018, and almost 60% of all citations were concentrated in the most recent five year period (2015 to 2019). The table also shows the average number of citations accumulated up to the end of the period divided into the total number of articles published to date. The average citations per article have steadily increased from 1,5 in 1999 to 16,8 in 2019.

Likewise, the number of countries that published articles on collective innovation increased rapidly during the study period. Starting with 2 countries in 1998, it was recorded a maximum of 23 countries in 2012 and 12 countries in 2019. The participation of more and more countries in this field of study shows that collective innovation is becoming a major global problem.

The reasons underlying the development of research on collective innovation are various. The public is increasingly aware of the need to create new knowledge to meet the new challenges of development for meadows ever and properly maintain the resources natural common to keep a fashion ideal operation. Likewise, the impacts of climate change on agricultural systems and lifestyles are increasingly present in the concerns of global society. It is important to put the actors at the center of discussions in order to develop appropriate

solutions to deal with them. So to overcome the crises of cooperation between actors threatening a common resource, (Labatut and Hooge, 2016) [11] propose the design of technical and organizational innovations, the redefinition of a common objective allowing collective action, the creation of sustainable innovation capacities. There are indeed innovative and participatory design strategies in a context of collective action between different individual and collective, private, cooperative and public actors. As for (Elmquist *et al.*, 2009) [6], the KCP method (Knowledge - Concept - Proposals) is put forward as one of the solutions to promote innovation in agriculture facing the challenges of sustainable development (Berthet, 2013) [1] in a context where farmers have an essential place in the design of innovations and where participatory research is an important lever (Bournigal *et al.*, 2015; Duru-Bellat, 2011; Étienne, 2010; Stassart and Jamar, 2012) [2, 5, 7, 15].

The fig below shows the evolution of publications by year. This fig 1 shows the interest aroused by this field of research since its inception, growing exponentially in recent years. Solid dots represent annual items of 1998 and the curve simulates the growth pattern of aggregate items.



Source: Scopus, November 2019

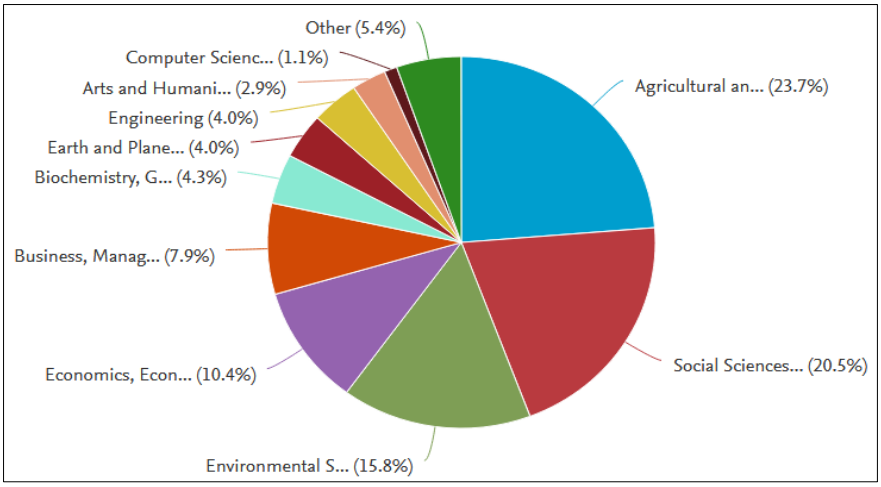
Fig 1: Evolution of publications by year

The results indicate that the number of articles published per year is growing remarkably. The chronological analysis of the 146 articles (Fig 1) underlines a strong increase in annual production since 1998 with three periods: low production from 1998 to 2005 (one or four articles per year); moderate growth between 2006 and 2012 (between 6 and 7 articles per year); strong growth from 2013 to 2019 (more than 16 articles per year since 2016). The number of published articles has increased in recent years, proving that studies of collective innovation are attracting the attention of researchers and are growing rapidly. Studies on collective innovation went from 1 article in 1998 to more than 16 in 2016.

3.2 Breakdown of production by subject and journal categories

Fig 2: Shows the evolution of the main thematic areas in which the articles published on the innovation collective been organized according to the classification of Scopus. They are bound mainly the categories of agricultural and social sciences. Note that a single study can be indexed in more than one category. Since our research aims to show the links between the different disciplines, we cannot consider a selection bias according to which an article is classified in different categories. For most of the study, the main category is agriculture, which released in 23.7% of the total number of publications. Then come the social sciences (20.5%); environmental science (15.8%), economics with 10.4%; management with 7.9% and biochemistry (4.3%) of the total number of articles.

The rest of the categories did not represent more than 4 % of the total number of articles published. This hierarchy was maintained throughout the study period.

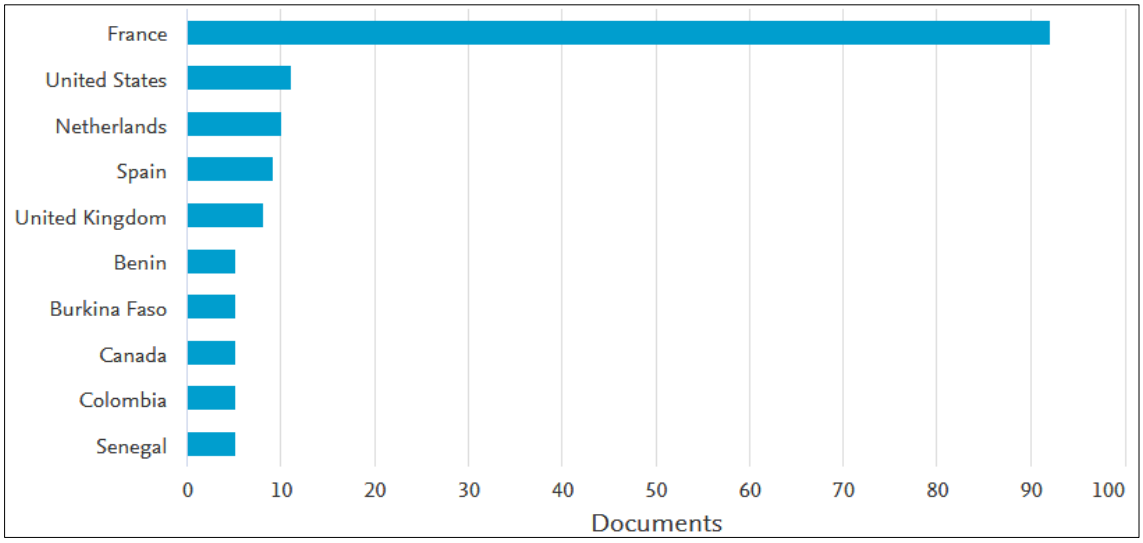


Source: Scopus, November 2019

Fig 2: Evolution of the main thematic areas

3.3 Breakdown of production by country, institutions and authors

Fig 3 shows the evolution of the number of articles on collective innovation in the 10 countries with the highest number of articles published from 1998 to 2019. The France is the country that has the most large number (maximum total) of articles on innovation between 1998 and 2019 (n = 92), followed by the USA (n = 11), Netherland (n = 10), of Spain (n = 9), the United Kingdom (n = 8) and African countries in particular Benin (n = 5) and Burkina Faso (n = 5). Between 1998 and 2019, the France has been the country that published the most articles on innovation group. It should be noted that several other African countries such as: Cameroon, Senegal and Morocco have also published no less articles (n = 3) on the theme.



Source: Scopus, November 2019

Fig 3: presentation of articles by country

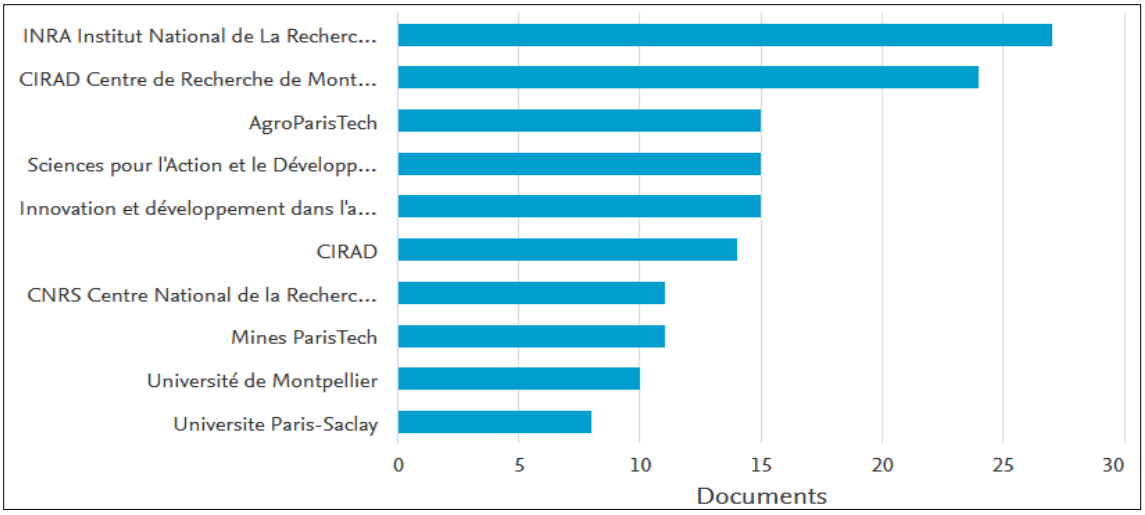
The table below shows the production of articles and their citations by country.

Table 2: Distribution of production by country

Country	Rank	Item Number	Citation of articles	Total citation / Article number
France	1	92	797	8.6
USA	2	11	426	38.7
Netherlands	3	10	130	13
Spain	4	09	44	4.8
United Kingdom	5	08	228	28,5
Benin	6	05	69	13.8
Burkina Faso	7	05	50	10
Canada	8	05	40	8
Colombia	9	05	73	14.6
Senegal	10	05	33	6.6

The country with the highest number of citations from 1998 to 2019 on collective innovation is France with 797 citations, followed by the USA with 426 citations, the United Kingdom with 228 citations, the Netherlands with 130 citations, Colombia with 73 and from Benin with 69 citations. However, the USA is the country where the average number of citations per article is higher (38,7%), followed by the United Kingdom with 28,5% of British avec14,5%, Benin with 13,8% and the Netherlands with 13%. When comparing the percentage of articles and the number of citations by country compared to the total number of published works and citations during the period, significant differences were found. The USA, the United Kingdom, Colombia and Benin are the four countries with the highest positive differences between the number of articles and the number of citations. This could be taken as a sign of recognition of the publications from these countries based on the citations. Conversely, Spain, Senegal, Canada and France are the countries where the number of citations is the lowest compared to the number of works published.

Fig 4 shows the documents produced by affiliation of the authors. The INRA (National Institute for Agronomic Research), CIRAD, AgroParis Tech were the three mains research institutes in this field with respectively 27, 24 and 15 items. Institutions such as Science for Action and Development then Innovation and Development in Agriculture are also productive (15 articles).



Source: Scopus, November 2019

Fig 4: Presentation of documents by affiliation

The table below shows the production of the articles, the number of citations, the co-authors and their affiliations.

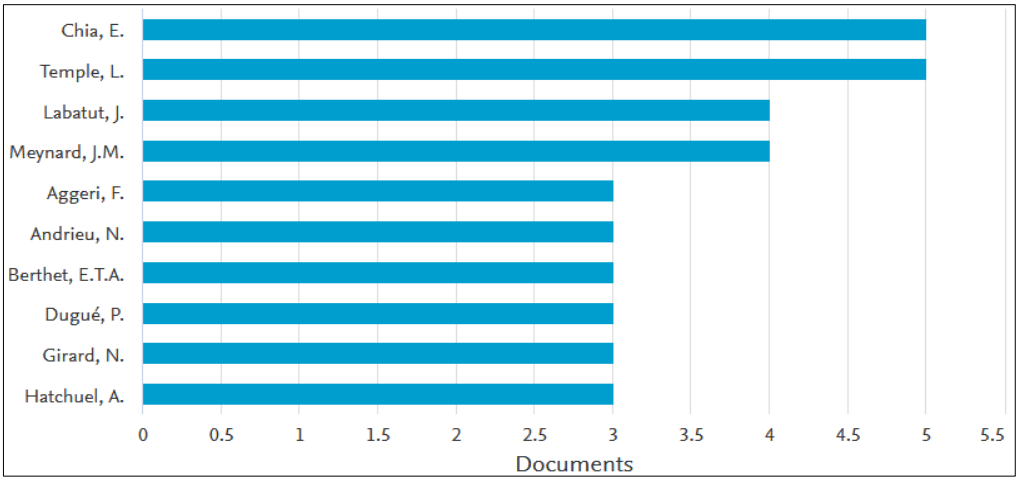
Table 3: Distribution of authors' production by affiliation and by country

Authors	Item number	Number quote	Citation by article	Co-authors	Index H	Affiliation	Country
Chia, Eduardo	5	127	25.4	85	6	INRA (National Institute of Agronomic Research), Paris,	France
Temple, Ludovic	5	208	41.6	113	9	University of Montpellier, Montpellier	France
Labatut, Julie	4	164	41	46	7	INRA Occitanie-To ulouse, Castanet-Tolosan	France
Maynard, Jean-Marc	4	3459	864.75	150	34	Sciences for Action and Agro Development ParisTech, Paris	France
Aggeri, F ranck	3	262	87.3	22	8	PSL University, Paris	France
Andrieu, Nadine	3	345	115	86	8	Centro Internacional de Agricultura Tropical, UMR Innovation, Cali, Colombia U niversity of Montpellier	France
Berthet, Elsa.TA	3	157	52.3	43	7	McGill University, Department of Natural Resource Sciences, Universite Paris-Saclay	France
Dugué, P atrick	3	262	87.3	83	8	Innovation and development in agriculture and food Montpellier	France
Girard, Nathalie	3	312	104	52	9	Agroecology, Innovations, territories - (AGIR), Castanet-Tolosan	France
Hatchuel, A rmand	3	1718	572.6	85	20	Mines ParisTech, Paris,	France

Table 3 shows the 10 authors with the highest number of articles published on collective innovation. Although the authors wrote their first article on collective innovation in the years 1998, they all continued this type of research with the publication of the works until 2019. These results show that this field of study interests several authors and brings together a group of authors with a long research career on the topic and who are references. The author with the greatest number of articles is Chia, Eduardo from INRA [1], Paris Tech with 5 articles, 127 citations accumulated from these studies, an H index of 6 of his publications, and an average of 25,4 citations per article. Temple, Ludovic of the University of Montpellier in France, is the researcher who recently joined this line of research, but with more than 15% more than Chia, Eduardo in terms of citation per article. Hatchuel, Armand de Mines ParisTech, Paris occupies the tenth position in terms of total number of articles, but accumulates 1,718 citations out of a total of 3 articles. The author with the highest number of citations per article is Maynard. Jean-Marc, a researcher who joined Sciences for Action and Development AgroParisTech, Paris, France, with 3459 citations, an average of 864,75citations per work and has the highest number of co-authors (n = 150) and 34 as index H. Terry A. Howell is the author of the oldest publication, dating from 1998. Authors who have had the least citation are Chia, Eduardo, Labatut, Julie and Temple, Ludovic are the authors with the lowest average citation per article with 25.4% respectively; 41% and 41.7%. Finally, it should be noted that the 10 authors who published the most articles are from France.

The fig below shows the situation of the 10 authors who published the greatest number of articles on collective innovation. Chia, E. and Temple, L. each have 5 articles, while Labatut, J. and Meynard, JM have 4 articles. Aggeri, F.; Andrieu, N. ;Berthet, ETA ;Dugué, P.; Girard, N. and Hatchuel each published 3 articles.

[1] Institut National de la Recherche Agronomique



Source: Scopus, November 2019

Fig 5: Presentation of documents by author

3.4 Keyword analysis

We have created a network map the impact of keywords, based on competition keywords, to 100 words with the greatest number of links and a minimum of 50 coincidences. Fig 7 displays the resulting scientific landscape. The most popular terms are those that appear in large circles. The fig shows the link between those considered to be hot spots in this area of research and three main groups are visible.

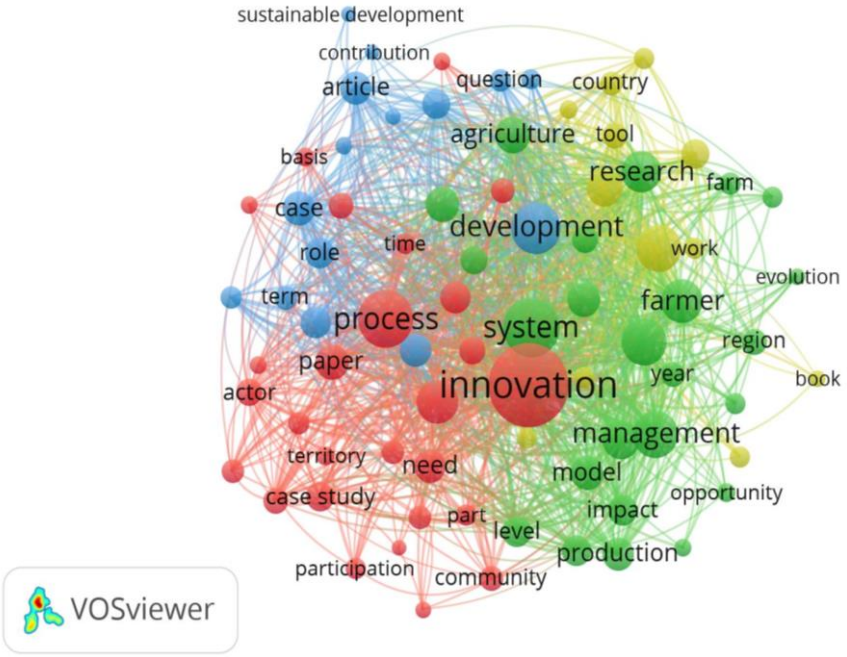


Fig 6: Scientific landscape of research on collective innovation

Fig 6 displays the scientific landscape of research on collective innovation. The most popular terms are those that appear in large circles. The fig shows the link between the different keywords and the possible groupings for the formation of clusters. In this study, three main clusters are considered and clearly visible.

The first cluster is represented by the term “Innovation”, which appears in red. This cluster brings together a set of terms related to innovation: innovation, innovation process, actors, participation. Terms related to collective innovation highlight the actors and their interactions, communities, stakeholders, territories, innovation needs, innovation time and ground rules.

The second cluster relates to "system", displayed in green. This cluster brings together a set of terms related to the system or collective action. Here we find terms like related to management system, production, agriculture, farmers, impacts and opportunities / benefits of management systems.

The third cluster concerns “development”, indicated in blue. It includes subjects related to the different agronomic practices of sustainable development, the roles of actors, institutions and their contributions to sustainable development.

It should be emphasized that future research axes will be developed on the basis of these three identified clusters.

4. Conclusion

The main objective of this study was to present a review of global research on collective innovation. To achieve this, a bibliometric analysis based on the Scopus database was carried out from 1998 to 2019. 146 articles were considered in the sample. The variables analyzed were: number of articles per year, subject categories, journals, distribution by country, institutions, author and keywords. The results indicated a remarkable growth in the number of articles per year, from 1 article published in 1998 to more than 13 in

2019. This has been particularly noticeable over the past five years, with over 47% of the total number of articles published during this period. The average number of authors per article increased from 1 to 5,5. The publication of articles on collective innovation has also spread to an increasing number of journals. Collective innovation research has become a global problem as an increasing number of countries participate in this research area, from 2 in 1998 to 12 in 2019. Currently, research on collective management of common resources is not exclusive to the agricultural sector, social and environmental sciences are also the main thematic areas. France is the country with the highest number of articles published, followed by the USA, the Netherlands, Spain, the United Kingdom, and in Africa countries such as Benin, Burkina Faso and Senegal. INRA, CIRAD and AgroParis Tech were the three main research institutes in this field. The 10 authors who have published the most articles in this field all come from France. The simultaneous map of identified keywords brings together the three main groups that can be considered as clusters in this line of research. These are: innovation, system and development.

However, for (Cerf, 2012) [3] in design theories, it remains essential to produce new organizational forms ensuring the recreation of collective innovation capacities. The development or adaptation of collective design and management methods is today a major issue for research and development in agriculture as well as in organizations *(*Hollensbe *et al.*, 2014; O'brien *et al.*, 2009) [10, 12]. But the cognitive, prospective and evaluative aspects of the actors themselves in the collective management of common agricultural resources must now be taken into account.

The results of this study may help researchers in this area by providing insight into global research.

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