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Review

Bibliometric Analysis of Trends in Global Sustainable Livelihood Research

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Received: 10 January 2019; Accepted: 6 February 2019; Published: 21 February 2019

Abstract: The concept of sustainable livelihoods (SL) is one of the most important subjects of sustainable development, and is an important long-term goal for poverty alleviation. There has been growing interest in the nature and practical application of SL in recent decades. This paper applies bibliometric analysis to collect and analyze data on sustainable livelihoods from the expanded Science Citation index (SCIE) and the Social Sciences Citation Index (SSCI). Bibliometric maps can assist greatly in visualizing and summarizing large volumes of data and in studying scientific outputs. The findings offer insights into research trends pertaining to SL, such as these: (1) In recent decades there has been an increase in both the number of papers on SL and their scientific influence. (2) The most active journals are Sustainability, Ecology and Society, Land Use Policy, and International Journal of Sustainable Development and World Ecology. (3) SL papers are distributed mainly in the fields of Environmental Sciences, Environmental Studies, Ecology, Planning & Development, and Green & Sustainable Science & Technology. (4) The USA and UK are leaders in SL research as measured by both the quantity and quality of SL publications. Some developing countries, notably India and China, have seen an increase in SL publications in recent years. (5) Wageningen University in Netherlands, the Chinese Academy of Science, and the Center for International Forestry Research (CIFOR), headquartered in Indonesia, have had a major influence in the field of international SL research. (6) International cooperation has a positive effect on the growth of SL research, suggesting that there is a need for strengthening cooperation among countries, international institutions, and individuals. (7) Major areas of SL research ("hot topics") are theoretical research on the SL concept; ecosystem conservation; poverty reduction in the poverty-stricken areas; the impact of climate change on livelihoods; and linkages between SL-related policies and institutional change.

Keywords: bibliometric analysis; sustainable livelihoods; sustainable development; visualization

1. Introduction

This article concerns itself with a concept that is especially relevant in developing countries: sustainable livelihoods (SL). The sustainable livelihoods approach (SLA), or sustainable livelihoods framework, is a core principle for addressing poverty in the world.

The SL concept was first clearly formulated in a 1987 report of the Brundtland Commission, and the idea (although without the name) was endorsed in the first UNDP Human Development Report in 1990. The concept then gained widespread attention in the last decade of the 20th century [1–3]. In 1995, for example, the World Summit for Social Development, held in Copenhagen, Denmark, issued the "Copenhagen Declaration," which expressed a commitment "to enabling all men and women to

attain secure and sustainable livelihoods through freely chosen productive employment and work." The Fourth World Conference on Women (FWCW) in Beijing in 1995 and the 1996 World Summit on Food Security in Rome offered additional vehicles for emphasizing the significance of SL and pursuing a path toward poverty alleviation. The following years saw an increase in both theoretical and empirical research on the SL concept, and to the present day, numerous international SL projects continue to contribute to the search for alternatives to mainstream development strategies. The SL concept has been tested both empirically and theoretically by researchers, and is now recognized and endorsed all over the world by individuals, governments, and Non-governmental organizations. SL was adopted as a concept by Chambers and Conway in 1992 after its appearance in The World Commission on Environment and Development in 1990, and was further studied and discussed by Scoones, 1998 [4]; Farrington et al., 1999 [5]; and Carney, 2002 [6]—all of whom are strong advocates of the Sustainable Livelihoods Framework, or Sustainable Livelihood Approach (SLA).

SLA gained firm support from the International Institute for Sustainable Development (IISD) in 1993, and later also from the Society for International Development (SID) in 1994; from the Overseas Development Institute (ODI) in 1998 and 1999 [5,7,8]; and from the Department for International Development (DFID) in 2000. Over recent decades, many development agencies have conducted empirical studies on SL. Up to the present, a variety of analytical frameworks have been proposed by different agencies, including "household livelihoods security," adopted by Care International in 1994. SLA was also promoted and employed by DFID and UNDP in 1995 [9].

Compared with traditional livelihood research, SLA is regarded as an improved and well-structured approach, providing a better micro-level understanding of poverty as it affects both policy and processes of institutional change [5]. The importance of SL research is made clear by the fact that it is now an indispensable part of national and international economic development and environmental conservation. Also, because of the ever-greater global implications of environmental change and impacts of human activities, SLA is being transformed into a multi-objective and interdisciplinary approach, resulting in a remarkable increase in relevant research. With the strengthening of its theoretical basis and the improvement of its overall analytical framework, the concept of SL is widely recognized by researchers as a vital global issue.

Now that SL has become a mainstream concept in international development, it is important to understand its evolution and progress, and to analyze the attributes and characteristics of its growing knowledge base. Contributing to SLA's development, many researchers have conducted a large number of studies from a variety of perspectives, such as: rural household livelihoods, including livelihood diversification [10–12]; livelihood vulnerability [13–15]; sustainable livelihood security [16,17]; rural livelihoods and poverty reduction [18–20]; land use change and rural livelihoods [21–23]; energy consumption and rural livelihoods [24]; and renewable energy technology and SL [25–27].

Connolly-Boutin and Smit developed a conceptualization of relationships among four distinct but inherently interconnected concepts, i.e., impacts of climate change, vulnerability and adaption, food security, and sustainable livelihoods [28]. One of their purposes was to identify the relationships and regularity among food security vulnerabilities, together with related multiple stresses and adaptive capacities. Another purpose was to improve existing management systems and enhance program effectiveness toward higher performance. SLA has been used in guiding policy-making in CM-SES (tropical coastal and marine social-ecological systems) and in evaluating current CM-SES management [29]. Scoones has reviewed some of the key historical moments in the development of the sustainable-livelihood (SL) approach, and, in addition, identified the tensions, ambiguities, and challenges that can arise in this approach, in order to help overcome the principal defects that show up in "real-world" applications of the livelihoods perspective [3]. Kelman and Mather adopted SLA as a significant method for understanding and implementing the benefits of volcanoes for local communities, as well as understanding and dealing with the risks [30]. Sneddon interpreted and summarized the evolution and development of sustainability-related theories in order to bring conceptual and practical perspectives of different researchers to the forefront of public attention [31].

A growing number of publications concerning SL research can readily be found, yet not enough attention has been paid to this research field, with the result that much current academic research on SL has not been interpreted clearly. Moreover, current academic review articles center mainly on the methodology, process, and content of SL research. Additionally, the majority of papers adopt traditional statistical approaches and descriptive analyses. To date, there has been a lack of systematic study of SL research in terms of the attributes and characteristics of its framework. Few existing reviews have attempted to provide a visual presentation of the trends in the evolution of SL or to explore the current focal points of research in this field [32].

To round out and extend previous reviews, this paper maps and evaluates the relevant SL literature for the purpose of identifying potential research gaps, broadening and strengthening its comprehensive knowledge base, exploring the forefront of trends in its development, and exhibiting the boundaries of existing academic work. The paper also seeks to reveal the cooperation network among various countries, institutions and even individuals in the SL field; moreover, it will provide scientific reference for the establishment of relevant policy. Software for bibliometric analyses and visualizations are adopted in this research in order to map out the knowledge structure of SL research, a technique that has been proven to be vital in the evaluation of social science research performance [33]. This paper also reports a further historical review method for a longitudinal literature review, which enables one to trace back the evolution of the SL concept. More specifically, this paper looks at: firstly, where the SL concept came from and how the perspective it engenders has evolved; secondly, the publication output and impacts of researchers who devote themselves to SL studies; thirdly, specific research subjects/themes; and finally cooperation networks tying together different countries, different institutions, and different scholars.

2. Research Methodology

2.1. Methodology and Primary Data Statistics

The analysis and classification of scientific work and publications that relate to SL from 1991 to 2017 are presented in this paper. The integrated workflow is detailed in Figure 1. The major research method adopted is bibliometric analysis, which has attracted increased attention recently, and plays an important role in systematic analysis in various fields [27,34,35]. SCIE and SSCI from the Web of Science have been selected as a important online bibliometric databases for searching and retrieving documents, in order to display the structural and dynamic aspects, and the evolution of scientific research [36]. Bibliometric analysis permits one to use both quantitative and qualitative analysis to measure and predict patterns of scientific publication and citation, generally focusing on published journal papers [37]. Qualitative bibliometric analysis is regarded as a significant component in evaluating the degree of maturity of a field.

International scientific influence of scientific papers is recognized as the most vital parameter to assess the quantity, quality, and efficiency of research performance [38,39]. This measurable parameter was adopted as one of the most crucial indicators of SL research performance. Alongside science mapping tools, scientific publications has been taken as an input in order to generate the visual representation of interactive quantitative and qualitative analysis and visual exploration within the dynamically changing system [40,41].

The research objectives in this study can be subdivided into four parts: research output, collaboration networks, academic impact analysis, and focal points of research ("hot topics") in SL. These are demonstrated in Figure 1. The measures of research output that were used in this study are the total number of articles recorded in the database (SCIE and SSCI) in English from 1990 to 2017; the number of articles from each country; the number of articles from each institution; and the number of articles by each researcher. To better understand collaborative networks, the knowledge structure of a scientific field can be analyzed on the basis of particular units of analysis, such as co-author

analysis [36,42]. The international dimension of a scientific field can also be analyzed and interpreted by measures of co-institution, co-university, and co-country collaboration.

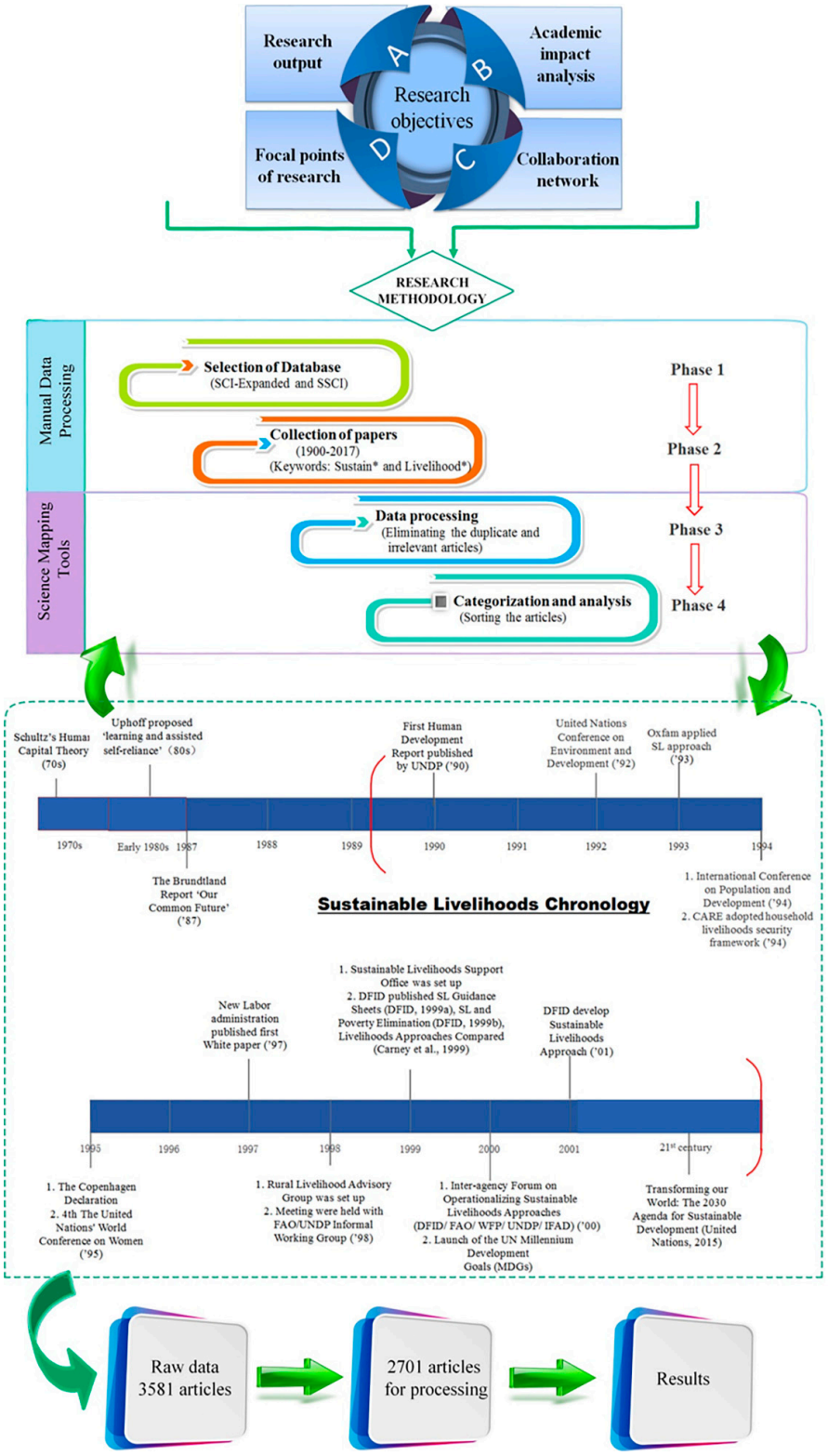

Figure 1. Integrated workflow in science mapping analysis (methodology from [1,3,45]).

Academic impact analysis in this research refers to the international citation of academic articles, which indicates the depth and breadth of the impact of a particular scientific field: in other words, the extent of dissemination of research results.

Research topics and dominant research areas in this paper have been studied in the form of the co-occurrence network structure of high-frequency keywords based on SL scientific literature [43]. Particularly, co-word analysis [44] facilitates the analysis of principal concepts treated in SL-related research and allows one to map the conceptual structure more clearly.

The research methodology in science mapping analysis consists of four main steps: firstly, selection of a database that is relatively authoritative and representative compared with others; secondly, data retrieval—keyword search in the selected database; thirdly, exclusion of duplicated, misspelled, and irrelevant articles after a data scrubbing process; and finally, categorization of published papers.

Research centered on SL has gone through three main stages (Figure 1 shows some historically important events): the first stage: the embryonic stage of the SL concept (from the 1970s to the early 1980s); second stage: the emergence of SL as a new paradigm (from the early to the late 1990s); and the third stage: innovation and expansion of SLA (since 2000) [1,3,45]. The paper reports only on work published after 1990, since SL-related data are sparse before then.

WOS includes the oldest publications, as its indexed and archived records go back to 1900; however, there are some limitations when researchers apply WOS, as it does not provide any data with respect to open access articles that is included, which makes it difficult for researchers to conduct an in-depth analysis. In addition, the WOS database only contains 4 independent databases, in other words, it does not include multiple expanded spectra of journals as a data source. As for this research, the authors choose two databases from WOS, as mentioned earlier.

2.2. Data Retrieval and Processing

To chart the development in the SL field, this research chose the SCIE and SSCI databases from the Web of Science Core Collection, because they are relatively representative and authoritative index databases that are available. Both SCIE and SSCI cover a large number of high-quality journals of the social sciences from different countries and regions, and are clearly important databases in the social sciences [39]. In order to search for the terms "sustainable" and "livelihoods" together, this paper adopted the two-term search string 'sustain* (which yields, for instance, "sustaining", "sustained", "sustainable," and "sustainability") and livelihood * (yielding "livelihood" and "livelihoods"). As noted above, this research focused on papers published in the period beginning in 1991, because there is little SL data prior to that year. It reports literature up to March 8, 2018 in this paper. In total, 3581 raw-data items were recorded based on a topic search of the terms "sustain *" and "livelihood *" in titles, abstracts, and indexing terms.

There are inevitably some irrelevant articles in the scientific papers retrieved from the bibliometric sources. For example, an article might include the phrase 'sustainable livelihoods', even though its subject matter is unrelated to SL. To be sure such irrelevant papers are excluded from our analysis, the two authors of this report worked under the guidance of the third author to go through the abstracts of all the papers manually and remove irrelevant articles. Even after filtering out irrelevant papers from the preliminary data, some errors still remained in the dataset. The next step was to enter the data into science mapping tools.

CiteSpace is a Java application developed at Drexel University [36] which is adopted in this study for the purpose of analyzing and visualizing patterns and trends in scientific papers. It was initially developed as a research tool to help detect newly-emerging trends in a research field [46]. Along with other science mapping tools such as Thomson Data Analyzer and Gephi [47], articles are eliminated automatically if they are duplications and are also excluded if the same paper written by the same author appears twice because the author's name or affiliation is written in different forms in different citations. This data-processing phase is one of the essential steps needed to increase the accuracy, and thereby, improve the quality of the units of analysis, resulting, in turn, in better research results.

This phase of our work (data scrubbing and cleaning) reduced the total number of publications in the dataset from 3581 to 2701.

These science mapping tools can automatically plot selected units of analysis using a mapping algorithm [36]. Different forms of networks and graphs can be built to help analyze the evolution of a particular research field, including detailed subject categories, most active journals, co-author organization networks, co-author networks, co-author country networks, and article co-citation. Normally, the analyst will select and filter the most important items in order to simplify and clarify the matrix. For example, the top twenty most active journals and subject categories can be filtered for conducting visualization modes.

3. Results and Discussion

3.1. Characteristics of Sustainable Livelihood Publication Output

3.1.1. Distribution of Publication Output by Year

As noted above, the final dataset for analysis consisted of 2701 papers on the topic of SL taken from the SCIE and SSCI databases. Trend analysis reveals striking features. Figure 2 shows that there was a dramatic increase in the number of published papers on the topic of SL globally, from 8 in 1991 to 325 in 2017. It is noticeable that there was a period of slow growth of publication output from 1991 to 1999, and rapid growth thereafter, although with a slight drop most recently. The number of SL-related publications reached a peak in 2016, with 327 papers included in SCIE and SSCI databases. This makes it interesting to consider what may happen in this field in the coming years.

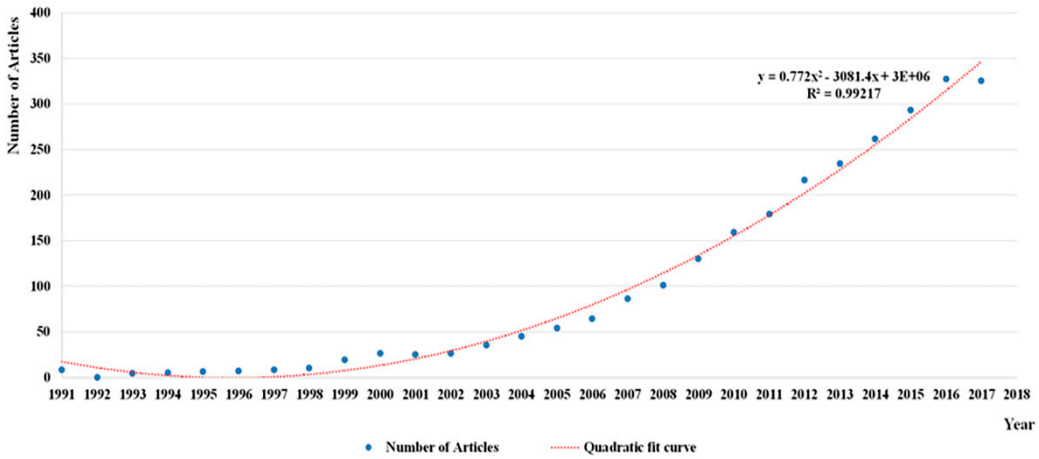

Figure 2. Publication output on the topic of SL from 1991 into 2017.

As stated in Section 1, the SL concept was introduced in the Brundtland Commission Report in 1987 and crystallized in the first UNDP Human Development Report in 1990 for the purpose of combining socioeconomic and ecological considerations in policy discussions and decisions [48]. The UN held its first Conference on Environment and Development in 1992, which seems to be the first milestone in the initiation of SL research. Since then, steadily more attention is being given to the subject of SL. Researchers have conducted numerous studies of the influences on people's livelihoods caused by environment vulnerability and unsustainable development. For example, protecting wetlands is of great importance for sustaining rural livelihoods and increasing food security [49]. African dryland vulnerability also threatens food supplies and adds to international insecurity [50]. And soil erosion in developing countries has threatened the livelihoods of millions of peasants who depend on agriculture for their livelihoods [51].

In the early 1990s, strides were made in developing SLA since some donor agencies saw the value of SL and employed SLA in their work. By the end of the 1990s, researchers were transitioning

from descriptive analyses to action-oriented endeavors that facilitated implementation of sustainable livelihoods [52]. In 1994, CARE International applied "household livelihoods security" as a guiding principle in its development work. In 1995, UNDP employed Employment and SL as one of its integrated human development mandates. In 1998, the Institute of Development Studies (IDS) put forward an analytical framework for sustainable rural livelihoods [4]. And in 1999, DFID established the Sustainable Livelihoods Framework.

Numerous empirical and systematic studies on SL have been undertaken in different places from the end of the 20th century to 2017, and the concept of SL has attracted more attention from researchers. There is a need to further expand the meaning of SL with the purpose of setting up a sophisticated theoretical framework. Researchers have outlined and summarized some of the practical, methodological, and operational implications in terms of SL [4,5] which is of great significance for guiding subsequent SL research. DFID published a series of SL Guidance Sheets, including "Sustainable Livelihoods—Current Thinking and Practice" [53], „Sustainable Livelihoods—Building on Strength" [54], and "Achieving Sustainability: Poverty Elimination and the Environment" [55].

3.1.2. Academic Impact of Sustainable Livelihood Publication Output

Citations are an effective way to measure the academic impact of papers, and also to show changes in the literature in intelligible ways over time. According to the WOS Core Collection, SL showed a substantial growth of citation impact in recent years, with 35,311 citations up to our retrieval date (8th March 2018). The average number of citations per published item is 13.07. The average number of citations per year of all published papers is 1307.8 (see Figure 3). In addition, the SL literature has 16 ESI highly cited papers (ESI highly cited paper means one whose number-of-times cited ranks in the top 1% in the world in the same subject and same publication year.) among the 2701 papers we studied. The numerously cited papers and ESI highly cited papers are important indicators of academic achievements on the subject of sustainable livelihoods.

h-index	Sum of Times Cited	Citing articles
69	**35,311**	**25,909**
Average citations per item	Without self citations	Without self citations
13.07	**32393**	**24,588**

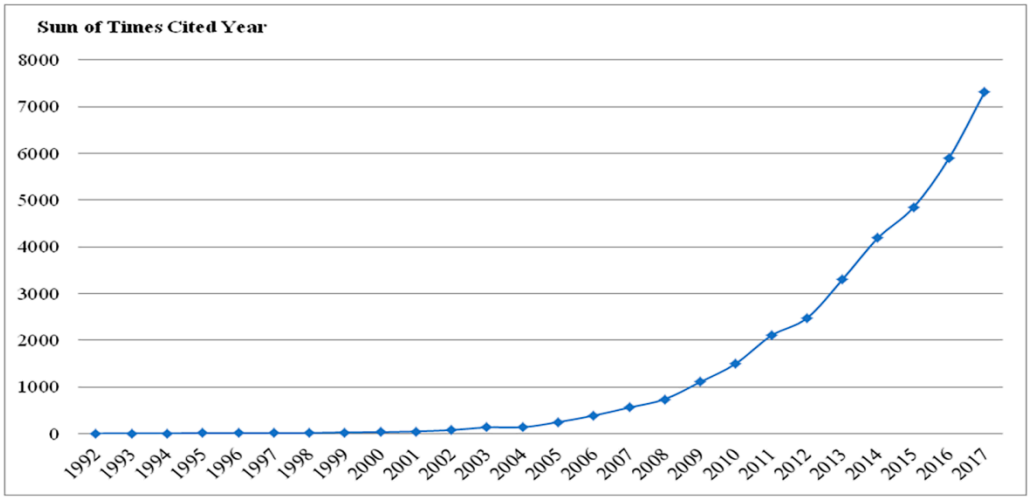

Figure 3. Citation report of sustainable livelihoods.

Both the publication output map and the citation analysis suggests that the number of SL papers and the number of them that are cited have risen sharply since 1992, indicating the growing recognition

of the importance of SL research and the increased attention it is receiving in the academic community. Table 1 lists the ten most-cited papers from 1900 to 2017. Of related interest are the countries from which most of the citations come. They are shown in Figure 4.

Table 1. The Top 10 most cited papers on sustainable livelihoods.

Title	Reprint Information	Journal	Times Cited	Year
Social and ecological resilience: are they related?	Adger, W.N.; Univ E Anglia, Sch Environm Sci, Norwich NR4 7TJ, Norfolk, England.	*Progress in Human Geography*	978	2000
Capitals and capabilities: A framework for analyzing peasant viability, rural livelihoods and poverty	Bebbington, A; Univ Colorado, Boulder, CO 80309 USA.	*World Development*	646	1999
Adapting agriculture to climate change	Howden, S.M.; Commonwealth Sci & Ind Res Org, Sustainable Ecosyst, GPO Box 284, Canberra, ACT 2601, Australia.	*Proceedings of the National Academy of Sciences of the United States of America*	613	2007
Theory and practice in assessing vulnerability to climate change and facilitating adaptation	Kelly, P.M.; Univ E Anglia, Climate Res Unit, Norwich NR4 7TJ, Norfolk, England.	*Climatic Change*	552	2000
Sustainable development: Mapping different approaches	Hopwood, B.; Northumbria Univ, Sustainable Cities Res Inst, 6 N St E, Newcastle Upon Tyne NE1 8ST, Tyne & Wear, England.	*Sustainable Development*	457	2005
The livelihoods approach and management of small-scale fisheries	Allison, E.H.; Univ E Anglia, Sch Dev Studies, Norwich NR4 7TJ, Norfolk, England.	*Marine Policy*	408	2001
Bottom up and top down: Analysis of participatory processes for sustainability indicator identification as a pathway to community empowerment and sustainable environmental management	Fraser, E.D.G.; Univ Leeds, Sch Earth & Environm, Sustainabil Res Unit, Leeds LS2 9JT, W Yorkshire, England.	*Journal of Environmental Management*	306	2006
Confronting the coffee crisis: Can Fair Trade, organic, and specialty coffees reduce small-scale farmer vulnerability in northern Nicaragua?	Bacon, C.; Univ Calif Santa Cruz, Santa Cruz, CA 95064 USA.	*World Development*	278	2005
Biodiversity conservation in tropical agroecosystems—A new conservation paradigm	Perfecto, I.; Univ Michigan, Sch Nat Resources & Environm, 440 Church St, Dana Bldg, Ann Arbor, MI 48109 USA.	*Year in Ecology and Conservation Biology 2008*	228	2008
Role of informal sector recycling in waste management in developing countries	Wilson, D.C.; Univ London Imperial Coll Sci Technol & Med, Ctr Environm Control & Waste Management, Dept Civil & Environm Engn, London SW7 2BU, England.	*Habitat International*	219	2006

Academic influence can be observed by citation. The cited articles come from more than 202 countries, including USA, UK, Australia, Germany, Canada, China, Netherlands, South Africa, and India, demonstrating that SL research is active in the global academic community. As shown in Figure 4, in all citing articles (24,588, excluding self-citations), the largest two in percentage terms are the USA and UK, which contributed 22.61% (5559) and 14.57% (3583), respectively.

As a general rule, the most cited papers are identified as landmark papers. As shown in Table 1, the authors of the ten most cited papers have a range of different approaches. Some feature problem-focused analysis and/or solution-oriented case studies in special areas or for targeted groups. For example, Adger highlights "social resilience," the ability of communities (especially resource-dependent communities) to face external stresses [56]. This is likely to become one of the significant concepts in framing future sustainable development. Other examples:

Allison and Ellis discuss the effectiveness of a livelihoods approach to dealing with fisheries management policies in developing countries [57]. Fraser et al. explore the importance of community involvement in sustainable environmental management [58]. Howden et al. propose some available adaptation approaches for recovering from or adapting to external stress placed on existing agricultural systems, including target diversification of production systems and livelihoods [59]. Their work offers a comprehensive and dynamic policy approach and a framework for systematic adaptation assessments. And Bacon concludes that participation in organic farming and fair trade is a pathway for farmers to improve their livelihood adaptive capacity [60].

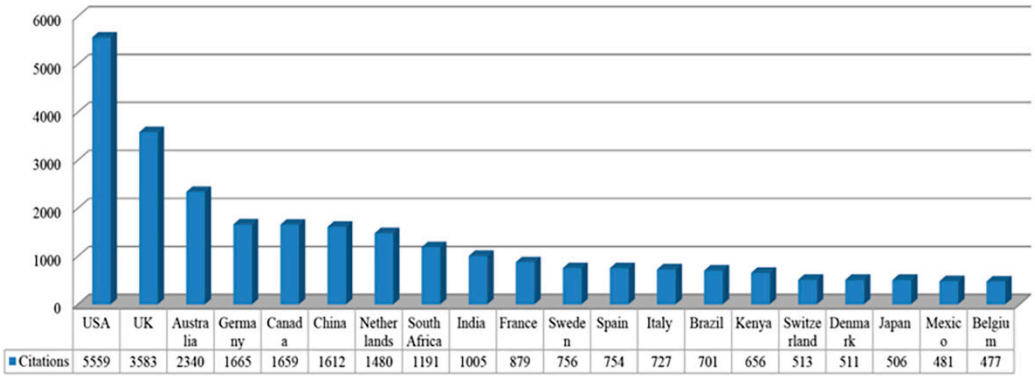

Figure 4. Top 20 citing countries on sustainable livelihoods.

Other papers among the most cited deal more theoretically with policy practices. Bebbington, for example, stresses the need to understand the analytical framework of five Latin American capitals in terms of sustainability and the implications for rural livelihoods—in particular, social capital, which is the most vital asset for rural people to improve their well-being [61]. Kelley and Adger throw light on the relationship between the concepts of vulnerability and adaptive capacity, and clarify four priorities for the most exposed groups to reduce their vulnerability: reducing poverty; increasing livelihood diversification; raising awareness of collective safety; and attaching importance to common property management rights [62]. Hopwood et al. summarize various trends of thought on sustainable development by adopting a mapping approach based on integrating environmental and socio-economic issues [63].

3.1.3. Distribution of Publication Output in Journals

Which disciplines are involved in SL? To help answer this question, this research has, as noted earlier, studied 2701 papers that were published in 593 international journals from 1991 to 2017. The top 10 journals among these 593 accounted for 15.62% of the 2701 SL-related papers. Table 2 lists these top 10 journals and rankings of their subject areas. Six of these 10 journals include Q1 ranking, and 5 include Q2 ranking, indicating that these journals have high international citation impact. This indicates that the research on SL is also highly relevant to the scientific community. The most active journal is *Sustainability*, with 57 papers, followed by *Ecology and Society*, *Land Use Policy*, and *International Journal of Sustainable Development* and *World Ecology*.

3.1.4. Subject Classification of Publications

Each article indexed by the data source (Web of Science) is assigned one or more subject categories. Figure 5 shows a graph of such subject categories based on the classification of subject categories in the Web of Science Core Collection. The publication output for SL research is distributed in 121 subject categories. The most active category is Environment Sciences (717 scientific papers), followed by Environment Studies (596 scientific papers). Approximately 48.6% of total SL publication output is assigned to these two subject categories. Other active subjects include Ecology, Planning & Development, Green & Sustainable Science & Technology, Geography, Agriculture Multidisciplinary, Forestry, Water Resources, Economics,

and Biodiversity Conservation. Figure 5 shows the top 20 active subjects of SL publication output, showing that SL research has been developing in a variety of categories.

Table 2. Top 10 active journals and journal rankings of sustainable livelihoods.

Source Titles	Amounts	Subject Categories	Journal Impact Factors Ranking
Sustainability	57	Environmental Sciences Environmental Studies Green & Sustainable Science & Technology	Q2 Q2 Q3
Ecology and Society	56	Ecology Environmental Studies	Q2 Q1
Land Use Policy	54	Environmental Studies	Q1
International Journal of Sustainable Development and World Ecology	51	Ecology Green & Sustainable Science & Technology	Q3 Q3
Global Environmental Change Human and Policy Dimensions	42	Environmental Sciences Environmental Studies Geography	Q1 Q1 Q1
International Forestry Review	42	Forestry	Q2
World Development	42	Economics Planning & Development	Q1 Q1
Marine Policy	41	Environmental Studies International Relations	Q2 Q1
Mountain Research and Development	41	Environmental Sciences Geography, Physical	Q4 Q4
Regional Environmental Change	38	Environmental Sciences Environmental Studies	Q2 Q1

Notes: Most of these journals have more than one subject category. There are four journal rankings for each subject category: Q1, Q2, Q3, and Q4, defined as follows. All journals covering a particular subject category are ranked by impact factor from high to low. Journals in the top quarter are ranked Q1, those in the second quarter, Q2, and so on.

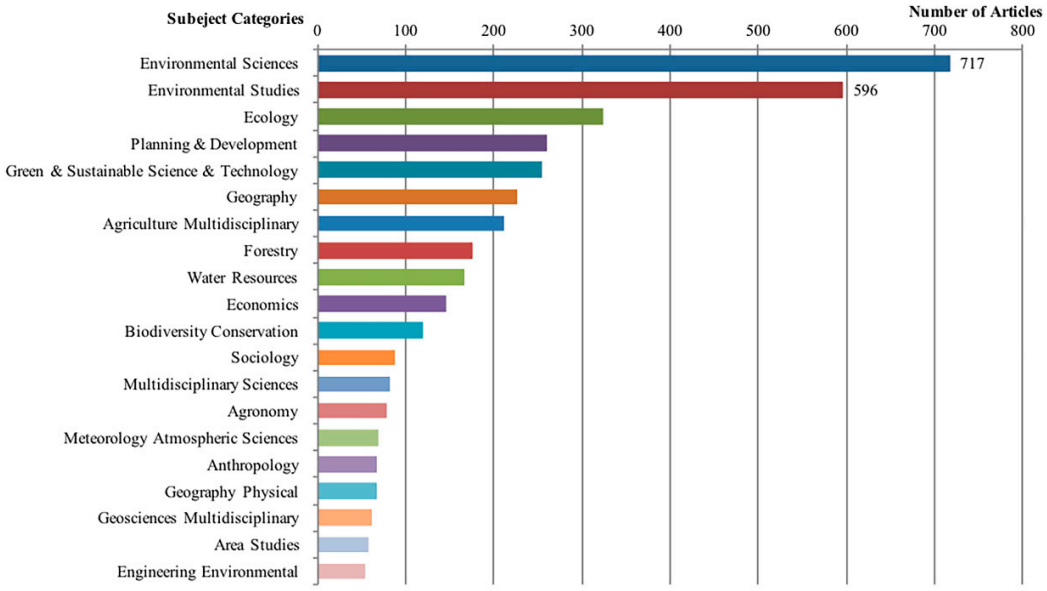

Figure 5. Top 20 active subjects in sustainable livelihoods publication output.

3.2. Major Academic Community of Sustainable Livelihoods

3.2.1. Distribution of Publications by Countries/Territories

The contributions made by different countries are estimated using the location of the affiliated institution of at least one author of each published article. The SL topic covers 138 countries. Figure 6 shows the top 50 most-active countries, with the top 10 being named. The sizes and colors of dots indicate the relative ranking of the countries. The country contribution analysis reveals that the top 20 most-active countries account for 85.6% of all publication output (2701 papers). USA, UK, and Australia have the highest publication output, with 557 papers (20.62% of the total), 426 papers (15.77%), and 274 papers (10.14%), respectively; followed by South Africa (201 papers), Canada (186 papers), Germany (171 papers), China (169 papers), Netherlands (161 papers), and Kenya (132 papers). The seven major industrial countries ("Group of Seven": Canada, Italy, France, Germany, UK, Japan, and US) were all included in the top 20 in publication output.

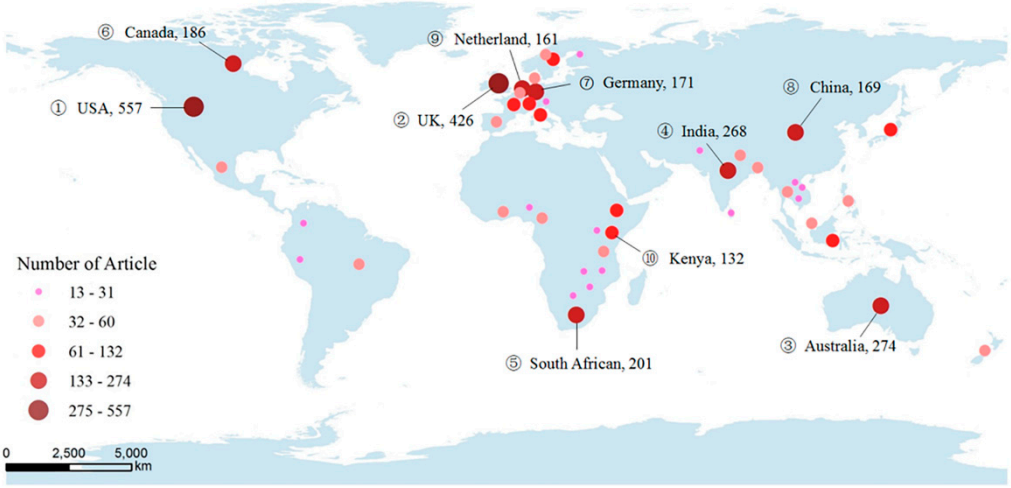

Figure 6. Spatial distribution of top 20 most productive countries producing SL articles.

Figure 7 offers a visual presentation of the publication output of the top 20 countries since 1991. The figure makes clear that three developed countries (USA, UK, and Australia) have consistently taken the leading positions in this research field. It is noticeable that the publication outputs of India, Germany, China, and Netherlands have increased rapidly since 2013. Following the first United Nations Conference on Environment and Development (UNEP) in 1990, researchers around the world published papers in the following year on the issue of environmental management and sustainability. For example, one concerned rapid resource transformation caused by increased population and having a serious impact on the sustainability of natural assets and ecological processes in tropical countries [64]. There were also five significant papers published by authors at British institutions in that year. One highlighted the significant contributions made by women in environmental management [65]. Another argued that sustainable livelihoods are important for people in marginal and fragile rural environment in the 21st century [66]. A third analyzed the difficulties and significance for Mongolia to manage its economic transition while protecting its valuable achievements in regard to social welfare [67]. Another took a human-focused approach to broadly-based concepts of sustainable development [68]; and a fifth discussed the significant role of wet areas in drylands, which play a role in sustaining rural livelihoods and increasing food security [69]. Authors from Sweden and Indonesia highlighted three interrelated dimensions of security: livelihood security, environmental security, and international security [50,69]. Around this time, researchers began to place much greater stress on the need to understand the SL concept, and also to recognize serious ecological issues in earlier research.

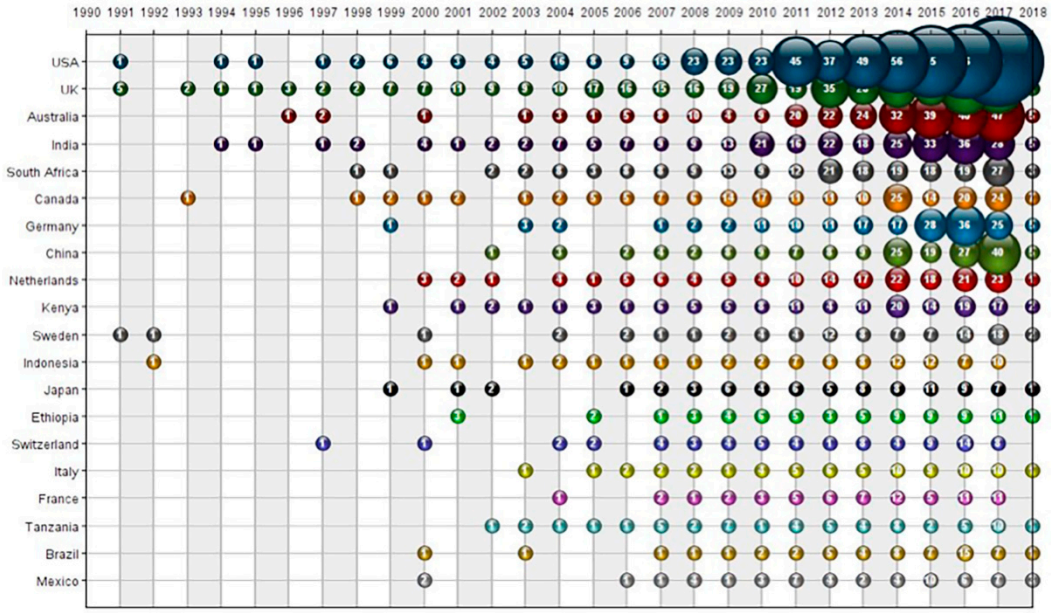

Figure 7. Temporal distribution of top 20 most productive countries of SL articles.

In the following, the terms 'international co-publication' or 'international papers' will be used to designate papers that have been published through the cooperation of authors from at least two different nations [70]. Figure 8 demonstrates the international cooperation links for 16 selected nations that are involved in SL research. Taking countries as the nodes within the network (the size of a node indicating the number of publications), lines between the nodes indicate collaboration between countries (the thickness of a line representing the amount of international co-publication). From a global perspective, it is notable that the major research communities have already formed a tight and integrated collaboration network, especially among the scientifically advanced countries. Countries may work collaboratively principally in their strong subject fields. Collaboration undoubtedly has a positive impact on published results [38,42]. American academic institutions and organizations are the main co-author partners in international co-authorship, and they have especially close working relationships with UK institutions/organizations in the field of SL. There are also strong and stable links between the UK and Australia, and between the USA and Canada.

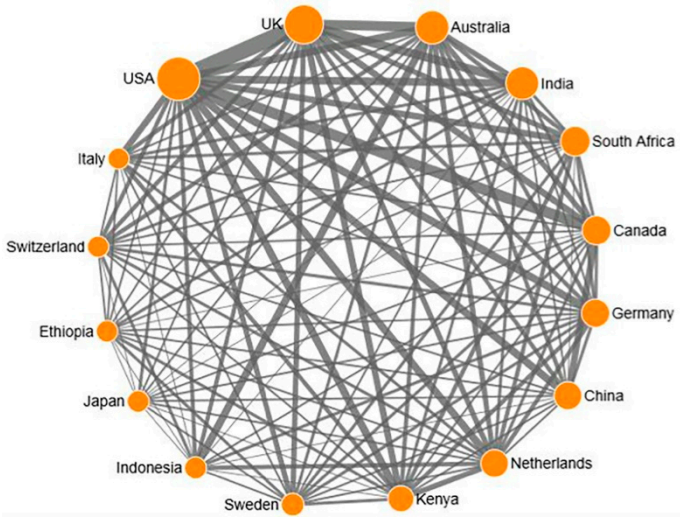

Figure 8. Cooperation network of co-publication of sustainable livelihoods papers among selected countries.

3.2.2. The Institutional Contribution and Social-Network Analysis

The aim of the institutional-contribution analysis is to distinctly depict the participation level of institutions/organizations in the SL field. Figure 9 reveals that Wageningen University in The Netherlands, with 71 papers, was first in its publication output, followed by the Chinese Academy of Science (61 papers), then the Center for International Forestry Research (CIFOR) in Indonesia and the University of Queensland in Australia, with 40 papers each. The differences in output among institutions ranked 3rd through 20th are relatively small. As Figures 8 and 9 make clear, SL research has attracted the attention of researchers from around the world. Figure 10 clearly shows the temporal distribution of papers from the top 20 most productive organizations since 1998. In that year (1998), there was just one SL paper from among the top 20 institutions. It came from the University of Leeds and was on the issue of household livelihood strategies.

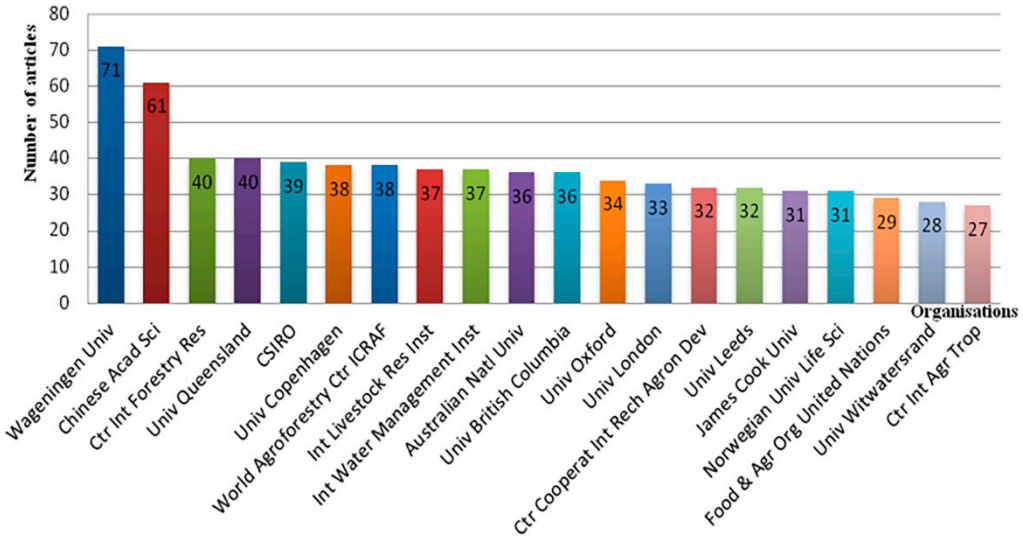

Figure 9. Top 20 most-productive organizations of sustainable livelihoods articles.

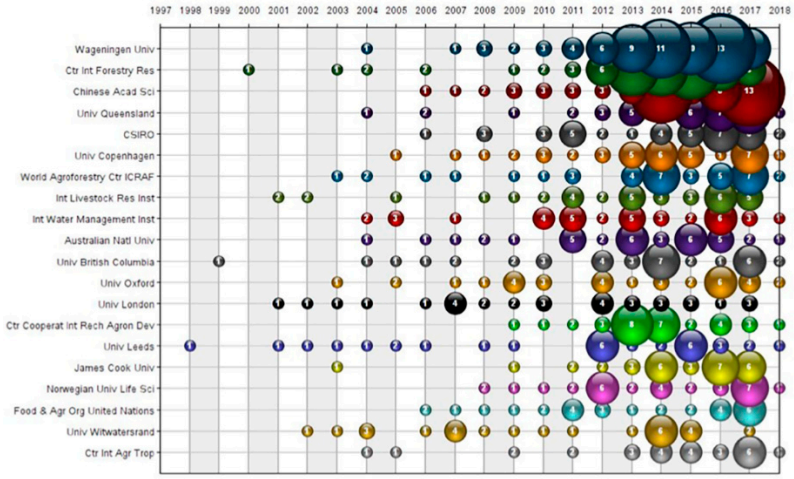

Figure 10. Temporal distribution of top 20 most-productive organizations of SL articles.

Social network analysis plays a critical role in determining the way organizations are managed, and also in recognizing strengths and weaknesses of particular research fields within research organizations. One advantage of adopting social network analysis is to reveal how professional knowledge is shared among organizations in an effective way. At the same time, it facilitates the evaluation of the performance of different research communities, entire social networks, and even individuals [71,72]. Individual performance is analyzed in Section 3.2.3 below. Figure 11 shows

the co-authorship network among organizations/institutions. Each of the 57 scientifically related organizations that are depicted have, within the period of this study, published at least 15 SL articles (the total of 1137 articles from this group accounts for 42.1% of the total publication output). Each node in the figure denotes an organization, and a line between two nodes indicates a collaborative relationship between two organizations. The size of the node indicates "degree centrality" of an author which refers to the number of co-authors who have a direct cooperative relationship with the main author. Also, the thickness of a line represents the degree of collaboration between connected elements in the network (to indicate the number of co-authored work between a pair of organizations). In order to ensure the clarity of the cooperative network, the threshold of cooperative intensity for this analysis is greater than or equal to 3.

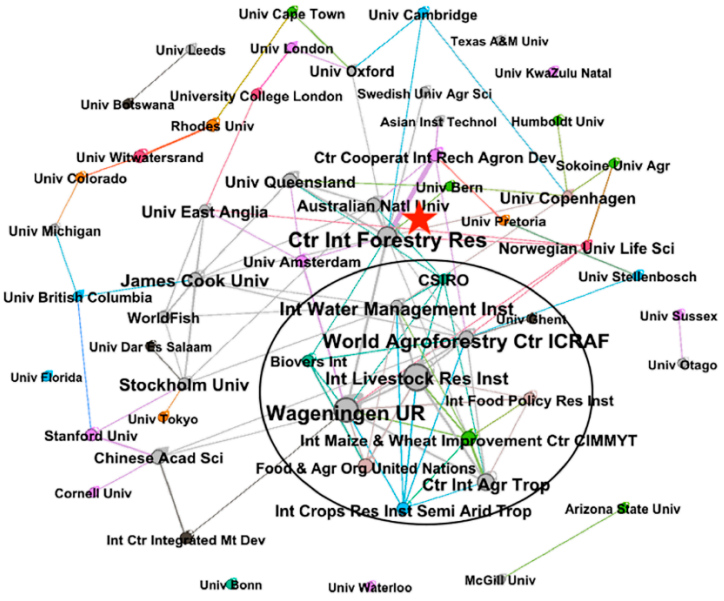

Figure 11. The co-authorship network of SL papers among principal research organizations in the field.

As Figure 11 emphasizes, collaboration among organizations/institutions is a relatively common phenomenon, and many active cooperative sub-networks have been established within the larger network. Among the high-frequency keywords that have been identified in this collaborative network are livelihoods, non-timber forest products, adaptation, land use, vulnerability, sustainable forest management, intensification, and food security. The strongest sub-network (with 12 members) is circled in the figure. It includes Wageningen University & Research (WUR), The World Agroforestry Centre (ICRAF), the International Livestock Research Institute (ILRI), the International Water Management Institute (IWMI), the International Center for Tropical Agriculture (CIAT), the Commonwealth Scientific and Industrial Research Organisation (CSIOR), and the Food and Agriculture Organization of the United Nations (FAO). In this sub-network, ILRI is the most active. One of its papers explores important issues that exist in Namaqualand, such as unequal spatial distribution of biodiversity and reduction in livestock production, and proposes feasible conservation initiatives for enhancing local livelihoods options [73]. Another of its papers highlights the interrelation between control over charcoal production and poverty alleviation in Mozambique [74]. Institutional collaboration within this sub-network is still in a preliminary stage. There remain great opportunities for multi-national cooperation.

In addition, the Center for International Forestry Research (CIFOR), marked with a red star in Figure 11, is also an impressive active contributor to SL research. It has already conducted collaborative scientific works on SL with 16 different institutions, including the Agricultural Research and International Cooperation Organization (CIRAD), the Australian National University, and the University of Queensland.

3.2.3. Identification of Highly Productive and Influential Authors

The top 10 most-productive SL authors in the period of this study are listed in Table 3. At the top of the list are Ranjay K Singh of the Central Soil Salinity Research Institute and Central Agricultural University in India and Lindsay Carman Stringer of Leeds University, each with 12 SL-related papers, as identified in the SCIE and SSCI database.

Table 3. Top 10 Most-Productive Authors of Sustainable Livelihood Articles.

NO.	Authors	Amount	Organization
1	Singh, Ranjay K.	12	Cent Soil Salin Res Inst, Cent Agr Univ
2	Stringer, Lindsay Carman	12	Univ Leeds
3	Binns, Tony	11	Univ Otago
4	Shackleton, Charlie M.	11	Rhodes Univ
5	Chirwa, Paxie W.	10	Univ Pretoria
6	Inoue, Makoto	10	Univ Tokyo
7	Milner-Gulland, E. J.	10	Imperial Coll London, Univ Oxford
8	Nath, Tapan Kumar	10	Univ Chittagong
9	Giller, Ken E.	9	Wageningen Univ
10	Cao, Shixiong	8	Beijing Forestry Univ
11	Witkowski, Edward T. F.	8	Univ Witwatersrand

Notes: Cao Shixiong and Witkowski Edward T F shared the tenth place with eight articles each.

Singh's research has centered on (1) the impact of climate variability on livelihood adaptations [75]; (2) agricultural resource conservation and livelihood adaptation strategies peculiar to tribal communities [76]; (3) livelihood security of indigenous groups [77]; and (4) the importance of traditional knowledge as regards sustainable development of livestock and sustainable natural management [78]. Stringer's research interests also cover a wide range: (1) the influence of international environmental agreements on the livelihood options of local communities [79]; (2) vulnerability of rural livelihoods to climate change and their possible livelihood options [80]; (3) exploring the relationship and association among aquaculture, livelihoods, and social networks of coastal communities [81]; (4) rural livelihood adaptation strategies to land degradation in Swaziland [82] and mangrove system degradation and loss in Southeast Asia [83], as well as proposals for policy reform; and (5) the benefit of supporting biofuels as a way to improve livelihoods and energy security in rural Mali [84].

International cooperation naturally reflects personal interests and motivations of individual scholars. Most of Singh's SL research has been focused on livelihood adaptation strategies which are unique to indigenous or grassroots rural community in developing countries. Stringer, by contrast, has emphasized interrelated factors associated with fragile ecosystems (especially the issue of land degradation) and rural livelihood options, and has proposed policy changes.

The trend toward greater co-authorship has occurred in almost all scientific disciplines [85,86]. Co-authorship in fact represents the most formal manifestation of intellectual cooperation in a scientific field. When two or more authors collaborate in research, not only will there be a greater quantity of scientific output, but probably higher quality will result as well [87].

The trend toward greater co-authorship of published articles is evident in the SL field, just as it is in other fields. This may be attributed in part just to the increase in the number of SL researchers, currently more than 7000, a number that has grown as interest in SL research has grown. One paper has probed the social network of researchers within a research community and its relevance to scientific cooperation [88]. Figure 12 displays a characterization of the co-authorship network in terms of 139 selected authors with, altogether, 528 papers (accounting for 19.6% of the total). For this figure, authors who have published at least four articles in the span of time have been examined. It is noticeable that the collaboration network illustrates not just connections but also a relatively high level of disconnection. Many nodes in the cooperative network map are isolated, and the cooperation intensity among some other nodes is relatively low, showing that there are

a large number of researchers who are not linked internationally to other researchers, or whose linkage is in small, otherwise disconnected networks. But significant collaborative networks for SL research have already taken shape as many sub-groups appeared. For example, Ken E. Giller (Wageningen University), Han van Dijk (Wageningen University), Xu Jianchu (Chinese Academy of Science, Kunming Institute of Botany), Ole Mertz (University of Copenhagen), and 12 other authors have formed the largest scale chain network. The second largest chain network is made up of Andreas Heinimann (University of Bern), Stephen Syampungani (Copperbelt University), David S. G. Thomas (University of Oxford), Chasca Twyman (University of Sheffield), and ten other authors. The third most evident co-author network consists of Patrice Levang (Wageningen University), Agni Klintui Boedhihartono (James Cook University), and six other authors. The density of co-authorship networks created by I. Scoones (University of Sussex), Isilda Nhantumbo (International Institute for Environment & Development), and four other authors is the highest among all sub-groups.

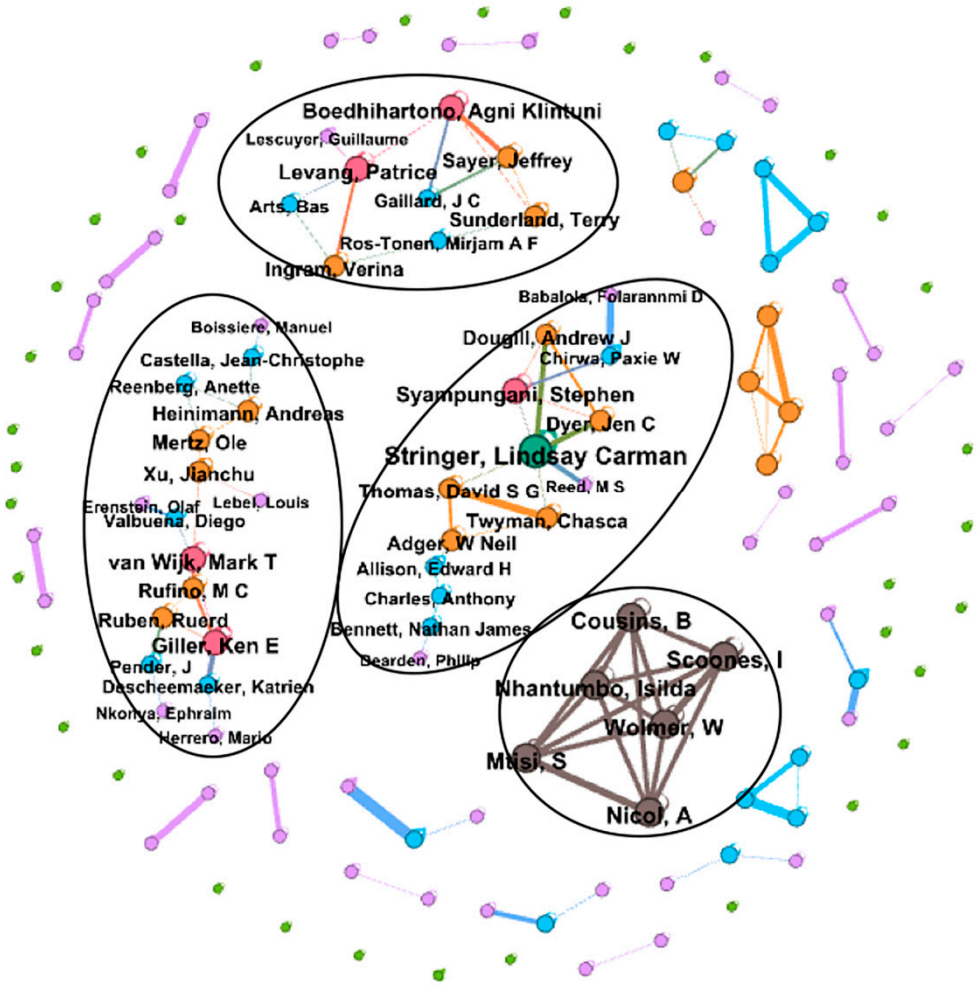

Figure 12. Co-author networks of sustainable livelihoods.

To gain a better understanding of the dynamics of co-authorship networks, the paper looked at the principal subjects addressed by the four cooperation sub-network shown in Figure 12. These are livelihood diversification as one of the significant ways for marginalized communal farmers to adapt to changes [74]; how charcoal production and trade influence rural areas [75]; and SL issues in southern Africa [49,89–91].

3.3. Topical Maps

Research themes ("hot topics") in a specific field can be defined by high-frequency keywords in an appropriate database. In general, keywords tend to summarize the contents of a research article, as well as serving to concentrate and refine the core ideas of the research [92]. For bibliometric application, Table 4 shows the top 100 keywords in SL papers—those appearing at least 17 times. Figure 13 gives a visual presentation of co-occurrence analysis, where a pair of words is used in the title, abstract, keyword list, or even in the body of the full document within and across a given set of published papers. The co-occurrence matrix or co-occurrence distribution provides an overview of research areas within the SL field in a given period of time [93]. It contributes to the understanding the conceptual framework of the field and reflects the knowledge network of researchers in the field [94]. It also exhibits the nature of a research front; identifies emerging trends; and highlights potential pivotal points (i.e., cognitive themes and their internal relevancy), according to Freeman's *betweenness centrality* [40,95]. In the visualization of Figure 13, the size of nodes indicates the degree of the "betweenness centrality" of the nodes; the color of the nodes is used to show a cluster of co-cited references that are tightly connected (the same color belongs to the same cluster, and the subject is analyzed according to the clustering); and the thicknesses of the lines connecting nodes represent the frequency of co-occurrence.

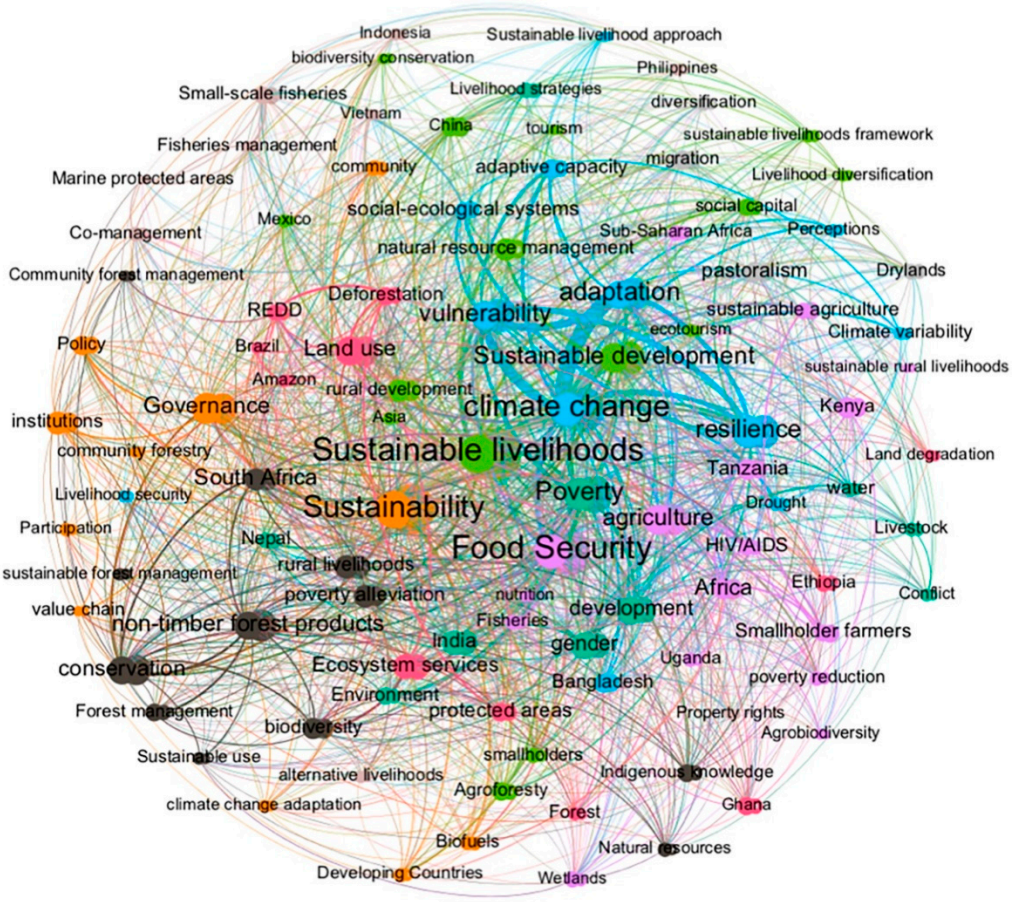

Figure 13. Cluster network based on sustainable-livelihood high-frequency keywords (≥17 times).

Table 4. High-frequency keywords in papers on sustainable livelihoods (≥17 times).

NO.	Keywords	Freq	NO.	Keywords	Freq
1	Sustainable livelihoods	165	51	social capital	29
2	Sustainability	157	52	Ghana	28
3	Food Security	147	53	community	27
4	climate change	137	54	Indigenous knowledge	27
5	Poverty	100	55	Co-management	26
6	adaptation	94	56	Environment	26
7	Sustainable development	92	57	Livestock	26
8	vulnerability	89	58	Sub-Saharan Africa	26
9	non-timber forest products	85	59	sustainable livelihoods framework	26
10	resilience	83	60	community forestry	25
11	conservation	77	61	biodiversity conservation	23
12	agriculture	76	62	Climate variability	23
13	Land use	72	63	Drought	23
14	Governance	69	64	poverty reduction	23
15	Ecosystem services	57	65	sustainable forest management	23
16	rural livelihoods	57	66	Developing Countries	22
17	India	55	67	Indonesia	22
18	South Africa	53	68	Livelihood diversification	22
19	gender	49	69	Fisheries management	21
20	Africa	48	70	Perceptions	21
21	development	47	71	alternative livelihoods	20
22	rural development	46	72	Land degradation	20
23	Smallholder farmers	46	73	nutrition	20
24	China	45	74	smallholders	20
25	biodiversity	44	75	water	20
26	sustainable agriculture	44	76	Wetlands	20
27	Kenya	38	77	Amazon	19
28	migration	38	78	Community forest management	19
29	pastoralism	38	79	diversification	19
30	Small-scale fisheries	38	80	Forest	19
31	Tanzania	38	81	Asia	18
32	institutions	37	82	climate change adaptation	18
33	Bangladesh	35	83	ecotourism	18
34	poverty alleviation	35	84	Livelihood security	18
35	social-ecological systems	35	85	Marine protected areas	18
36	protected areas	34	86	Natural resources	18
37	Nepal	33	87	Philippines	18
38	Policy	33	88	Property rights	18
39	REDD	33	89	Sustainable use	18
40	Deforestation	32	90	Uganda	18
41	Drylands	32	91	Agrobiodiversity	17
42	adaptive capacity	31	92	Brazil	17
43	Biofuels	31	93	Conflict	17
44	Ethiopia	31	94	Mexico	17
45	Livelihood strategies	31	95	Participation	17
46	HIV/AIDS	30	96	Sustainable livelihood approach	17
47	natural resource management	30	97	sustainable rural livelihoods	17
48	Agroforesty	29	98	tourism	17
49	Fisheries	29	99	value chain	17
50	Forest management	29	100	Vietnam	17

Figure 13 demonstrates eight principal cluster groups. However, the SL research themes can be roughly divided into five categories by analyzing cluster network and high-frequency keywords. In this research, keywords with extraordinarily high frequency ("livelihoods," for instance, which appeared 430 times) have been removed, without any noticeable impact on the results. Principal SL topics cluster in the following areas.

1. **Theoretical research on the SL concept** Keywords include *sustainable development* (92); *rural development* (46); and *natural resource* management (30). Research of this type mainly examines and analyzes livelihood resilience [96–98], vulnerability [99,100], and security status [101,102] of specific types of rural households based on various models [103] and frameworks. Most of these articles adopt the sustainable livelihoods approach (SLA) developed by the Department of International Development, and use an evaluation index system [13,104] for the sake of improvement of livelihoods of rural communities. These kinds of theoretical research put forward effective and reasonable livelihood adaptation strategies. Poverty is a colossal challenge, with 10.7% (or 767 million people) of the world's population (7.44 billion people) living on less than US$1.90 a day (the international extreme poverty line), according to a global poverty estimate in 2013 [105]. It is generally accepted that the establishment of an effective, innovative indicator system, as well as monitoring programs, will be critical to the success of global poverty alleviation.
2. **Research on ecosystem conservation** Keywords include *non-timber forest products* (85); *conservation* (77); *land use* (72); *ecosystem services* (57); and *biodiversity* (44). An overview of cluster networks makes clear that the dominant sub-clusters consist of work related to the conservation of forest, land, and marine ecosystems. Biodiversity and conservation of natural resources have become global environmental concerns, and human activities are considered to be largely responsible for loss of global biodiversity [106,107], unsustainable harvest of bushmeat [107,108], and forest degradation [109–111], as well as other impacts. These most significant environmental issues, in turn, have a vital impact on agriculture, forestry, animal husbandry, and fisheries, thereby affecting the sustainable livelihoods of rural residents. In the context of poverty and environmental issues, researchers have examined the potential for adopting practices of sustainable use of natural resources [112], fisheries management [113], forest protection and management [114], and indigenous wisdom [115], to mention a few of the areas under study.
3. **Research on poverty reduction and SL in special poverty-stricken areas** Keywords include *food security* (147). *poverty* (100), *agriculture* (76), *Africa* (48), and *gender* (49). International SL research is concentrated, not surprisingly, on areas that are in very early stages of development and are ecologically fragile, notably countries in Africa (such as Tanzania, Kenya, and Uganda) and in South Asia (such as Bangladesh, Nepal, and India). Africa has one of the lowest levels of economic development in the world, and more than 20 African countries, because of their relatively low human development index, came in at the very bottom of the list, put forward in the Human Development Report 2009 [116]. Most African countries have an arid climate, which has led to a notoriously backward agricultural development, with decreasing land availability in the drought-prone agricultural regions. Poverty has also had a severe impact on Africa, contributing to relatively low life expectancy, violence, political instability, and disease burdens, among other adverse effects. Researchers have made a number of proposals, including adaptive strategies for rural households in response to climate change [117–119], policy reform [120], structural adjustment and market liberalization [121], disease control and poverty alleviation [122], and combatting food insecurity [123]. As for South Asia, consider India as an example. It has a huge population and is likely to overtake China as the world's most populous country between 2020 and 2030. At the same time, per capita income in India is still at the level of developing countries. Significant future increase of its poor population is likely to have major repercussions on land use [124], food security [125], ecosystem services [126], and water resources [127], as well as promoting increased wealth inequality in some of the less-developed South-Asia countries. The scientific community also attaches importance to issues such as gender inequality [128,129] and the potential influences of diseases on household livelihoods [130] in South-Asia countries.
4. **Research on the impact of climate change on livelihoods** Keywords include *Sustainable livelihoods* (165), *climate change* (137), *vulnerability* (89), *resilience* (87), and *adaptation* (94).

Global climate change is occurring throughout the world and impacting the many links between ecosystems and mankind. There is a growing recognition that climate change and poverty are closely interconnected, affecting rain-fed agriculture, water availability, and human well-being. Although the focus and interpretations of the links between climate change and livelihoods vary, experts working in the area deal primarily with adaptation, resilience, vulnerability to climate change, and mitigation to enhance national and regional coping capacities.

5. **Research on SL-related policies and institutional change** Keywords include *sustainability* (157), *governance* (69), *institutions* (37), and *policy* (33). In general, policies implemented by governments at all levels, and even measures undertaken by international or non-governmental organizations have some direct and/or indirect effects on the livelihoods of rural people. Researchers draw on case studies to formulate different analytic approaches for evaluating the system of policy-making, conducting in-depth analyses of existing policies, proposing applicable adaptive policies to enhance local livelihoods, and promoting environmental stewardship. Among topics of greatest concern in recent years are policies in regard to ecological protection [131] and fishery management [132].

Because of the increase in the volume of technical publications, the detection and tracking of topic bursts in order to stay up-to-date with trends in many fields has been recognized by the scientific community [133]. Additionally, the burst detection result of keywords is a valuable indicator for drawing a knowledge map and characterizing topic streams in scientific literature [134]. The top 35 SL-related keywords appearing most frequently were selected for burst detection from a total of 209 keywords throughout the 27-year time span (1991–2017). Occurrence bursts as detected in association with 35 keywords are shown in Figure 14 (the heavy red lines represent the time periods of burst detection, with the total time span of the study being indicated by the heavy blue lines). The keywords with the highest strength of burst detection in the studied period are migration (8.0768), diversity (8.8499), biodiversity conservation (8.5229), resource (9.229), adaptive capacity (8.5824), and social ecological system (9.2563). Additionally the keywords social capital, dynamics, West Africa, drought, resource management, non-timber forest management, and gender, which appear continuously for more than seven years, indicate longstanding SL concerns of the scientific community.

The keywords showing the greatest strength (>7) before 2010 are dynamics, water, poverty alleviation, migration, and Tanzania. Salam et al., (2006) examined the current situation and dynamics of community forest management in Thailand, and pointed out that community forest management practices in Thailand are active and promising [135]. Water shortages and water-induced hazards can seriously affect the livelihoods of households whose main source of income are agriculture and aquaculture [136,137]. With poverty still a serious problem in many developing countries, especially in Africa and South Asia, researchers have proposed many strategies and approaches for addressing this problem [138,139].

SL keywords that reveal topics of great importance since 2010 are South Africa, natural resource management, diversity, biodiversity conservation, protected area, resource, and challenge. Jacobs and Makaudze (2012) reviewed the current situation in rural poor South Africa and analyzed the pros and cons of pro-poor agrarian reform and rural development policies [140].

The majority of farmers in underdeveloped areas rely heavily on local natural resources such as non-timber forest products [141] and aquatic resources [142]. This kind of human intervention—the utilization and manipulation of environmental resources—is having unanticipated consequences. The excessive exploitation of natural resources will have a severe impact on biodiversity conservation [143] and on natural resource management and protection in and around protected areas [144]. Improved efficiency in natural resource management needs to be considered as one of the major strategies for improving agricultural activity [145] and resolving poverty problem in rural areas.

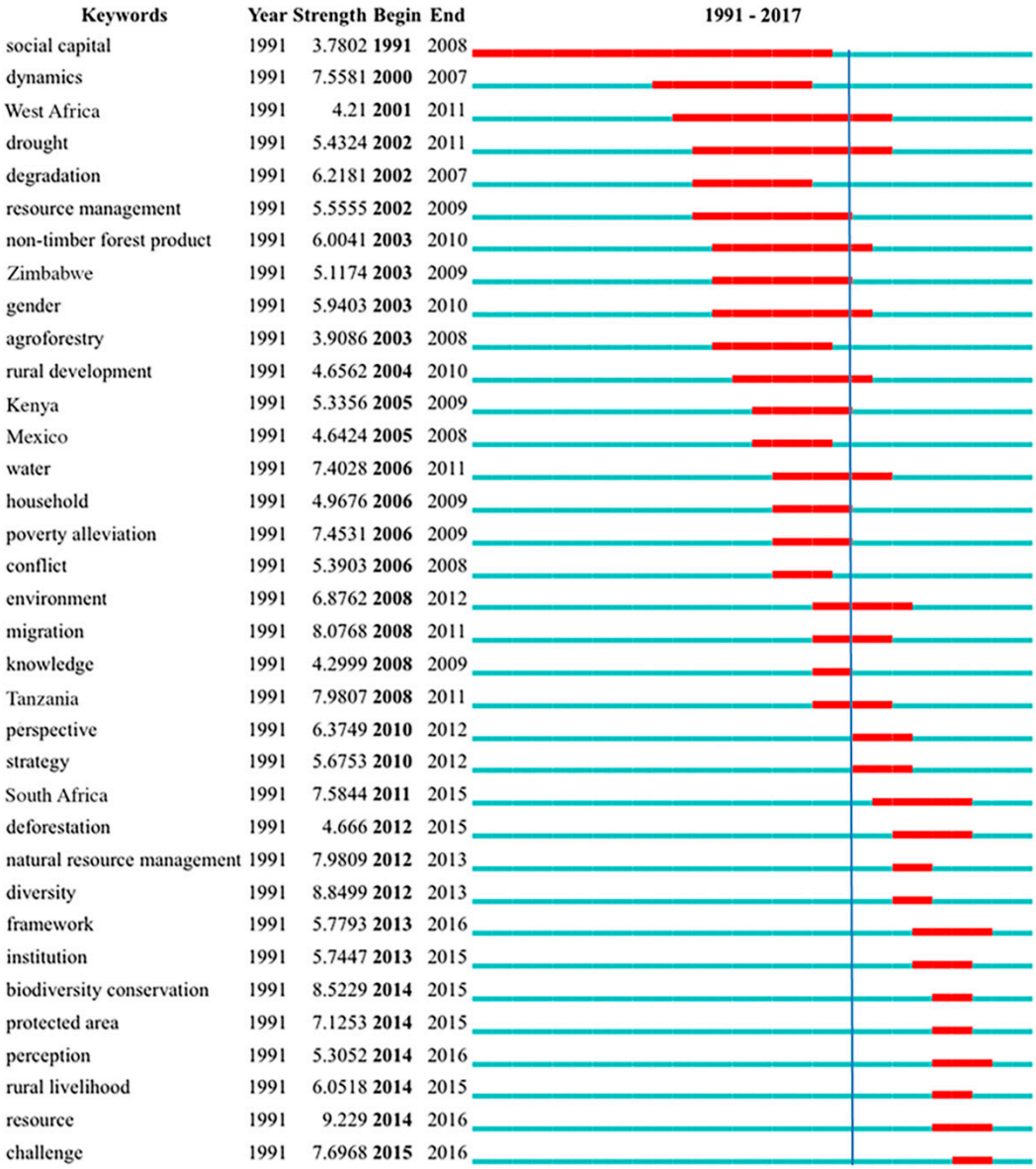

Figure 14. The burst detection results of the top 35 most frequent SL-related keywords.

4. Concluding Remarks

This study examined some of the bibliometric issues associated with the assessment of research trends in sustainable livelihoods (SL) research, including analysis of research output and academic impact, exploration of collaborative networks, and identification of "hot topics."

As reported in Section 3, the first papers on what was clearly called SL research were published in 1991. In the more than two decades since then, it is noticeable that the more research papers and publications also gave a boost to SL researches, in particular, by aiming at reduction of extreme poverty and hunger, achievement of universal primary education, promotion of gender equity and empowerment of woman and so on. Since 2000, the quality and complexity of the SL literature have been generally quite high, meaning that the SL field is reaching advanced levels of maturity.

There is also a growth in citation impact. There were 2701 papers related to SL according to the retrieved results, which were cited (32,393 times) in a total of 24,588 papers (excluding self-citation). All of this indicates that the SL field is of great interest to a wide range of disciplines from many countries and regions around the world. Moreover, after the concept of SL was proposed, it becomes a

common understanding that the international communities promote sustainable development globally and achieve SL for the poor.

From the bibliometric analysis of most cited papers, it has been observed that papers which were cited more frequently include research on theory and methods with respect to SL. By further looking into these highly cited papers, it has been found that these papers involve studies on SL strategies in special regions, which reveals that there is a significant regional dependence in terms of realization of SL (e.g., closely related to local climate, culture, topography, and so on). Such papers provide a referential approach for achieving SL within countries and internationally. A great deal of attention is being given at present to this multi-disciplinary and problem-oriented field (especially environmental issues). Furthermore, SL papers have been published by a wide range of journals.

From a global perspective, the USA, UK and Australia are the leaders in SL studies, in quantity and quality of SL publications as well as in academic influence. The USA and the UK can be considered the most important partners in the network of international collaboration. It is universally acknowledged that they are the birthplace of the concept of SL. These are countries that recognize the significance of the concept of sustainable development in the earliest time, and actively disseminate it. Thanks to the promotion of these countries, research on SL is now a global concern. At the same time, a relatively close cooperation network among countries has been formed. Despite a large number of cooperatively authored papers recently, cooperation among scientific institutions still needs to be substantially strengthened. It should also be noted that although there are a large number of researchers involved in national and international co-authorship networks, with some of them closely grouped, there are still many researchers who are relatively isolated from one another. A further increase in interactions among researchers and in international co-authorship would no doubt contribute to the promotion of even greater quality of SL publications.

With respect to social network analysis, what have been called "hot topics" can be divided into five categories based on keyword frequency analysis, i.e., Theoretical research on the SL concept, Ecosystem conservation, Poverty reduction and SL in the most poverty-stricken areas, the impact of climate change on livelihoods and SL-related policies and institutional changes. SL research is currently receiving a great deal of attention, as SL science is transitioning from theoretical analysis to practical application, thereby contributing even more to poverty alleviation.

Funding: This study was supported by the NSFC-ICIMOD Joint Research Project (grant no.41661144038), and the National Natural Science Foundation (grant no.41741001).

Conflicts of Interest: The authors declear no conflict of interest.

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