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Forest Landscape Restoration and Local Stakeholders: A Global Bibliometric Mapping Analysis

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Abstract: Forest landscape restoration (FLR) has a central place in current global debates about the sustainability of natural resources, climate change mitigation and adaptation, livelihoods and biodiversity conservation. FLR approaches support the involvement of different social actors in participatory decision-making processes. We conducted a bibliometric analysis research to provide an overview of scientific publications in forest restoration, FLR and local stakeholders (LS) studies, and, specifically, examine if the studies (1) recognised the relevance of the local level actors and (2) collected primary and/or secondary data on LS using different methods from related publications since 2000. We used the Web of Science (WoS) and Scopus as bibliographic sources. We analysed five main research aspects: (1) publication year, (2) most productive countries according to the total number of publications, (3) most influential journals and cited papers, (4) most influential authors ranked by number of publications, their respective organisations and country collaborations, and (5) a co-occurrence analysis of countries' collaborations and keywords. We found that forest restoration, FLR and LS studies have been growing over the years, especially in the last decade. However, only 50% (99 records) of the studies recognised the relevance of the local level actors and also collected primary and/or secondary data through different methods. Authors from organisations in North and South America, and Oceania were the ones with the most publications, with only 20% (4 authors) of the top 20 authors having degrees in social sciences. Studies about "ecosystem services", "ecological restoration", "natural regeneration", "livelihoods", "Bonn challenge" and "governance" have become the main subject of research along the years within the scope of FLR at the local level. Finally, the results showed the gaps that should be considered in future research to improve the involvement and more direct participation of LS, as well as the participation of interdisciplinary and social science researchers in FLR research teams.

Keywords: bibliometric mapping; network analysis; FLR; forest restoration; landowners; rural owners; farmers; livelihoods; rural livelihoods; smallholders

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1. Introduction

In 2000, the term "forest landscape restoration" (FLR) was first defined as the aim to restore forests at a landscape level and meet both human needs and ecological priorities. It was coined to combine biodiversity conservation and production while serving ecological and economic interests, important aspects that ecological restoration alone did not cover properly [1,2]. According to the Global Partnership for Forest Landscape Restoration (GPFLR), FLR is characterized as being an active and participatory process that integrates

people in order to identify, negotiate, and implement practices that restore the balance between ecological, social, and economic benefits of forests and trees embedded in a more comprehensive pattern of land use [3]. At the landscape level, the goal of FLR is to restore ecological functionality and enable improvements to human well-being, especially in degraded landscapes [4].

We currently face challenges in transforming degraded and unproductive lands into functional landscapes and restored ecosystems that promote multiple benefits to society and future generations. FLR seeks a balance between restoring ecosystem services such as wildlife biodiversity, habitats, water regulation, carbon storage, and supporting the productive functions of land for agriculture and other relevant uses [5]. Furthermore, successful FLR opposes environmental degradation, strengthens landscape resilience, and protects forest-based livelihoods to meet the changing needs of society [6]. The path to FLR needs to be built on solid ground and present a holistic vision, addressing economic, cultural, and political issues, engaging social actors ranging from farmers to smallholders, local communities, forestry agencies, business leaders, policy makers and politicians [7–9]. The local stakeholder's (LS) participation and active engagement in planning restoration interventions is fundamental to restoration initiatives [7–11]. However, engaging LS in both the planning, implementation and monitoring of restoration initiatives is a major challenge, whether in research or in practice [9,12,13].

FLR is centred on the people who live and work in the landscape and whose livelihoods will benefit from and diversify through restoration activities [14]. Thus, restoration decisions at the landscape level necessarily involve stakeholders with different interests, such as rural communities, environmental groups, forest owners, local authorities [8], and stakeholders above the landscape level. In this context, processes to allow LS to present their needs, priorities, and expectations, through constructive discussions for negotiated solutions, are fundamental [15] but also a challenge. When stakeholder engagement is poor and/or interpersonal relationships are fragile, tenuous involvement towards FLR might fall apart once project funding runs out [8].

Conducting research to understand who the social actors that live in the landscape are (involving social and interdisciplinary sciences) and developing participatory research with co-construction of knowledge contributes to the success of restoration initiatives, in particular, with local stakeholders such as landowners, rural owners, farmers and smallholders, as they are key decision makers for forest restoration on private or communal properties. However, there is still a knowledge gap as to what extent local level actors have been involved in FLR initiatives, and what the main lessons learned are.

In this context, bibliometric methods have been used in qualitative approaches to organise, monitor, describe, and evaluate documents from literature reviews [16]. For example, Bibliometric Mapping analysis (BM) reports the structure of scientific literature using information on authors, countries, organisations, citations or keywords shared among articles. It can also present the impact or influence of a single study on the broader literature, using data on the number and nature of citations that it receives [16,17]. BM has benefitted from recent advances in (big) data text mining and network analysis [16–18] and allows the analysis of changes in the network of publications throughout time, documenting and visualising the progress of a particular scientific field through quantitative and qualitative parameters [19–21].

In this study, we conducted a bibliometric analysis to provide an overview of scientific publications in forest restoration and FLR that (1) recognised the relevance of the local level actors and (2) collected primary and/or secondary data on LS through different methods.

2. Materials and Methods

2.1. Data Collection

Bibliometric indicators were developed considering two bibliographic sources for the period 2000–2021: (1) Science Citation Index Expanded (SCI-E)—Clarivate Analytics' ISI—Web of Science© platform [22], including the following Citation Indexes: Science

Citation Index Expanded (SCI-EXPANDED), Social Sciences Index (SSCI) and the Emerging Sources Citation Index (ESCI). The "Topic" field was used, covering the title, abstract, keywords and WoS-assigned keywords called Keywords Plus [23]; (2) Scopus platform [24], using the title, abstract and keywords. Therefore, our database is biased towards articles published in English, and does not represent the totality of the literature published by scientific journals or the grey literature. Moreover, we highlight the importance of performing this analysis in different time spans to detect changes in trends.

WoS and Scopus are often used for conducting academic and bibliometric studies [25–27] as well as to locate and synthesize meaningful information across the environmental literature [28]. Keywords Plus enhanced the title-word and author keyword indexing by supplying additional search terms extracted from the titles of article references on WoS and Scopus [29]. Keywords Plus has been used in research concerning the knowledge structure of scientific fields in terms of bibliometric analysis [30,31], but it may also bring some noise to results. Publications recovered through Keywords Plus were carefully analysed and the publications that moved away from the central theme were excluded from the analysis.

We used the following search strings: ("forest restoration" OR "forest landscape restoration" OR "forest and landscape restoration") AND (landowner* OR "rural owner*" OR farmer* OR livelihood* OR smallholder*). We acknowledge that local actors cover a wide range of stakeholders such as local government officials/agents, local NGOs, community forestry, university research and others. However, in this study, we refer to landowners, rural owners, farmers and smallholders as local stakeholders, particularly because of their role in decision-making for forest restoration The application of Boolean operators and quotation marks was the key factor in selecting the final dataset [32]. Only articles and review papers were considered in this analysis since they represent most documents with complete research results [23,26]. In total, 377 publications were retrieved (2000–2021) and datasets were downloaded on June 29, 2021 (Figure 1). A duplicate analysis was performed in the R environment with the 377 papers in order to eliminate duplications, resulting in 223 papers. After this, articles that did not present in the title or abstract the keywords used in the search string or that were repeated were eliminated, resulting in 197 papers for the final analysis (Figure 1, Supplementary Materials, Table S1).

2.2. Data Analysis

All analyses were performed using the "Results Analysis" tool provided by the WoS and Scopus sources with MS Excel (v. 2016) spreadsheets and R software [33] to carry out calculations and draw indicator graphs. The analysed bibliometric indicators were: (i) number of papers by publication year, (ii) most productive countries according to the total number of publications, (iii) most influential journals and cited papers, (iv) most influential authors ranked by number of publications, their respective organisations and country collaborations (v) a co-occurrence analysis of countries' collaborations and keywords.

The top 20 most cited papers, the top 15 journals, and the top 20 authors ranked by total number of citations and publications, respectively, were based on WoS and Scopus ranking using the "Results Analysis" tool provided by the bibliographic sources (Supplementary Materials, Tables S2–S4). Using different bibliographic sources contributes significantly to revealing a more accurate and comprehensive picture of authors' scholarly impact [34]. The geographic distribution of the top 10 most productive countries was analysed with the support of MS Excel (v. 2016) spreadsheets and QGIS® (v. 3.16) according to the total number of publications used to categorize the mapping classes (Supplementary Materials, Tables S1 and S5).

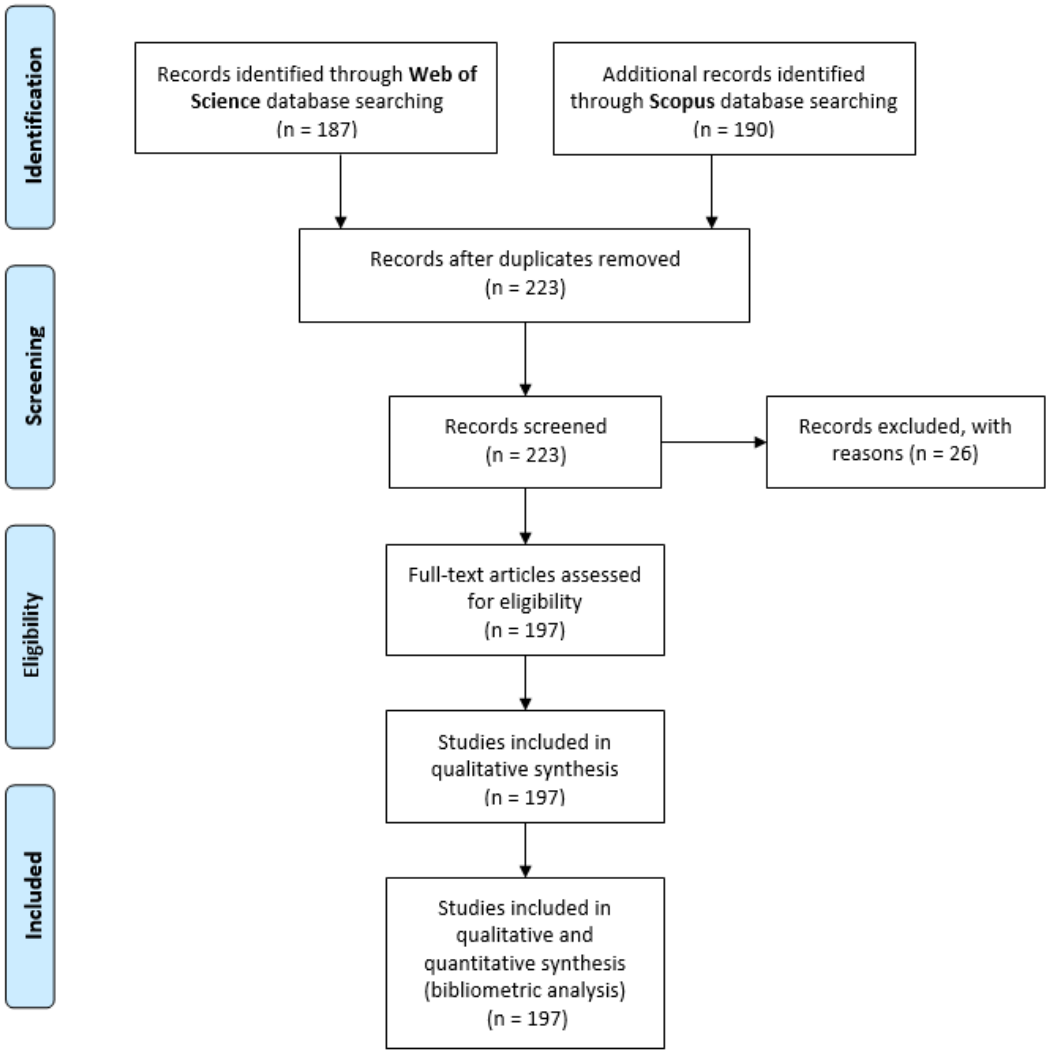


Figure 1. Flow diagram depicting the study selection process based on PRISMA guidelines.

Bibliometric mapping was developed using VOSviewer (software version 1.6.6) [35] to visualise and understand how the terms are organised regarding the central concept, forest restoration, FLR and LS (e.g., farmers, landowners). We adopted only countries' collaboration and keywords that occurred a minimum of 5 times and had 1 strength link. We extracted information from the author and institutional affiliation based on the information provided in each article (Supplementary Materials, Table S1), which may not represent all the authors' academic connections or present affiliations. Repeated words (i.e., search terms, repeated author's keywords) and meaningless words (i.e., forest restoration, forest landscape restoration), called stop words, were not considered [28,36]. The VOSviewer software [37,38] is a tool that uses clustering algorithms and features based on the strength of the links between items to help in the analysis of network collaboration (e.g., authors, organisations, countries, and keywords) [26,28].

Finally, we analysed the abstracts of the 197 final articles in study to select those that recognised the relevance of the local level actors and collected primary and/or secondary data on local stakeholders through different methods (Supplementary Materials, Table S1). When the analysis of the abstract was not enough to identify our criteria, we analysed the material and methods section of the articles. For the top 15 journals, we analysed their aim and scope to select those that included publishing interdisciplinary work with the humanities and/or work at the local scale (Supplementary Materials, Table S3). For the top 20 authors, we analysed whether they are social researchers (based in undergradu-

ate, master, PhD, or post doc degrees in Social Sciences field) (Supplementary Materials, Table S4).

3. Results and Discussion

3.1. Publication Outputs: Research Activity

We found that the number of article publications in forest restoration or FLR and LS studies had increased since 2001, illustrating a growing interest on the local level actors by the FLR community (Figure 2 and Supplementary Materials, Table S1). However, only 50% (99 records) of the publications recognised the relevance of the local level actors and collected primary and/or secondary data using different methods. Of the total number of publications, 81% were published after 2012, and 65% of the most cited articles were published in the last decade (after 2010). The years 2017 and 2020 corresponded to the years with the highest numbers of publications, with 19 and 40 papers, respectively. There were no publications in 2000 and 2005. In addition, the year 2021 also shows a significant increase in publications, being 26 at the time the data was exported.

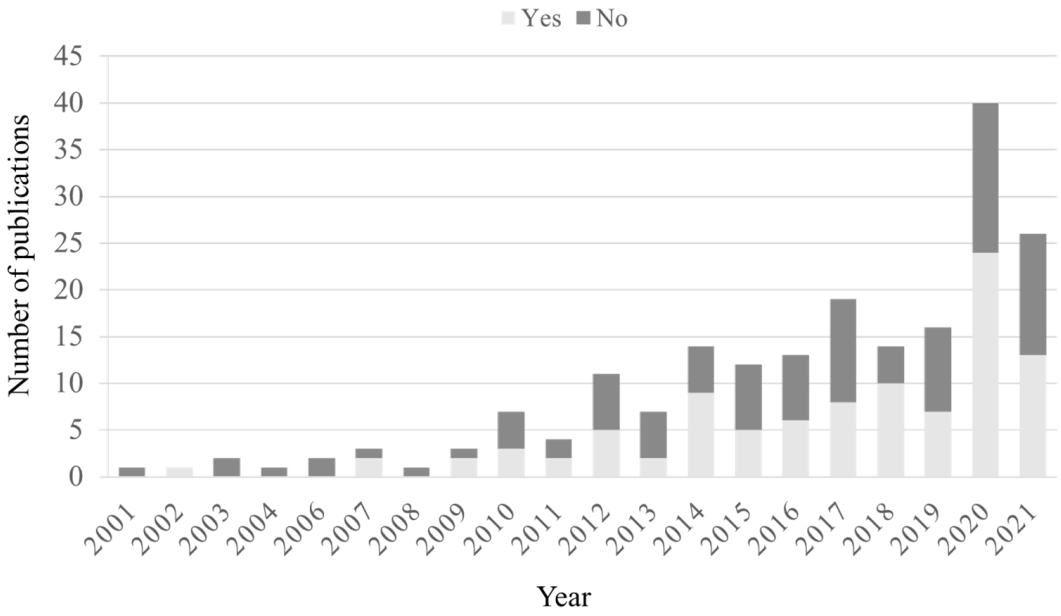


Figure 2. Total global number of article publications from WoS and Scopus from 2000 to 2021. Yes indicates the articles that included the established analysis criteria and No the articles did not include.

In the last decade, both the number of studies that have recognised the relevance of the local level actors and that of those that have not have increased to the same extent (Figure 2). The first paper that approached LS in forest restoration was published by Leopold (2001), while the first two papers that recognised the relevance of the local level actors in the research were by Kamwenda (2002) and Combalicer et al. (2007) [39–41].

In Costa Rica, Leopold (2001) showed that native rainforest restoration could be stimulated by planting mixed stands of native hardwoods, providing a possible source of income for small farmers, stabilising the soil, and stimulating biodiversity restoration [39]. The author emphasizes the relation between forest restoration and rural livelihood, and the provision of ecosystem services.

In Shinyanga, a region in the northeastern Republic of Tanzania, the exploitation of rangeland forestry resources is a severe problem for the agropastoralists. However, a traditional management system, locally termed "ngitili" (dry-season fodder reserves) among the Wasukuma agropastoralists of Shinyanga, has proved to be instrumental in range management and forest restoration [40]. In the Barobob watershed in the Philippines, restoration was developed through an integrated watershed management based on community forest management [41]. The involvement of LS, positive community perceptions,

and democratic and participatory governance were key to watershed forest restoration and protection, according to the authors.

The increasing number of forest restoration and FLR publications approaching LS could be related to the increasing international visibility of forest restoration on a global scale and the fact that in most countries, FLR will have to be developed on private or communal properties. The negative consequences for biodiversity and human well-being from deforestation and forest degradation have stimulated the establishment of national and international policies for large-scale forest restoration, such as the UN Decade of Restoration (2021–2030).

In this context, between the years 2010 and 2014, numerous initiatives were proposed on a national, regional, and global scale, aiming to restore more than 350 million hectares of degraded forests by the year 2030. In 2010, the Convention on Biological Diversity established guidelines for the restoration of 15% of degraded ecosystems by 2020. In 2014, the Bonn Challenge was launched at the United Nations World Summit in New York, which aims to restore 150 million deforested hectares on the planet by 2020, followed by an additional 200 million hectares by 2030 [42].

Additionally, that same year, at the Conference of the Parties to the United Nations Framework Convention on Climate Change in Lima, the goal of restoring 20 million hectares in Latin America and the Caribbean by the year 2020 was presented. In 2019, the United Nations declared the decade of ecosystem restoration between the years 2021 and 2030 [43]. Therefore, forest restoration agreements established since 2010 push for the adoption of FLR approaches and governance models that engage LS as a means of achieving better ecological and livelihood outcomes [8,9,43–45].

Countries

Articles on forest restoration, FLR and LS were published by authors and co-authors from 54 different countries worldwide. Figure 3 shows the top 10 most productive countries in terms of number of publications over the last 20 years, measured by either first author or co-authors, considering the organisation to which they belonged.

More than 36% of the total number of published papers were produced by researchers from the USA in collaboration with other authors. The other countries with the highest numbers of papers published were Brazil (29%), Australia (15%), China and the United Kingdom (8%), France and Canada (7%), the Netherlands and Switzerland (6%), and Germany (5%) (Figure 3 and Supplementary Materials, Tables S1 and S5). Authors and co-authors from organisations in the United States, Brazil and Australia published 80% of the total number of papers, but in most publications they are co-authors.

3.2. Most Cited Papers and Main Journals

The number of citations for each paper ranged from 40 to 176, considering the WoS and Scopus bibliographic sources (Table 1). The most cited article (176) was published in 2015 by Robin Chazdon and co-authors in the journal "Conservation Letters", proposing the creation of a knowledge agenda titled Emerging Goals and Policies in order to address knowledge gaps and guide implementation of FLR at local and global scales [7]. As part of the agenda proposed by the authors, they raise questions about (i) local knowledge needed to configure landscapes restoration combined with production, food–water–energy security, biodiversity conservation and poverty alleviation, and (ii) financial resources displayed by private enterprise and financial institutions to local governments and landowners to guarantee restoration and generate new revenues. They argue that knowledge production for FLR requires multidisciplinary research teams working in collaboration with landowners, local research institutions, and agriculture/forestry extension services familiar with specific social and environmental landscapes' contexts. The authors believe that, as the policy-driven knowledge agenda for global FLR becomes more local, multiple groups of stakeholders will engage in the long-term process of restoration, including farmers, villagers, communities, municipality leaders, forestry agencies, and business leaders, among others.

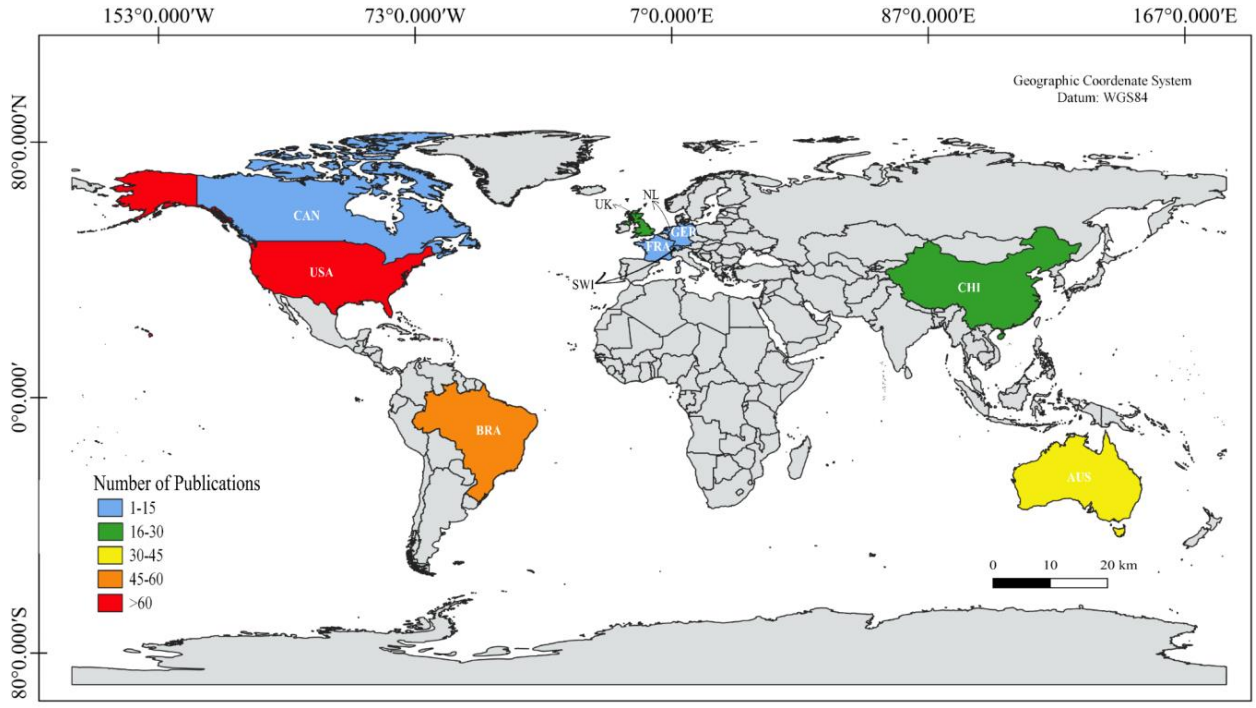


Figure 3. Top 10 most productive countries according to the total number of publications. USA = United States, BRA = Brazil, AUS = Australia, CHI = China, UK = United Kingdom, FRA = France, CAN = Canada, NL = Netherlands, SWI = Switzerland, GER = Germany.

Table 1. Top 20 most cited papers ranked by WoS and Scopus.

Authors	Title	Year	Journal	Rank: Cited by WoS	Rank: Cited by Scopus
Chazdon, R.L., et al.	A Policy-Driven Knowledge Agenda for Global Forest and Landscape Restoration	2015	Conservation Letters	151 (1°)	176 (1°)
Le, H.D., et al.	More than just trees: Assessing reforestation success in tropical developing countries	2012	Journal of Rural Studies	98 (2°)	108 (2°)
Vieira, D.L.M., et al.	Agro-Successional Restoration as a Strategy to Facilitate Tropical Forest Recovery	2009	Restoration Ecology	85 (3°)	94 (5°)
Zahawi, R.A., et al.	Hidden Costs of Passive Restoration	2014	Restoration Ecology	83 (4°)	81 (7°)
Yi, Z.F., et al.	Developing indicators of economic value and biodiversity loss for rubber plantations in Xishuangbanna, southwest China: A case study from Menglun township	2014	Ecological Indicators	83 (5°)	94 (4°)
Melo, F.P., et al.	Priority setting for scaling-up tropical forest restoration projects: Early lessons from the Atlantic Forest Restoration Pact	2013	Environmental Science & Policy	80 (6°)	85 (6°)
Le, Q.B., et al.	Land Use Dynamic Simulator (LUDAS): A multi-agent system model for simulating spatio-temporal dynamics of coupled human-landscape system 2. Scenario-based application for impact assessment of land-use policies	2010	Ecological Informatics	76 (7°)	95 (3°)

Table 1. *Cont.*

Authors	Title	Year	Journal	Rank: Cited by WoS	Rank: Cited by Scopus
Azevedo, A.A., et al.	Limits of Brazil's Forest Code as a means to end illegal deforestation	2017	Proceedings of the National Academy of Sciences of the United States of America	73 (8°)	75 (8°)
Chazdon, R.L. and Uriarte, M.	Natural regeneration in the context of large-scale forest and landscape restoration in the tropics	2016	Biotropica	68 (9°)	67 (9°)
He, J. and Sikor, T.	Notions of justice in payments for ecosystem services: Insights from China's Sloping Land Conversion Program in Yunnan Province	2015	Land Use Policy	68 (10°)	-
Lespez, L.	Geomorphic responses to long-term land use changes in Eastern Macedonia (Greece)	2003	Catena	66 (11°)	71 (10°)
Richards, R.C., et al.	Governing a pioneer program on payment for watershed services: Stakeholder involvement, legal frameworks and early lessons from the Atlantic Forest of Brazil	2015	Ecosystem Services	54 (12°)	57 (12°)
Brancalion, P.H.S. and Chazdon, R.L.	Beyond hectares: four principles to guide reforestation in the context of tropical forest and landscape restoration	2017	Restoration Ecology	49 (13°)	53 (14°)
Leopold, A.C., et al.	Attempting restoration of wet tropical forests in Costa Rica	2001	Forest Ecology and Management	49 (14°)	52 (15°)
Orsi, F. and Geneletti, D.	Identifying priority areas for Forest Landscape Restoration in Chiapas (Mexico): An operational approach combining ecological and socioeconomic criteria	2010	Landscape and Urban Planning	45 (15°)	56 (13°)
Satake, A. and Rudel, T.K.	Modeling the forest transition: Forest scarcity and ecosystem service hypotheses	2007	Ecological Applications	45 (16°)	47 (17°)
Huang, L., et al.	Forest restoration to achieve both ecological and economic progress, Poyang Lake basin, China	2012	Ecological Engineering	44 (17°)	51 (16°)
Gardiner, E.S., et al.	An efforestation system for restoring bottomland hardwood forests: Biomass accumulation of nuttall oak seedlings interplanted beneath eastern cottonwood	2004	Restoration Ecology	44 (18°)	47 (18°)
Adams, C., et al.	Impacts of large-scale forest restoration on socioeconomic status and local livelihoods: what we know and do not know	2016	Biotropica	42 (19°)	-
Ricketts, T.H. and Lonsdorf, E.	Mapping the margin: comparing marginal values of tropical forest remnants for pollination services	2013	Ecological Applications	40 (20°)	-

Le et al. (2012) published the second most cited paper in 2012, in the "Journal of Rural Studies", which presented a conceptual model for assessing reforestation success that links key groups of indicators and success drivers [44]. The agenda and the model are important and necessary to better guide reforestation project planning and public policy formulation that may contribute to LS in tropical developing countries, especially in alleviating poverty, providing ecosystem services from the forest and achieving a better quality of life. Vieira et al. (2009) published the third most cited article in 2009, in the journal "Restoration Ecology", about an agro-successional restoration proposal that incorporates a range of agroecological and agroforestry techniques to overcome the socioeconomic and ecological obstacles to restoring agricultural lands [46] (Table 1).

The top 20 most cited papers (Table 1 and Supplementary Materials, Table S2) approached LS but only 25% recognised the relevance of local stakeholders and collected primary and/or secondary data through different methods. Below we will discuss these articles from the most to the least cited paper.

Assessment of future socio-ecological consequences of land-use policies is useful for supporting decisions about what and where to invest for the best overall environmental and developmental outcomes. Azevedo et al. (2017) evaluated that potential using data from state-level land registries (CAR) in Pará and Mato Grosso (Brazil), which were precursors of a new national land registry (SICAR), and quantified the impact of CAR on deforestation and forest restoration, investigating how landowners adjusted their behaviours over time, using geospatial analyses and stakeholders' interviews [47].

Around the world, there are some environmental programs that encourage the conservation and restoration of forests by LS through payments. In China, one of the world's largest payments for ecosystem services (PES) scheme (China's Sloping Land Conversion Program—SLCP) relies on financial incentives and pays millions of farmers to convert cropland in upper watersheds to tree plantations. He and Sikor (2015) examined the outcomes of the SLCP by way of a case study on the Yangliu watershed in the Yunnan province, in order to understand the observed outcomes in terms of people's participation in the implementation of the SLCP, land-use changes and livelihood effects [48]. In the Poyang Lake basin, southern China, Huang et al. (2012) evaluated how forest restoration projects that consider ecological, social and economic perspectives can improve both the environment and farmers' livelihoods, and assessed the effectiveness of the Mountain–River–Lake Program in this basin [49]. In Brazil, Richards et al. (2015) provided a history of the 10-year-old Conservador das Águas program in Extrema, a city in Minas Gerais, located within the Atlantic forest. The program coordinated restoration activities that have increased native forest cover by 60% in targeted sub-watershed through contracts with 53 landowners, and has established long-term collaborations among government agencies, civil society, and landowners [45].

Finally, Adams et al. (2016) constructed a conceptual framework to analyse the effects of large-scale restoration on local livelihoods and used it to review the scientific literature and reduce this gap in knowledge. The results are mixed but show that there is limited evidence indicating that large-scale forest restoration can contribute to improving local livelihoods [10].

Most Influent Journals

The papers retrieved were published in a wide range of different journals. However, most journals (about 99%) have published fewer than 16 papers in the last two decades. The top 15 journals ranked by total number of publications, which represent about 48% of all publications, are listed in Table 2 (Supplementary Materials, Tables S1 and S3). "Forests" and "Restoration Ecology" were the top journals used to disseminate results from FLR research. Despite the importance of the number of articles published, the top 15 journals did not necessarily publish the more cited papers (Table 1).

Table 2. Top 15 journals ranked by total number of publications (NP) based on WoS and Scopus.

Rank	Journals	NP
1	Forests	16
2	Restoration Ecology	14
3	Forest Ecology and Management	11
4	Land Use Policy	8
5	Biotropica	7
6	Land Degradation & Development	6
7	Sustainability	6
8	Journal of Rural Studies	5
9	Ecosystem Services	4
10	Journal of Environmental Management	4
11	Agroforestry Systems	3
12	Ecological Applications	3
13	Ecology and Society	3
14	International Forestry Review	3
15	Journal of Applied Ecology	2

Scientific journals have different scopes and aims. A total of 33% of the top 15 journals (Table 2 and Supplementary Materials, Table S3) declare publishing interdisciplinary research between ecology and the social sciences and work at the local scale in their scope and aims, namely "Forest Ecology and Management", "Sustainability", "Journal of Rural Studies", "Ecosystem Services" and "Ecology and Society", while 67% are largely focused on the biological aspects of FLR, mainly on ecology.

3.3. International Collaboration and Productivy

The authors responsible for the largest number of publications are distributed across different organisations and countries (Table 3, Figure 3). Approximately 8% of the papers have Pedro Brancalion from University of São Paulo, Brazil, as author or co-author, while 7% and 5% are authored by Robin Chazdon and John Herbonh, respectively, from the University Sunshine Coast, Australia. Brancalion and Chazdon have a background in forestry and forest ecology and have published several papers together, while Herbohn's background is in the social sciences (Supplementary Materials, Table S4).

Most of the top 20 authors ranked by the number of publications belong to the same organisations (Table 3). The most productive organisations are located in Brazil, the United States and Australia (Table 3), which do also establish collaborations with foreign authors. Figure 4 shows the collaboration connections among the different countries, which form four different clusters (yellow, red, blue and green). The node size reflects the frequency of the country's collaboration with other countries. The line between two countries indicates a collaborative relationship; the thicker the line, the higher the collaborative frequency (Figure 4). The United States, Brazil, Australia, United Kingdom, France, Canada and India are the countries that have the most connected members (Figure 4 and Supplementary Materials, Table S1). With the exception of Brazil and France, all of them are English-speaking countries, which is a bias in our study sample.

Table 3. Top 20 authors ranked by number of publication (NP), according to WoS and Scopus bibliographic sources, and distribution of their organisation.

Rank	Author	NP (WoS)	NP (Scopus)	Organisation
1	Brancalion, P.H.S.	16	15	University of São Paulo, Brazil
2	Chazdon, R.L.	14	11	University Sunshine Coast, Australia
3	Herbohn, J.	11	11	University Sunshine Coast, Australia
4	Gregorio, N.	8	8	University Sunshine Coast, Australia
5	Holl, K.D.	6	6	University of California Santa Cruz, United States
6	Mansourian, S.	5	3	University of Geneva, Switzerland
7	Aronson, J.	4	3	Missouri Botanical Garden, United States
8	Guariguata, M.R.	4	2	Center for International Forestry Research CIFOR, Peru
9	He, J.	4	1	Yunnan Agricultural University, China
10	Rodrigues, R.R.	4	3	University of São Paulo, Brazil
11	Stanturf, J.A.	4	4	Estonian University Life Science, Estonia
12	Viani, R.A.G.	4	3	University Federal of São Carlos, Brazil
13	Baynes, J.	3	3	University Sunshine Coast, Australia
14	Calle, A.	3	3	University of California Santa Cruz, United States
15	Fantini, A.C.	3	3	University Federal of Santa Catarina, Brazil
16	Gutierrez, V.	3	3	WeForest Asbl, Belgium
17	Harrison, S.	3	3	University of Queensland, Australia
18	Kettle, C.J.	3	3	Swiss Federal Institute Technology, Switzerland
19	Kumar, C.	3	4	International Union for Conservation of Nature, United States
20	Meli, P.	3	3	University of São Paulo, Brazil

NP: number of publications. The current link status of the researchers may not be up to date as it reflects the organisation where these researchers were affiliated at the time of these publications.

Notably, authors and co-authors from the USA, Brazil and Australia organisations contributed significantly to the development of research on forest restoration and FLR that approaches the importance of the local level and/or local stakeholders' involvement (Figure 4). The number of publications approaching the importance of LS in forest restoration and FLR has been growing in the last 20 years (Figure 2); however, analysing the academic background (undergraduate, master, PhD, and postdoc degrees) of the top 20 authors (Table 3, Supplementary Materials, Table S4), only 20% had degrees in social sciences. The involvement and engagement of social scientists is very important to expand and refine theoretical and methodological frameworks. Interdisciplinary teams contribute to the enrichment and improvement of data collection and analysis methods that encourage the involvement of LS.

3.4. Analysis of Keywords

Keywords are essential to identify the most addressed topics in publications [50,51], research trends [52], and possible knowledge gaps [53]. The keywords' analysis showed us both the most relevant topics and the main research trends in the area [54]. Low-cited keywords may indicate a lack of continuity in a specific research topic or a significant disparity in the research's focus [52,55].

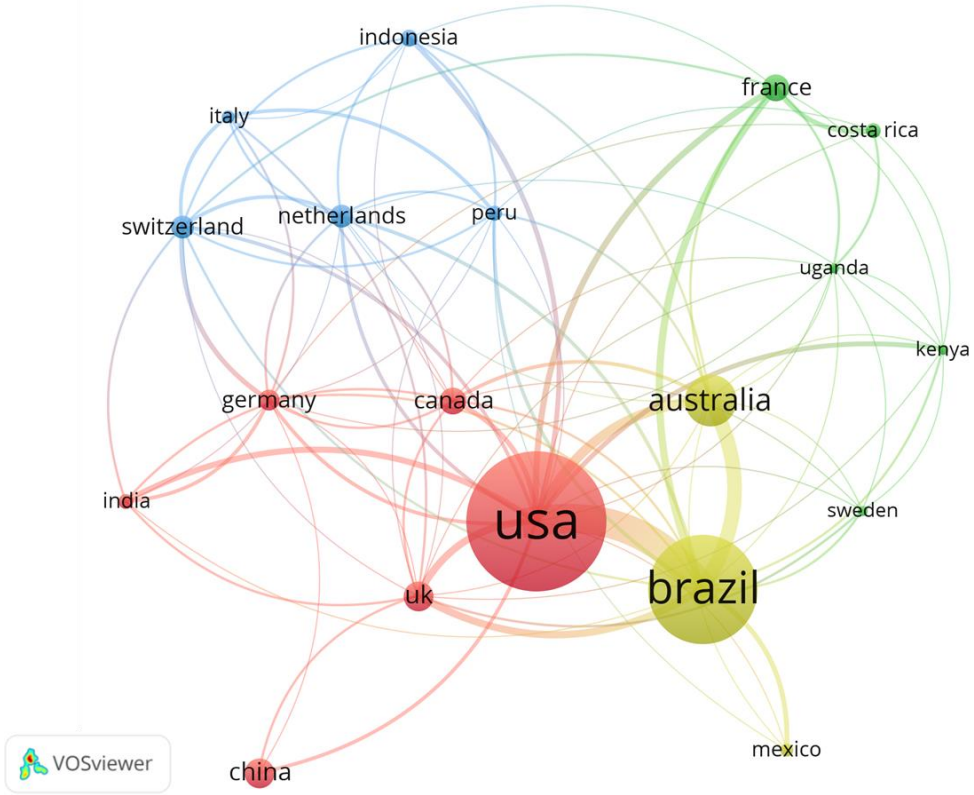


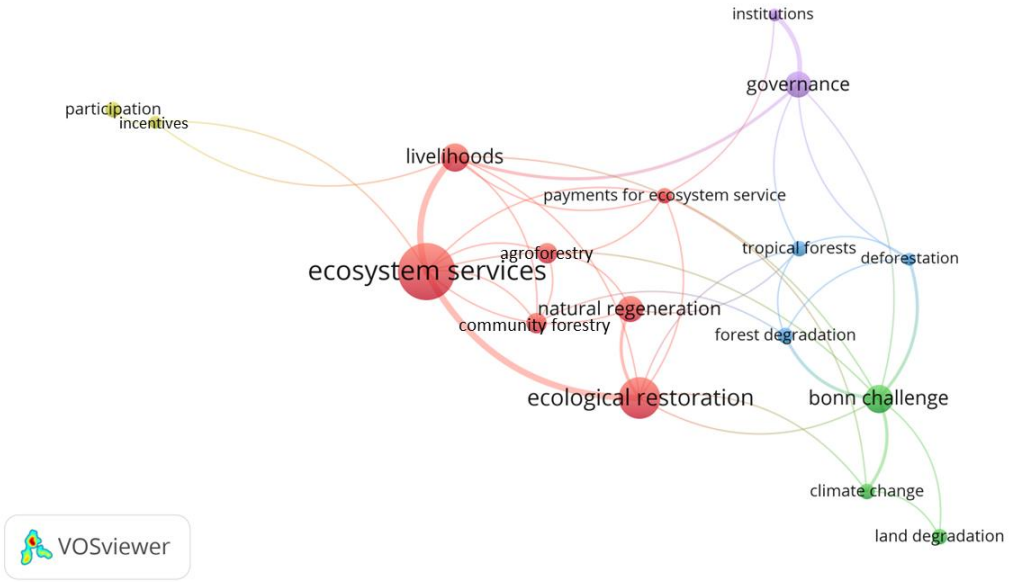
Figure 4. Network visualisation map for country collaboration. Only country collaborations that occurred a minimum of 5 times and with 1 link strength has been used. The node's size is proportional to the number of accumulated country's occurrence. The shorter the distance between two different nodes, the stronger the relationship between the country collaboration. The line between two countries indicates a collaborative relationship; the thicker the line, the higher the collaborative frequency. United States (USA): 73 occurrences and 77 total link strength, Brazil: 57 and 70, Australia: 27 and 35, United Kingdom: 16 and 29, France: 14 and 23, Canada: 14 and 21 and India: 8 and 16.

A total of 17 keywords were found, which were grouped into 5 differentiated clusters by colour (red, green, blue, purple and yellow; colours not related to Figure 4 colours) (Figure 5 and Supplementary Materials, Table S1). The node's size is proportional to the number of accumulated keyword occurrences [26]. The shorter the distance between the different nodes, the stronger the relationship between the keywords (Figure 5), meaning that they were used together.

3.4.1. Red and Green Clusters

"Ecosystem services" is the main keyword addressed by the papers (red cluster) and presents a strong link with "ecological restoration", followed by "livelihoods", "natural regeneration", "agroforestry", "community forestry" and "PES". "Bonn challenge" is the second most used keyword (green cluster) and has strong links with "climate change" and "land degradation" (Figure 5).

In our bibliographic search, only 50% of the articles under study (Figure 2) and 25% of the top 20 most cited papers (Table 1) recognised the relevance of the local level actors and collected primary and/or secondary data, and this gap can also be evidenced by the low occurrence of keywords which refer directly to the local level or local stakeholder, such as "livelihoods", "community forestry" and "participation", compared to keywords applied in more general contexts. These are terms more intertwined with the involvement and participation of LS, as shown by Huang et al. (2012), He and Sikor (2015) and Richards et al. (2015) in China and Brazil, respectively, where socioeconomic data were collected when studying PES programs [45,48,49].



Red Cluster	Occurrences	Total Link Strength
ecosystem services	22	30
ecological restoration	16	20
livelihoods	11	19
natural regeneration	10	14
agroforestry	8	9
community forestry	8	8
PES	6	9

Green Cluster	Occurrences	Total Link Strength
Bonn challenge	11	22
climate change	6	9
land degradation	6	8

Blue Cluster	Occurrences	Total Link Strength
forest degradation	6	9
tropical forests	6	9
deforestation	5	9

Purple Cluster	Occurrences	Total Link Strength
governance	10	16
institutions	5	10

Yellow Cluster	Occurrences	Total Link Strength
participation	6	4
incentives	5	7

Figure 5. Network visualisation map of keywords. Only keywords that occurred a minimum of 5 times and with 1 link strength have been used. The node's size is proportional to the number of accumulated keyword occurrences. The shorter distance between the different nodes, the stronger the relationship between the keywords. Abbreviation: PES = payments for ecosystem services.

FLR is much more than simply expanding ecosystem-based activities on farms; it involves planning and coordinating restoration across the landscape to ensure that the large-scale ecological processes needed to generate ecosystem services can develop, while the livelihoods of people living on the landscape are improved [14]. However, LS participation and active engagement in planning restoration interventions is a premise for achieving livelihood improvement and successful forest restoration [7,8,10,11,56], which remains a challenge and a knowledge gap, according to our analysis.

Analysing all the keywords, we can observe that the LS terms used in our search screening (landowner, rural owner, farmer and smallholder) are not represented among the most used, indicating they are not central to the studies, even though the keyword "livelihoods" (11 occurrences) was found (Figure 5).

3.4.2. Yellow, Blue and Purple Clusters

"Participation" (yellow cluster), "forest degradation" and "tropical forests" (blue cluster), and "governance" (purple cluster) are the main keywords addressed in the theme scope and have a strong link with "incentives", "deforestation", and "institutions", respectively (Figure 5). However, the keywords in the purple and yellow clusters have low links, evidenced by the long distance between the different nodes. The closest links are related to "livelihoods" (Figure 5).

Different models of governance are used to manage forests all over the globe. FLR governance is understood as the broad set of institutions and stakeholders of multiple levels and interests that interact among them to influence the implementation of restoring a forest landscape [8,57]. FLR challenges include reconciling human well-being with ecological integrity, supporting public policies that facilitate restoration, defining who decides what to restore, who finances restoration, and who benefits from it, and ensuring that stakeholders are engaged, and commitments are negotiated among them [58]. Although the importance of governance in the success of FLR initiatives has been recognized in the literature [59], more qualified practitioners and decision makers are needed in many countries to assist public and private organisations, farmers and other producers, and communities and institutions in the design, planning, monitoring, and implementation of restoration [2].

"Institutions" (purple cluster) determine what people can do, should do, or cannot do in specific situations [60]. In this respect, it is important to identify the existing institutional arrangements in order to understand their social, ecological, political, and economic performance [61]. New institutions and governance models need to be developed for implementation, reporting, tracking, and adaptive management of FLR programs at local, national, and international scales. These institutions will need to build social capital by facilitating environmental governance at multiple levels. Often, these organisations will be the best vehicle for identifying obstacles to progress and for connecting researchers and policy makers [62]. In addition, according to Chazdon et al. (2015), public policies need to be developed to encourage individual social actors to implement restoration on some or all of their lands, to coordinate diverse activities within landscapes, and to maximize the overall benefits for the community at large [7]. Local-scale restoration initiatives would need to be supported by larger-scale state programs, non-governmental organisations, and public–private partnerships.

The keywords of the yellow, blue and purple clusters also have strong links with the red and green clusters, specially related to "ecosystem services", "ecological restoration", "livelihoods" and "PES" (red cluster), "forest degradation" and "tropical forest" (blue cluster) (Figure 5). PES programs represent a policy approach to promote land uses that provide ecosystem services through payments to land managers for providing ecosystem services. While financial incentives pay landowners a value for both ecosystem services and opportunity costs, the landowners' decision to enrol in the PES program will be influenced by other social, political, economic, and biophysical factors [45,63]. However, it is fundamental that the PES projects and programs consider the factors presented in order to have success and a greater adherence to the programs. Linked to the PES program, "agroforestry" (red cluster) has been driven by the need to restore farmers' agricultural lands around the world, especially in the tropics. Agroforestry includes different models for restoring lands in a cost-effective way, incorporating agroecological and agroforestry techniques, the provision of human livelihoods, and overcoming the socioeconomic and ecological obstacles to restoring these lands (Vieira et al., 2009).

According to Chuang et al. (2007) and Li et al. (2009), low-cited keywords may indicate a lack of continuity in a specific research subject or a significant disparity in the research's focus [52,55]. We found that studies related to the keywords that occurred just five and six times ("deforestation", "institutions", "incentives", PES", "climate change", "land degradation", "forest degradation", "tropical forests" and "participation") need to be further explored within the scope's theme; for this to be achieved, the direct involvement and participation of LS in forest restoration and FLR research and projects is essential.

4. Conclusions

In conclusion, this paper presented a bibliometric analysis of forest restoration, FLR and LS studies in the literature, using WoS and Scopus as bibliographic sources. It was possible to notice an increase in the number of publications on the topic under study from 2014, with more than 10 studies registered per year, representing a recent and developing trend of international interest. However, the studies that recognised the relevance of the stakeholders at the local level were few: only 50% of the articles under study and 25% of the top 20 most cited papers, indicating that there is still a research gap in this topic in which local actors need to be directly involved.

Our bibliometric analysis' limitation was in downloading the articles, as the research areas of the articles were not available, despite us trying to download the articles retrieved more than three times. Furthermore, we used the keywords (landowner, rural owner, farmer, livelihood and smallholder) to represent the LS, which allowed us to perform the analyses and present an important result within the study's theme; however, other keywords that refer to the LS could also be added. We used Web of Science and Scopus as the main bibliographic sources, although we recommend that future studies consider other bibliographic sources to ensure that more articles and journals are covered. Based on our findings, the papers under study addressed the participation of LS in forest restoration, and this approach is important; however, we recommend a more direct involvement and participation of LS in order to increase the number of publications that recognize the relevance of the local level actors collecting primary and/or secondary data on them, as well as the participation of interdisciplinary and social science researchers in teams investigating FLR and the success restoration of the landscape, providing ecological functionality and enabling improvements to human well-being.

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