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Worldwide Research on Socio-Hydrology: A Bibliometric Analysis

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Abstract: The technical and scientific analysis regarding studies of the water surface or groundwater has increasingly taken on a great social impact, which has led to the creation of the term socio-hydrology. Since decision making has a greater weight, considering the social perspective, its study has become more important in the past 20 years. This article aims to carry out a bibliometric analysis related to socio-hydrology using the Scopus database and the application of VOSviewer software for the evaluation of the intellectual structure of socio-hydrology, its conceptual evolution, and its tendencies. The methodology considers (i) search criteria of the research field, (ii) search and document selection, (iii) software and data extraction, and (iv) analysis of results and trends. The results show us the term socio-hydrology as a new scientific discipline that has traces in the Scopus database in the past two decades. However, its application stems from recognising ancestral knowledge alongside other forms of knowledge. Socio-hydrology practice requires participatory models, where the community has a great influence, and for the most part, it guarantees results for the common good. The trend of this topic is growing and open to the criteria of sustainability.

Keywords: socio-hydrology; intellectual structure; bibliometric analysis; co-citation; Scopus

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1. Introduction

Water is an essential resource for life and its development, but its proportion in the world is not balanced [1]. Worldwide, water withdrawals and reservoirs have decreased their annual discharge to the oceans by 2.7%, with significant changes in the seasonal cycle of streamflow [2]. Water resource management involves the organisation of hydrological, infrastructure, and human activities for sustainable water supply [3]. Urban growth is responsible for the increase in demand for freshwater resources [4]. The lack of access and good management has generated many ecological and human crises, including the destruction of aquatic ecosystems, species extinction, millions of deaths from water-related diseases, and local and international problems. New approaches to water management that include sustainability principles are needed [5]. In 2015, the Sustainable Development Goals (SDGs) emerged, which have goals for access to water and safe sanitation [6] to thus achieve a sustainable future for all of society [7]. To promote effective water management, a series of tools have been created, such as the Water Poverty Index (WPI), which incorporates physical, social, economic, and environmental information related to water's lack and access. It also considers the use of water for productive purposes [8]. Another tool is the integrated Structure–Actor–Water (iSAW) framework, which includes the key components and linkages of a coupled human–water system [9].

As a consequence of contamination by human activities, the amount of surface water has been affected, and groundwater has depleted due to overexploitation of the resource [2], as is the case in India [10], Oriente Medio [11], China [12], and the United States of America [13,14]. In China, in the Tarim River Basin (TRB), due to its extremely arid climate, the population has been limited until the water infrastructure is built [15]. In a global context, Brown and Lall [16] proved that the gross domestic product (GDP) is directly linked to year-on-year and intra-year variations in rainfall for non-oil-producing nations. In contrast, aridity and floods negatively influence GDP growth [17].

The exploitation and sustainable management of groundwater play an indispensable role in agricultural production, especially in areas where surface water resources are scarce or are reducing [18]. Whether due to population growth, urbanisation, or the usual extreme climatic conditions, accelerated global transformations have generated unfavourable hydrological, ecological, and environmental variations in the main river systems [19]. The increase in threats to water resources makes it increasingly essential to integrate social and ecological dynamics in evaluating response and adaptation strategies to improve resilience [20].

People are completely dependent on supplied water for their natural cycle. For this reason, hydro-sociology arises from a concern about the scale of impact of human activities on the hydrological cycle [21], which is the first approach to socio-hydrology, defined as the interaction between humans and water [22]. Socio-hydrology was later defined as “the science of people and water” [23], which introduces bidirectional feedbacks between human–water systems, differentiating it from other related disciplines that deal with water. Another important aspect is a field from the hydrological study that contemplates people’s social and spatial organisation around water in the landscape [24]. In implementing this term, hydrologists posed a series of research questions to include the social sciences within hydrology [25]. Socio-hydrology has been implemented as a new science based on discovery through observation, understanding, and forecasting socio-hydrological phenomena [26]. In addition, it aims to understand and interpret patterns and phenomena that arise from rewards in coupled water–society systems as a result of decisions and acts of water management [27]. Within a socio-hydrological framework, the impact of climate change is measured in the face of the optimal response to floods through a strategy to raise dikes, since the higher the impacts, the higher the dikes [28].

In this science development, other terms related to socio-hydrology have emerged, such as the socio-hydrological system (SHS), defined as a set of water resources whose flow and use are controlled by a composition of hydrological cycles and a social system [29]. Another term is integrated water resources management (IWRM), a social process that relates hydrology to society [30]. In 2015, the term socio-hydrogeology was introduced, defined as “a way of incorporating the social dimension into hydrogeological investigations” [31]. Socio-hydrology is considered a multidisciplinary field, which includes the dynamic reactions and interactions between water and people [32]. The definition of the term and its relationship with other sciences is described in Figure 1.

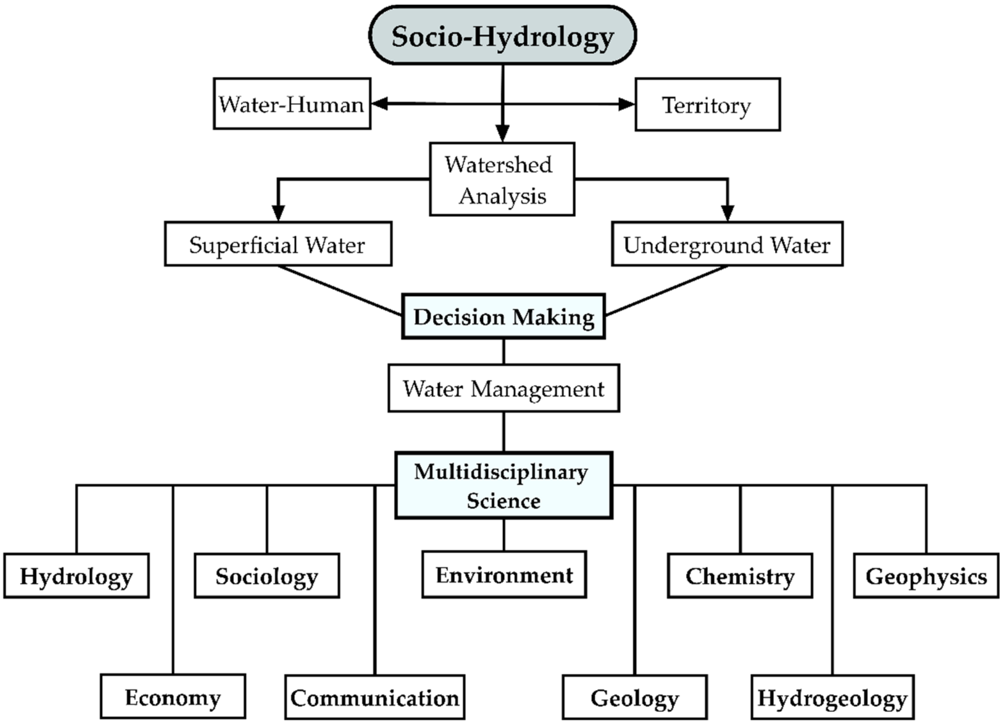

Figure 1. Conceptual scheme.

Socio-hydrology is related to other sciences. In sociology, there have been problems in the regulation of solid waste that increase the concern for water quality, where the socio-hydrological context is essential to address the chronic water crisis [33]. Likewise, it is shown how the traditional local knowledge acquired by the communities about the hydro-social cycle contributes to community water management and the application of new water management practices to address problems such as water scarcity [34]. Local governments are in charge of implementing management programs that reduce the demand for fresh water, but saving water depends mainly on people's conservation habits [35]. In this sense, a socio-psychological model of environmental decision making was designed that encompasses key challenges in integrating the social sciences into integrated models [36]. In environmental sciences, the availability of water is increasingly affected by climate change, especially in arid and semi-arid areas, such as the Capibaribe River basin in Brazil [37]. The rapid retreat of glaciers manifests global climate change and influences the hydrological cycle, impacting water resources [38].

The media discuss issues related to socio-hydrology, such as floods, droughts, management of urban supply, and agricultural irrigation, issuing interpretations according to their perspective of the hydrological cycle's action on society [39]. There is also a relationship with geology due to the socio-natural influences that have material consequences for the morphology of rivers, providing ways of understanding the nature of geomorphological interventions, for example, in the restoration of rivers [40]. Regarding economics, socio-hydrology represents the relationship between socio-economy and water [41].

In Figure 2, the evolution of the definitions of the term socio-hydrology is presented, recorded in a scientific publication in 1979, attempting to create a nexus between social aspects and water, considering the demand of social groups for water resources, relating them to the existence of ancestral knowledge of the communities regarding water management [42]. In 2012, publications concerning this issue took on greater strength. In 2015, the term socio-hydrogeology appeared, from this moment on being a constant in scientific publications that address water with special consideration of the human aspect. These interactions are bi-univocal and leave teachings, techniques, and a new vision for the integral management of water.

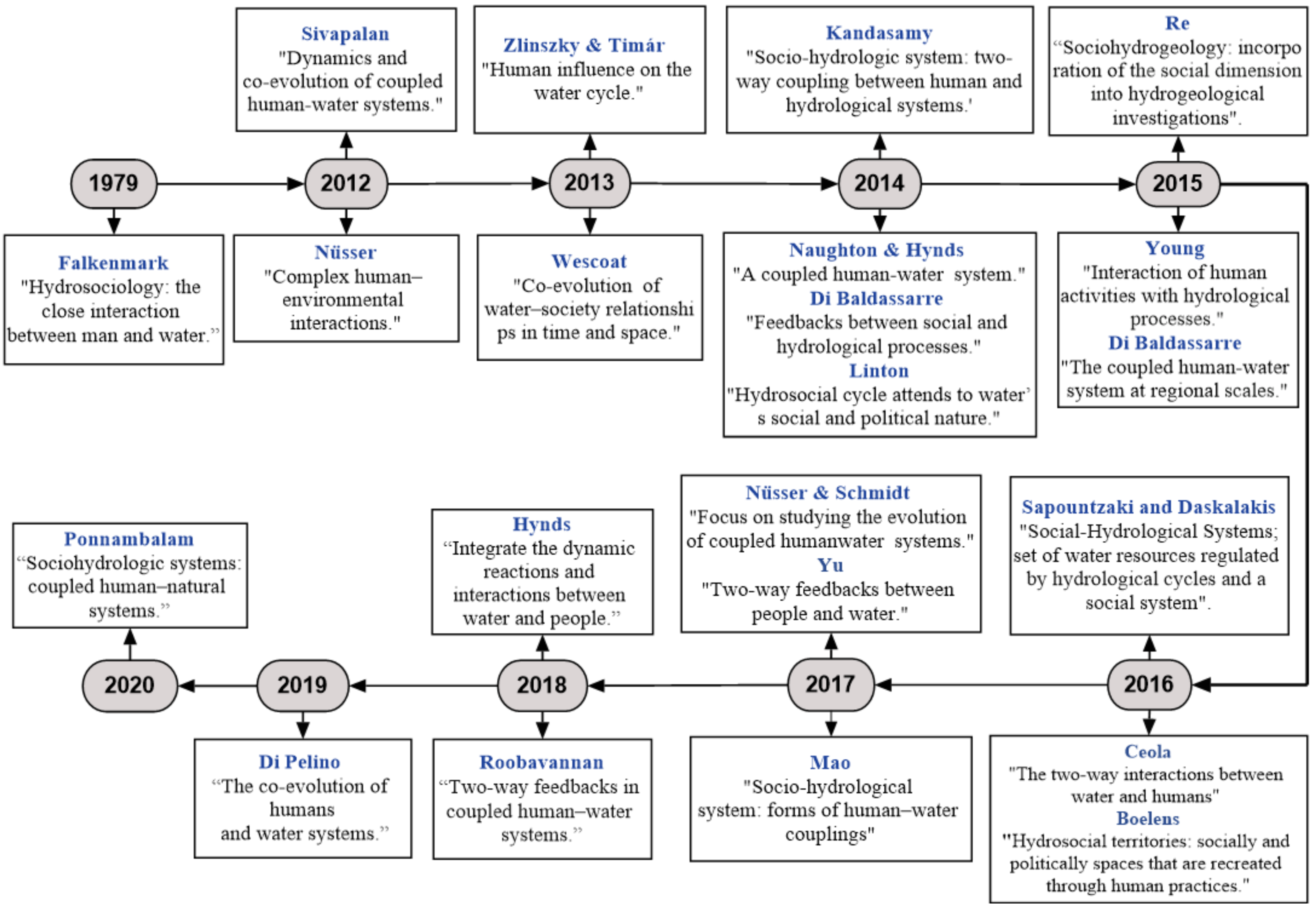

Figure 2. Chronological diagram of the definitions of socio-hydrology.

Some questions have arisen regarding the water–society relationship: What are the main areas of interest related to socio-hydrology? Which journals have had the greatest impact on the socio-hydrology research line? and Who are the most productive authors in socio-hydrology? Despite the importance of developing this new science in the bibliometric field, there is little information that reveals this structure [25,26]. This study will approach this topic from the point of view of bibliometric studies, from a worldwide database of scientific works from the past 40 years.

The studies on socio-hydrology from the bibliometric review field represent a contribution to the scientific community that would allow us to know the origin, evolution, and trends of socio-hydrology in the scientific base. This bibliometric study will help to extract experiences, methods, and projections that support sustainability in water resources.

This work aims to carry out an analysis of the intellectual structure related to socio-hydrology using the Scopus database (launched by Elsevier, Amsterdam, Netherlands) and the application of VOSviewer software (developed by Jan van Eck and Ludo Waltman, Leiden, Netherlands) for the evaluation of the structure of socio-hydrology, its conceptual evolution, and its tendencies.

The article comprises six main sections: firstly, introduction, which includes a small review of the scientific literature on the subject; secondly, materials and methods, where the database and predictors used are described; the third part shows the main results obtained; the fourth section includes a discussion of the study, which mainly indicates the emerging lines of research; fifth, we have the conclusions, which include the limitations of the study; and finally, in the sixth part, the references used are listed, which support this research.

2. Materials and Methods

The literature review is of utmost importance in the knowledge management of a topic that corresponds to an area of research, since it allows evaluating scientific production [43,44]. This type of review requires a formal and reproducible methodological structure, a systematic review of the literature [45,46]. This rigorous process is also present in bibliometric studies, allowing additional information to be obtained that literature reviews cannot cover [47,48].

Bibliometry is considered a field of research whose use has increased in the professional and academic field by generating a complete map of knowledge structure in a given field [49,50]. It allows analysing scientific production and its characteristics, evolution, and trends, considering the authors, countries, institutions, and journals [51–53]. It is noted that bibliometrics has made contributions to various academic disciplines such as earth sciences [49,54,55], education [56,57], and business and management [58–60].

This study contemplates a systematic process of four phases (see Figure 3) that allow the analysis and bibliometric maps to be carried out: (i) search criteria of the research field, (ii) search and document selection, (iii) software and data extraction, and (iv) analysis of results and trends.

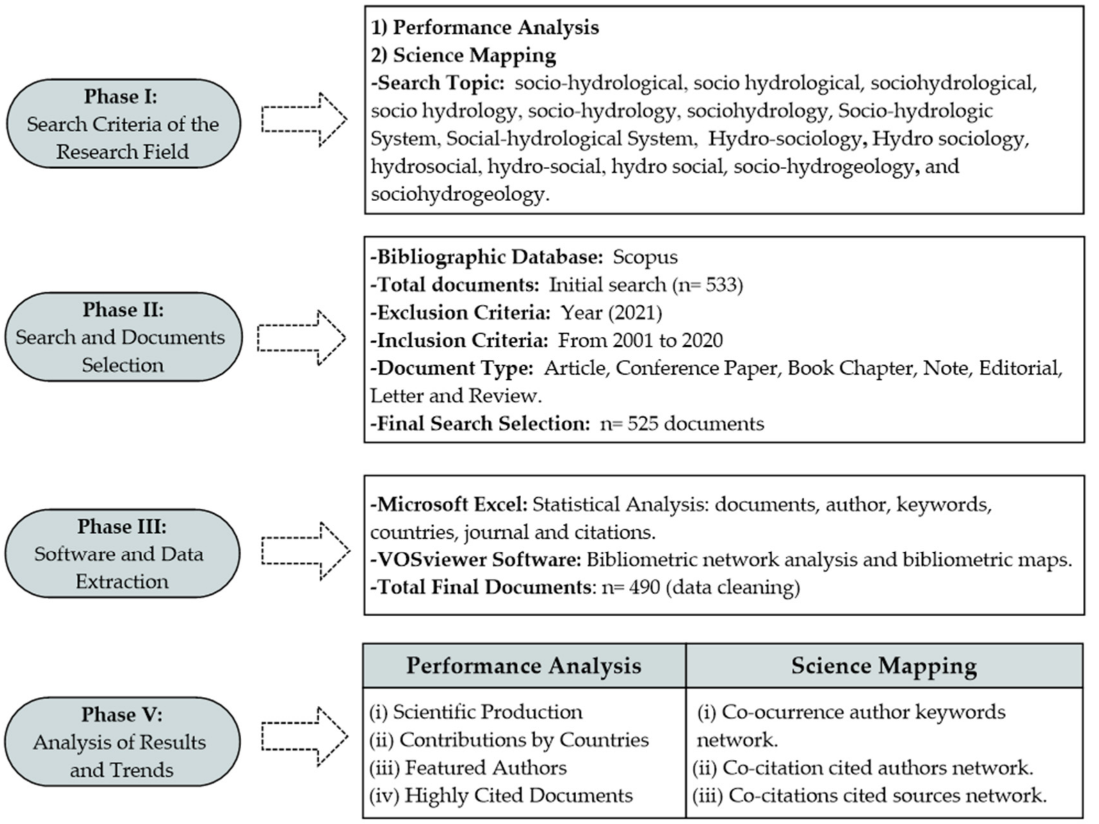

Figure 3. Methodological scheme of the process carried out in this study.

2.1. Phase I: Search Criteria of the Research Field

This study has the purpose of evaluating the conceptual evolution of socio-hydrology through a bibliometric analysis. The selected search terms were the following: socio-hydrological [61], socio hydrological, sociohydrological, socio hydrology [62], socio-hydrology [63], sociohydrology, socio-hydrologic system [64,65], social-hydrological system [29], hydro-sociology [22], hydro sociology, hydrosocial [66], hydro-social [67], hydro social, socio-hydrogeology [31], and sociohydrogeology. Different researchers have used these terms in different periods of time (Figure 2), showing the evolution of this topic. These terms have made it possible to delimit the field of study of socio-hydrology.

2.2. Phase II: Search and Documents Selection

The selection of a reliable database that has quality information is one of the requirements for conducting bibliometric studies [68]. Bibliometric analysis uses the Web of Science (WoS, launched by Clarivate Analytics, London, United Kingdom) and Scopus databases widely. However, both databases differ in terms of scope, the volume of data, and coverage policies [69]. The results (articles) and impacts (citations) of countries obtained from the two databases are highly correlated. Therefore, we selected the Scopus database [70] due to institutional access and significant coverage of journals (20,346 journals in Scopus vs. 13,605 in WoS). It means that Scopus indexes 66.07% more unique journals than WoS [71]. Scopus includes rich metadata records of scientific articles and complete profiles of authors and institutions. This information comes from advanced algorithms, which guarantees high precision and data recovery [72]. Finally, it presents more coverage in Ibero-American countries' publications in articles and journals [73], ease in exporting bibliographic information, and a complete overview of world research production [74,75].

The data collection was carried out in January 2021 using a series of descriptors related to the term socio-hydrology, contained in the title, abstract, and keywords, together with Boolean logical functions (AND, OR), which allowed the search to be carried out: (Topic Search) TS = (TITLE-ABS-KEY ("socio-hydrological") OR TITLE-ABS-KEY ("socio hydrological") OR TITLE-ABS-KEY ("sociohydrological") OR TITLE-ABS-KEY ("socio hydrology") OR TITLE-ABS-KEY ("socio-hydrology") OR TITLE-ABS-KEY ("sociohydrology") OR TITLE-ABS-KEY ("Socio-hydrologic System") OR TITLE-ABS-KEY ("Social-hydrological System") OR TITLE-ABS-KEY ("Hydro-sociology") OR TITLE-ABS-KEY ("Hydro sociology") OR TITLE-ABS-KEY ("socio-hydrogeology") OR TITLE-ABS-KEY ("sociohydrogeology") OR TITLE-ABS-KEY ("hydrosocial") OR TITLE-ABS-KEY ("hydro-social") OR TITLE-ABS-KEY ("hydro social")). We obtained 533 documents as an initial search result.

In the database's construction, several implicit and explicit selection criteria must be met for the documents obtained [43]. As the first criterion, we considered using articles, book chapters, reviews, editorials, letters, and notes [76]. Additionally, since this is a relatively new topic, all languages were considered, so we wanted to explore its progress over time fully [77]. As the second criterion, it was decided to exclude the year 2021, as it is the current year, obtaining 525 documents.

2.3. Phase III: Software and Data Extraction

The data collected from the Scopus database were exported into a Microsoft Excel spreadsheet, in comma-separated value (CSV) format, to carry out their respective treatment and analysis using Excel [78]. The database includes thousands of data on different variables (authors, institutions, countries, languages, keywords, abstracts, and references, among others) [79,80], requiring a review of possible errors [81,82]. This review consists of cleaning duplicate files, incomplete records (documents without authorship, title, or year of publication), or erroneous records that could not be completed manually [83]. Under these considerations, 35 documents were eliminated, obtaining a database of 490 documents.

For the graphical representation of bibliometric maps that are easy to interpret, VOSviewer software [84], developed by the University of Leiden, was used, which allows the construction and visualisation of two-dimensional bibliographic networks [85]. VOSviewer software has been used in studies in different research areas [85–90].

2.4. Phase IV: Analysis of Results and Trends

Bibliometric studies employ two main techniques, performance analysis and science mapping [91]. Performance analysis constitutes the analysis of scientific publications' structure, such as the year of publication, the number of documents, journals, countries, authors, and affiliations [47]. Science mapping allows the graphical representation of research fields and subfields while the links between them are observed [58,92]. These maps show the relationships between various variables, such as co-occurrence with author keywords, co-citation with cited authors, citation with sources, and co-authorship with authors [93]. For the author–keywords co-occurrence network, knowledge areas related to the study subject are assigned, depending on each cluster generated by the software [94].

3. Results

3.1. Performance Analysis

3.1.1. Scientific Production Analysis

A total of 490 documents are distributed between the years 2001 and 2020. The socio-hydrology research field is made up of seven types of documents: articles (396), which represent 80.81% of the total documents, followed by reviews (32), conference papers (21), book chapters (16), notes (12), editorials (9), and letters (4), as shown in Figure 4.

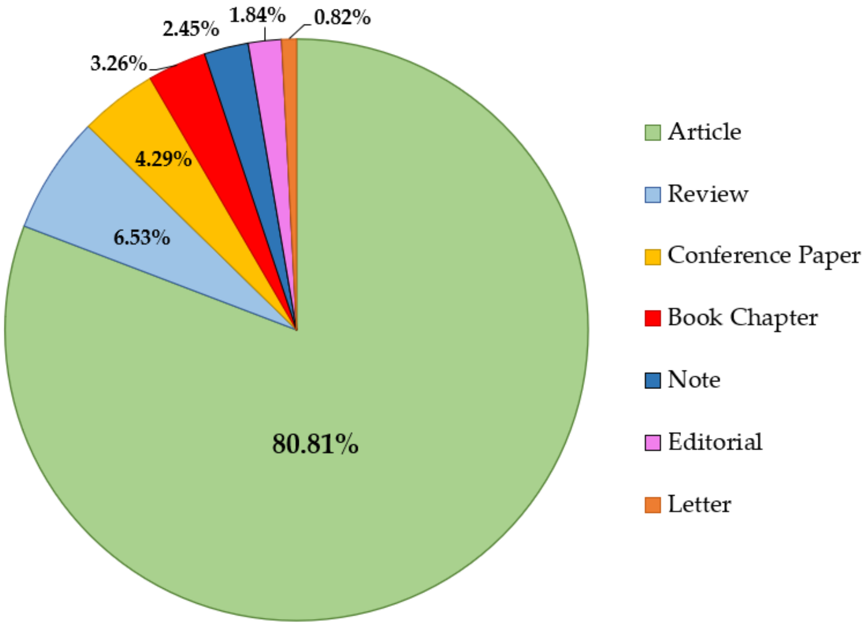

Figure 4. Document types associated with socio-hydrology.

The scientific production in the socio-hydrology line of research shows a growth in the interest in the academy's subject (see Figure 5), presenting 490 documents in the years 2001–2020. The analysis of the results is divided into two periods: introduction (2001–2010) and growth (2011–2020).

Period I (2001–2010): The publication growth was limited; it did not exceed 13 publications, representing 2.65% of the total production in this area of knowledge. However, a previous publication related to the subject in 1989 was entitled "Multi-disciplinary Planning and Managing of Water Reuse" [95]. This publication was discarded in the analysis because no more publications were registered during the period 1900–2000, indexed in Scopus. The first article related to socio-hydrology was published in 2001 by the authors Turton, Schreiner, and Leestemaker [96] in the journal Water Science and Technology. This study deals with the role of women in the management of water resources. Second is the article published in 2003 in the journal Water Policy by Meissner and Turton [97], in which hydro-social contract theory is discussed. The most cited publication corresponds to the authors Brown, Keath, and Wong [98], with 345 citations, who propose a framework that supports the progress of the urban water transition policy. This study was published in 2009 in the journal Water Science and Technology.

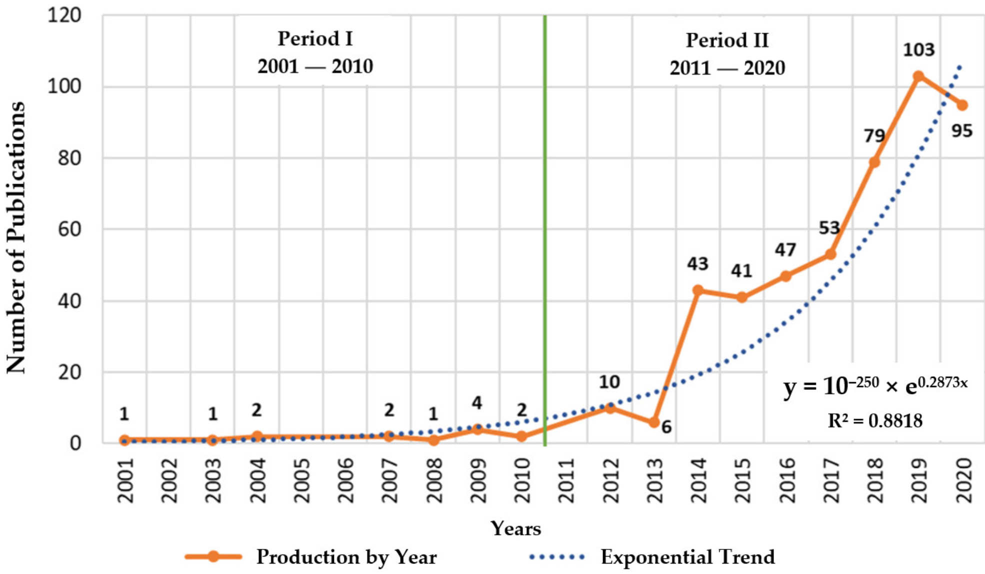

Figure 5. Scientific production in the period (2001–2020).

Period II (2011–2020): In this period, there was a noticeable growth in publications on the subject. Initially, 10 documents were published; the most relevant document reached 465 citations and was published in Hydrological Processes in 2012 by Sivapalan, Savenije, and Blöschl [23]. In this study, socio-hydrology is introduced as a new science that analyses human–water system co-evolution. Second was an article published in the same year by authors Norman, Bakker, and Cook [99], covering water governance and its policies, with 71 citations in the journal Water Alternatives. In the last three years, many publications were included, reaching 79 documents in 2018, 103 in 2019, and 95 in 2020. Among the most relevant publications according to the number of citations, the following stand out: First is Baldassarre's article, which mentions the challenges posed by climate change, globalisation, urbanisation, and social isolation for disaster risk reduction [100]. This article was published in the journal Earth's Future and reached 24 citations. Second is Boelens' article [101], in which mega-hydraulic projects such as dams are discussed, have regained a new momentum worldwide, reaching 23 citations and published in the journal Water (Switzerland). Third is Musacchio's article [102], which analyses the European Directive's effectiveness from a socio-hydrogeological perspective regarding the affectation by nitrates in Italy in the Lombardy plain. This article reached 14 citations and was published in the journal Ambio.

In this period, 477 documents were published, representing 97.35% of the total production. In general, the most prominent documents for their more significant number of citations were the article by Sivapalan [23], recognised by the pioneer in developing this new science of the socio-hydrology and, later, Linton's article [66]. It introduces the hydro-social cycle, based on the definition of the hydrological cycle, but unlike this, the hydro-social cycle contemplates the social and political nature of water. This article was published in the journal Geoforum and obtained 307 citations.

Additionally, scientific production was evaluated using Price's law [103]. This law evaluates the increase in research in the field of study by showing exponential growth [81,104,105]. The entire production of the study field was estimated, and an exponential growth model was generated (see Figure 5). The equation $y = 10^{-250} \times e^{0.2873x}$ was obtained, where the value of $R^2 = 0.8818$ verifies that the field of study is in exponential growth.

3.1.2. Contributions by Countries

The contribution by different countries facilitates the understanding of the relationship between knowledge and its institutions [106]. A bibliometric map of bibliographic coupling of countries was made to measure the references of a set of documents in the database, specifically the countries involved [107]. In the bibliographic coupling of countries, a threshold of at least five documents per country was established; using VOSviewer, 28 countries reached the established threshold. Table 1 shows the top 15 countries according to the number of documents about socio-hydrology.

Table 1. Top 15 countries with the highest number of publications.

Ranking	Country	Publications	Citations	Total Link Strength
1	United States of America	171	3009	76,382
2	Netherlands	83	2237	49,965
3	United Kingdom	63	1276	31,783
4	Australia	44	1599	26,571
5	Canada	38	1059	22,725
6	Germany	37	329	16,040
7	Sweden	33	404	22,858
8	Austria	27	1309	22,068
9	China	27	298	22,282
10	France	24	564	13,388
11	Spain	23	171	9256
12	Italy	21	201	14,135
13	India	19	292	8967
14	Switzerland	17	157	9011
15	Brazil	14	108	4404

Figure 6 shows the analysis of bibliographic coupling by country. Nodes represent these countries, and the proportion of their size is a function of the number of documents. The lines that join the nodes (links) represent the interconnection between countries, showing their strength of collaboration, the more comprehensive the line, the greater the relationship's strength. The figure shows 28 countries grouped in five colour clusters and 750 links, with a relationship strength of 399,986. The most outstanding node is the United States of America, with 171 documents and 3009 citations, followed by the Netherlands, with 83 documents and 2237 quotes.

The appendix section (S1) shows the five clusters mentioned above. Cluster 1 (red) includes 13 leading countries, among which the United States of America, with 171 documents, and Australia, with 44, stand out. The last and fifth cluster (purple) is made up solely of Switzerland, with 17 publications.

In Figure 7, the map includes the 71 leading countries that have contributed to socio-hydrology. Colours distinguish them according to the number of publications on the subject. In white are observed countries without publications on the subject.

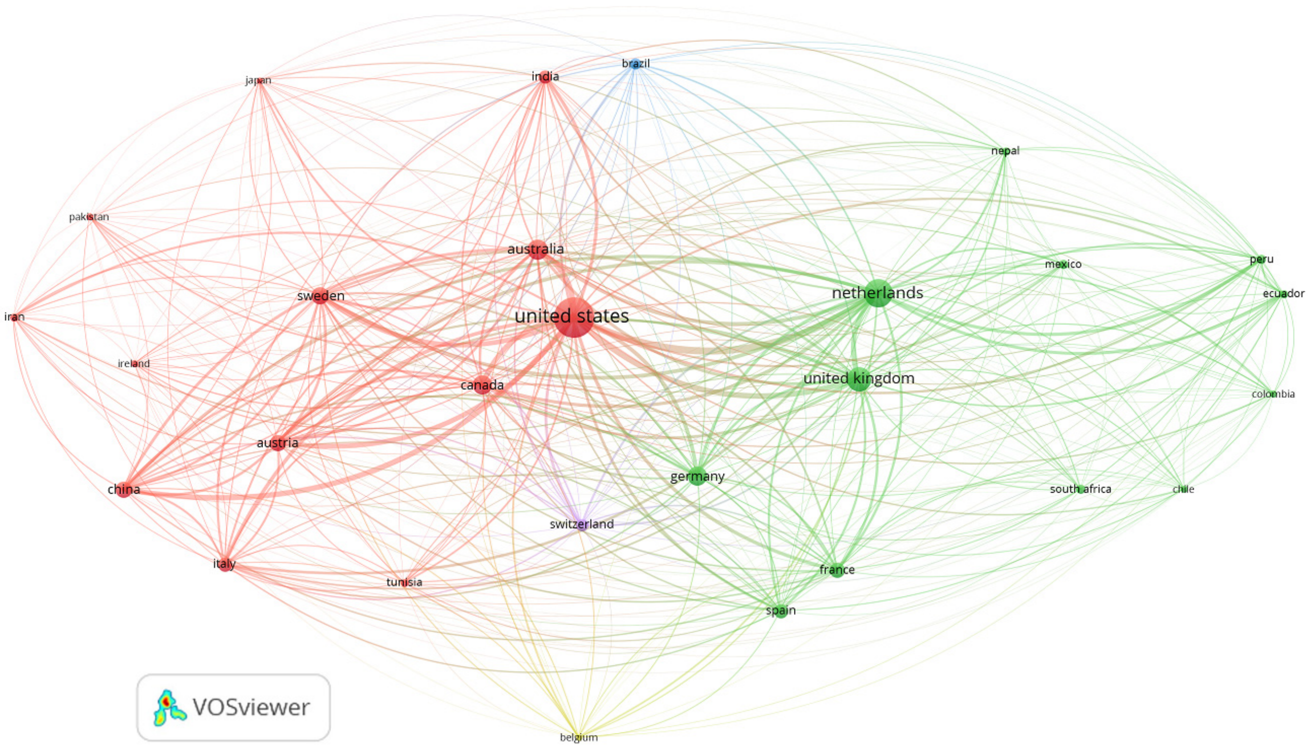

Figure 6. Bibliographic coupling of countries.

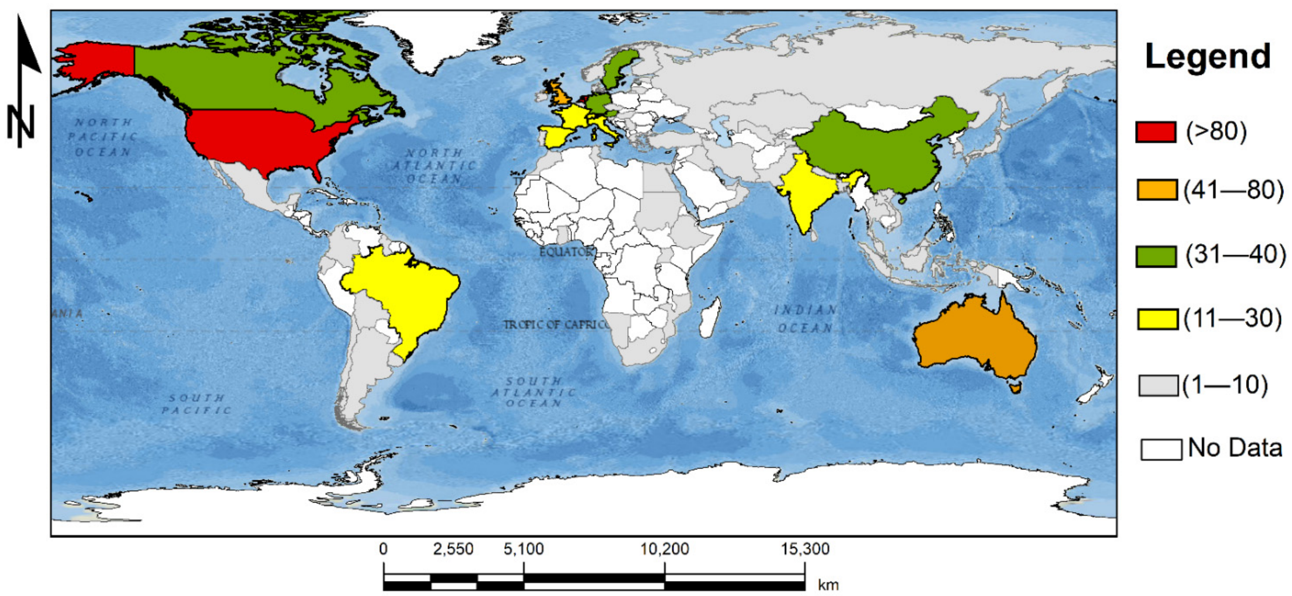

Figure 7. Countries' contribution to socio-hydrology.

3.1.3. Featured Authors

This field of study has received the contribution of 1138 authors. Table 2 shows the 15 main authors who have contributed to this field of knowledge. Rutgerd Boelens of Wageningen University & Research (Wageningen, The Netherlands) is the author with the most contributions [67]. His most important investigations, according to the number of citations received, examine the collective management of water in Spain, the relationships in water management, power, and cultural policies in the Andes [108], and the governance of water in the context of territorial pluralism in Ecuador [109].

Table 2. Top 15 featured authors.

Author	University	Country	Documents	Citations
Boelens, R.	Wageningen University & Research	Germany	27	730
Sivapalan, M.	University of Illinois Urbana–Champaign	United States of America	26	1135
Di Baldassarre, G.	Uppsala Universitet	Sweden	17	681
Blöschl, G.	Technische Universitat Wien	Austria	16	1162
Vos, J.	Wageningen University & Research	Netherlands	12	206
Garcia, M.	Arizona State University	United States of America	11	130
Viglione, A.	Politecnico di Torino	Italy	10	653
Kuil, L.	Waterschap (Waterboard) Drents Overijsselse Delta	Netherlands	9	594
Nüsser, M.	Universität Heidelberg	Germany	9	133
Pande, S.	TU Delft	Netherlands	9	102
Linton, J.	Universite de Limoges	France	7	391
Brandimarte, L.	Royal Institute of Technology (KTH)	Sweden	7	363
Hoogesteger, J.	UNAM Campus Morelia	Mexico	7	296
Sanderson, M.R.	Kansas State University	United States of America	7	114
Savenije, H.H.G.	Delft University of Technology	Netherlands	6	582

The author Murugesu Sivapalan, from the University of Illinois Urbana-Champaign (Champaign, IL, USA) is in the second position regarding scientific production (see Table 2). His most outstanding work shows social and natural scientists' perspectives to understand human interaction and the water cycle [110]. Other authors, mostly belonging to the European Union, have also dealt with this field of study.

When analysing the authors' names, information processing must minimise possible errors. Different versions of the same author's name may appear since they could appear by their first name, middle name, or abbreviations [80,111]. We should review the author ID in Scopus, and if necessary, we should review the author's profile. An example of this is the author Jackson who appears in the database in two ways (Jackson S. and Jackson S.L.).

3.1.4. Highly Cited Documents

In evaluating a field of study, the citations obtained for the publications referring to the subject should be considered. The scientific production in socio-hydrology (490 documents) presents 7843 citations. Table 3 shows the 15 most cited documents, representing 35.89% of the total and having more than 70 citations.

The most cited article corresponds to Sivapalan, which included socio-hydrology as a new science that considers the interaction of human practices with the water cycle as a coupled system, seeking to predict socio-hydrological phenomena that affect the landscape and its population [23]. Secondly, Brown's study proposes a framework that supports the progress of the transitional urban water policy for a better understanding of the hydro-social contracts in force in many cities and thus achieves a more sustainable water management [98]. The third most cited document is by Linton and Budds, which includes the definition of the hydro-social cycle, based on the water–society link and the hydrological cycle concept, which is a socio-natural process [66].

Table 3. Top 15 most cited documents.

R	Authors	Years	Title	Citations	Reference
1	Sivapalan, M., Savenije, H.H.G., Blöschl, G.	2012	Socio-hydrology: a new science of people and water	465	[23]
2	Brown, R.R., Keith, N., Wong, T.H.F.	2009	Urban water management in cities: historical, current and future regimes	345	[93]
3	Linton, J., Budds, J.	2014	The hydrosocial cycle: defining and mobilizing a relational-dialectical approach to water	307	[66]
4	Wong, T.H.F., Brown, R.R.	2009	The water sensitive city: principles for practice	244	[112]
5	Di Baldassarre, G., Viglione, A., Carr, G., Kuil, L., Salinas, J.L., Blöschl, G.	2013	Socio-hydrology: conceptualising human-flood interactions	231	[113]
6	Swyngedouw, E.	2007	Technonatural revolutions: the scalar politics of Franco's hydro-social dream for Spain, 1939–1975	200	[114]
7	Di Baldassarre, G., Viglione, A., Carr, G., Kuil, L., Yan, K., Brandimarte, L., Blöschl, G.	2015	Debates—perspectives on socio-hydrology: capturing feedbacks between physical and social processes	178	[115]
8	Boelens, R., Hoogesteger, J., Swyngedouw, E., Vos, J., Wester, P.	2016	Hydrosocial territories: a political ecology perspective	147	[67]
9	Viglione, A., Di Baldassarre, G., Brandimarte, L., Kuil, L., Carr, G., Salinas, J.L., Scolobig, A., Blöschl, G.	2014	Insights from socio-hydrology modelling on dealing with flood risk: roles of collective memory, risk-taking attitude and trust	125	[116]
10	Boelens, R.	2014	Cultural politics and the hydrosocial cycle: water, power and identity in the Andean highlands	124	[108]
11	Elshafei, Y., Sivapalan, M., Tonts, M., Hipsey, M.R.	2014	A prototype framework for models of socio-hydrology: identification of key feedback loops and parameterisation approach	107	[117]
12	Meehan, K.M.	2014	Tool-power: water infrastructure as wellsprings of state power	103	[118]
13	Vogel, R.M., Lall, U., Cai, X., Rajagopalan, B., Weiskel, P.K., Hooper, R.P., Matalas, N.C.	2015	Hydrology: the interdisciplinary science of water	94	[119]
14	Savenije, H.H.G., Hoekstra, A.Y., Van Der Zaag, P.	2014	Evolving water science in the Anthropocene	73	[120]
15	Lane, S.N.	2014	Acting, predicting and intervening in a socio-hydrological world	72	[121]

R: ranking.

3.2. Science Mapping

3.2.1. Co-Occurrence Network of Author Keywords

A keyword co-occurrence network analysis generates a network in which terms that appear most frequently in the field of study are exposed. The network allows exploring concepts or topics (keywords), thematic groups (clusters), and occasional gaps in existing research [48,122].

The visual and multidimensional representation was carried out through VOSviewer software [84,123]. A total of 1401 keywords were obtained; 44 of them have a co-occurrence of at least five times. In Figure 8, six clusters are shown, exposing 43 nodes, 203 links, and a total link strength of 396. The term socio-hydrology has 134 occurrences, a relationship with 34 terms, and the most relevant word in cluster 5 (purple). Supplementary Materials Table S1 shows the co-occurrence of the author keyword network with the six clusters.

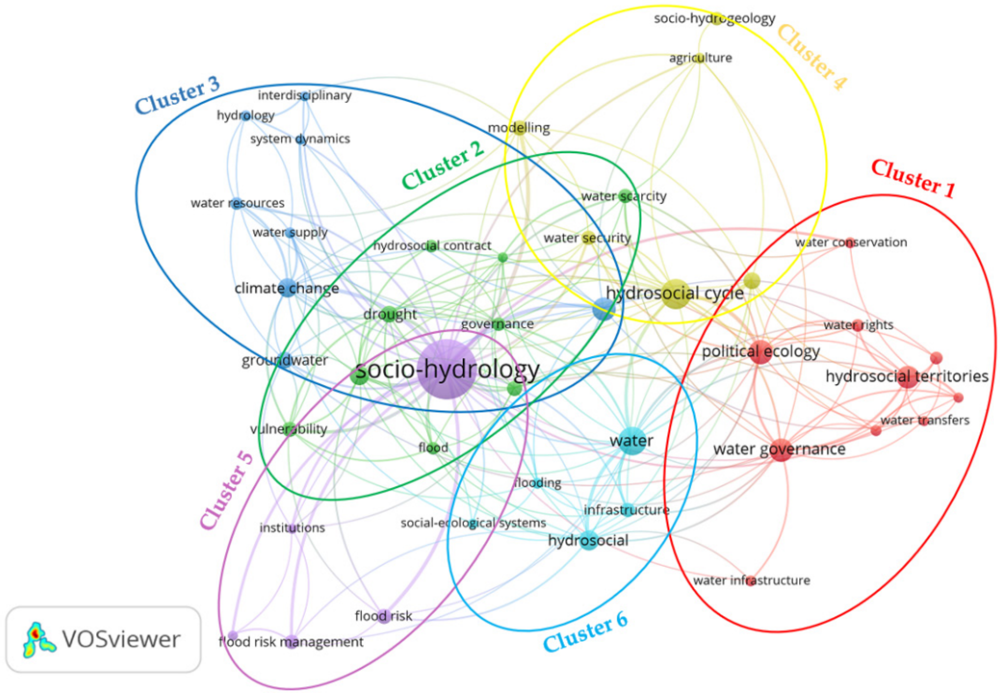

Figure 8. Co-Occurrence of Author Keyword Map.

According to the number of nodes (10), the most extensive research area is cluster 1 (red), as seen in Figure 8. According to the co-occurrence of terms, this class is considered the fifth-most important research group and has been called ´Political Water´, since the term with the highest co-occurrence is political ecology (25), followed by water governance (23). Several authors stand out in this cluster, such as Norman, who included debates about scale policies and their relationship with water governance debates [99]. This article has 71 citations and was published in the journal Water Alternatives. According to Woyessa, human activities harm ecological systems and their services through various actions such as land and water use, pollution, and climate change [124]. This study was published in the journal Advances in Geosciences.

Perreault stated that water governance's conceptualisation is applicable at a hydro-social scale, such as river basin management, canal irrigation corporations, and municipal service companies, among others [125]. This study reached 61 citations and was published in the journal Water International. Next, how hydro-social relationships speed up the development of the concept of indigenous water governance is analysed [106], and this study was published in the journal Geoforum and obtained 40 citations. In 2016, the definition of hydro-social territories was introduced as spatial configurations of people, institutions, and others who seek to control water [67], reaching 147 citations and being published in the journal Water International. Finally, a socio-environmental model was proposed to address a specific problem in water management without considering other factors such as social, political, and spatial delimitation, among others [126].

Cluster 2, ´Water Sustainability´ (green), presents a generic framework for socio-hydrological models applied to agricultural basins and would allow hydrologists to obtain a better representation of human feedback on hydrological processes [117]. Likewise, a socio-hydrological model of resilience to floods was generated and thus understood the characteristics that harm human flood systems' long-term resilience [127]. In contrast, a hydroclimatic, hydro-social, and hydro-ecological perspective was proposed to address a resilient life support system affected mainly by climate change, population growth, and increased demand for water [128]. Finally, it is stated that from the point of view of the hydro-social cycle, the problem of water scarcity grows mainly due to inconsistencies in the water infrastructure [129].

Sustainable development is achieved in a society based on education and participatory governance [130,131]. Resilience can justify various policy goals in the water sector, flood resilience, river resilience, and water resilience [132]. The concept of resilience allows us to understand the variation of deltas and their management in a more sustainable way and also understand the socio-hydrological dynamics [133]. Long-term sustainability and resilience are related to the overall bottom line of a healthy community resilient to excessive degradation and long-term net loss [34]. The concept of resilience has been applied in various contexts in recent years [61,134], in hydrological resilience [135,136], systems resilience ecological (aquatic) [137,138], and community and urban resilience to disasters and hazards [139,140].

According to the number of nodes (8), the third-most extensive research area is cluster 3, called ´Water Management´, and is shown in blue in Figure 8. In this cluster, several authors stand out who have studied socio-hydrology for several years. Viglione used a dynamic model to represent the interaction between the hydrological and social system components, contributing to coping with flood risks in a community [116]; this article was published in the Journal of Hydrology and reached 125 citations. Vogel stated that hydrological systems' changes affect socio-economic, ecological, and climatic systems [119]. This study was published in the journal Water Resources Research and obtained 94 citations. Likewise, a model was built that integrates the dynamic evolution of the water balance and the human response coupled within a hydrographic basin [141]; this publication reached 42 citations and was also published in the journal Water Resources Research. Agent-based modelling (ABM) was developed to provide insights into water policymakers [142].

Cluster 4 represents the fourth research area, which consists of five nodes, named ´Hydro-social Cycle´ (yellow). Several authors stand out in this cluster, among the most relevant ones being Linton, who indicated that the relationship between water and society has gained great interest in recent years, which is why the concept of the hydro-social cycle was included [66]. This publication reached 307 citations. Next, an analysis of the hydro-social cycle was carried out from political-ecological production [108]; this research reached 124 citations. Integrating the human dimension in water science research was proposed as a water dynamic component [143]. Another important aspect of the hydro-social cycle is water security and its relationship with water–human coupled systems [144]. The hydro-social cycle must be linked to water management, social and legal regulations, the state, and the environment [145].

The fifth research area is cluster 5 (purple), ´Socio-Hydrology´, which consists of five nodes. This cluster is qualified as the most relevant within the six clusters described, because it includes the term socio-hydrology, which presents 134 co-occurrences. In this cluster, several authors stand out, among them being Sivapalan, who included socio-hydrology as a new science, where people, together with their actions, integrate the dynamics of the water cycle [23,110]. This document reached 465 citations and was published in the journal Hydrological Processes. Secondly, there is Di Baldassarre's publication, where socio-hydrology is conceptualised, considering a community that begins its settlement and development in alluvial plains (a place prone to flooding) [113]. This publication reached 231 citations in the journal Hydrology and Earth System Sciences. Another way of approaching socio-hydrology is to construct a mathematical model that compares the potential damages by floods in ecological societies with technological ones [146]. Furthermore, with a socio-hydrological model, the risk of floods could be assessed, considering the interactions between floods and societies [115].

The sixth research area is cluster 6 (turquoise), which consists of five nodes, named ´Water Infrastructure´. In this cluster, a case study in Tijuana by the author Meehan stands out, which shows that ordinary water supply infrastructures make up their hydro-social cycle, managing to limit and coexist with state power [118]. This article reached 103 citations and was published in the journal Geoforum. Later, Linton stated that water management in the 20th century was characterised as modern water, representing water outside of its social context [147]. State authorities use illegal forms of water supply, but it was also pointed out that stopping the illegality of water would preserve the hydro-social order [148]. Water management should be based on socio-hydrological systems models, which allow the interpretation of co-evolution patterns of coupled human–hydrological systems through climatic gradients, socio-economic conditions, and socio-cultural conditions [64].

3.2.2. Cited Authors Co-Citation Network

This type of analysis allows investigating the discipline's bases to show the evolution of the field of study with a quantitative approach [149,150]. The network allows observing the authors who support the intellectual structure and who visually stand out on the network [43,151].

The bibliometric network was built with VOSviewer software, using a similarity measure called the strength of association to analyse the data related to the co-citations [85]. The socio-hydrology database contains 27,624 cited authors, of which 266 have at least 20 citations. Figure 9 shows the network consisting of five clusters, 254 nodes, 21,600 links, and a total link strength of 407,584. Table S2 in Supplementary Materials shows the co-citation of the cited authors network with the five clusters mentioned.

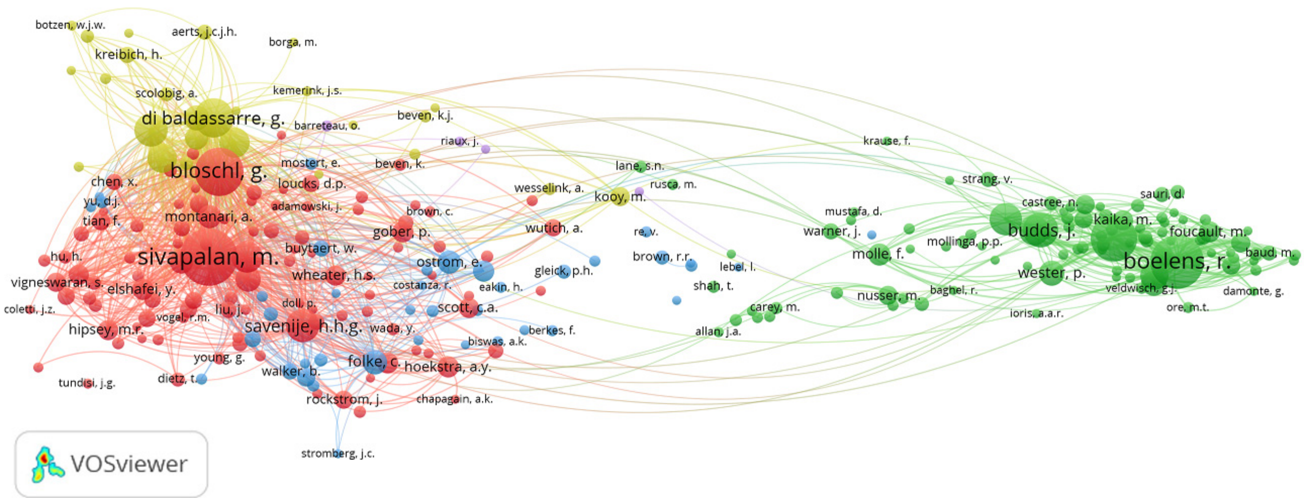

Figure 9. Authors' Co-Citation Bibliometric Map.

Table 4 includes the 15 most cited authors, who in this case have more than 149 citations. The most representative authors are Sivapalan, Boelens, and Bloschl.

Table 4. Top 15 most co-cited authors.

Ranking	Authors	Citations	Total Link Strength
1	Sivapalan, M.	718	46,475
2	Boelens, R.	629	25,825
3	Bloschl, G.	513	31,110
4	Swyngedouw, E.	486	16,165
5	Di Baldassarre, G.	344	20,780
6	Budds, J.	274	8391
7	Savenije, H.H.G.	252	16,217
8	Viglione, A.	249	15,997
9	Linton, J.	234	7027
10	Srinivasan, V.	214	14,077
11	Bakker, K.	210	6739
12	Carr, G.	210	13,263
13	Kuil, L.	196	12,660
14	Hoogesteger, J.	180	8120
15	Wester, P.	149	5962

Cluster 1 (red), called Human–Water Interactions (see Figure 9), includes 94 authors (nodes), led by Sivapalan with 718 citations, Savenije with 252 citations, Srinivasan with 214 citations, and Konar 144 citations. Among the most outstanding publications of this cluster, a study by Sivapalan stands out, which for the first time, proposed a socio-hydrological framework, which deals with water security based on human–water interaction [23]. Reinforcing this framework, Gober proposed integrating governance mechanisms for the management of emerging systems, linking science, politics, and the socio-hydrological agenda [152]. Srinivasan proposed integrating people's adaptive responses to socio-hydrological models since they intervene in the availability of water [153]. Pande proposed applying these socio-hydrological models, which helps to understand a small farmer's system, including certain essential factors: water storage capacity, capital, livestock, soil fertility, access to grazing, and labour [154].

Likewise, Gober affirmed the need to include political decisions and human behaviour in hydrological models to support government decision making [155]. In addition, Srinivasan affirmed that to issue long-term predictions, projections of alternative and co-evolutionary trajectories of the socio-hydrological system should be carried out, allowing one to avoid errors in the models and to recognise a safe operating space [156]. Falkenmark provided a hydroclimatic, hydro-social, and hydro-ecological vision of interfering in a resilient life support system affected mainly by climate change [128].

Cluster 2 (green), 'Water Power', contains 94 authors (nodes), led by Boelens with 629 citations, Swyngedouw (486), Budds (274), and Linton (234). In this cluster, the most significant publications have been made by Boelens, who defines water territories as hydro-social spatial networks [157]. These models are responsible for the analysis of flows, infrastructures, and water control [158]. Later, in a case study in Chile, Budds examined how water's political framework has contributed to water scarcity problems, exploring water–society interactions and their influence on nature [159]. On the other hand, Linton mentions alternative forms of water (modern water), which arise from hydro-social relationships and dominate water resource management practices in various places [160]. Swyngedouw analyses Spain's hydro-social progress, understanding it as a socio-physical process that allows the generation of new technologies and the registration of social groups related to each other [114]. Finally, both human and non-human actors are integrated into hydro-social transformation processes. Furthermore, hydro-social territories are spatially limited socio-natural networks [161,162].

Cluster 3 (blue), 'Resilience and Socio-Ecological Systems', contains 31 authors (nodes), led by Folke with 135 citations, Ostrom (127), Pahl-Wostl (98), and Carpenter (76). Certain publications are more relevant in this cluster, such as the one by Brown [98], which contributes to our understanding of hydro-social contracts and thus achieves a more sustainable water management. Subsequently, a socio-hydrogeological vision was implemented to assess the quality of groundwater [163]. Finally, Yu mentioned that socio-hydrology analyses socio-ecological systems, focusing on the human–water link's co-evolution that favours water safety and sustainability [164].

Cluster 4 (yellow), 'Hydrological Risk Management', contains 28 authors (no-two), led by Bloschl with 513 citations, followed by Di Baldassarre (344), Viglione (249), Carr (210), and Kuil (196). A case study by Di Baldassarre stands out, which showed that the alluvial plains of Bangladesh act as complex water–human systems [165]. Later, he mentions the importance of socio-hydrological frameworks for their application to interpret interactions between humans and water in various areas [166]. A socio-hydrological study was developed to examine the risk of flooding in Rome through a long time series of hydrological processes and information about people's interactions with the environment [167]. Kuil proposes that it is necessary to evaluate water stress and people's relationship through socio-hydrological models to protect water security [168]. Another contribution of this author is the socio-hydrological models in agriculture, allowing one to explore how the farmer's perception of water availability affects the selection of crops and resource allocation [169].

Cluster 5 (purple), 'Technologies of Water Government', contains seven authors (nodes), led by Kooy with 80 citations, Barreteau (28), Wesselink (36), Barreteau (27), Re (25), and Riaux (24). The contribution of the author Riaux has shown interdisciplinary dialogues between hydrologist-anthropologist (2013) and hydrogeologist-anthropologist (2014). In 2020, a socio-hydrological negotiation was carried out in a case study in Central Tunisia [170–172].

3.2.3. Co-Citation Cited Sources

This analysis highlights the main authors in this area of knowledge related to citation records [43]. A minimum threshold of 20 citations was considered, and we managed to analyse 78 scientific sources. Table 5 shows the 15 most relevant co-cited scientific sources about socio-hydrology.

Table 5. Top 15 scientific sources co-cited on socio-hydrology.

Ranking	Scientific Source	Co-Citations	Total Link Strength
1	Water Resources Research	951	23,629
2	Hydrology and Earth System Sciences	762	18,919
3	Geoforum	584	10,769
4	Water International	395	7377
5	Journal of Hydrology	379	9943
6	Hydrological Processes	310	8103
7	Ecological Economics	294	7922
8	Water Alternatives	288	5214
9	Science	256	6629
10	Annals of the American Association of Geographers	233	4728
11	Global Environmental Change	205	5518
12	Hydrological Sciences Journal	205	5982
13	Water Resources Management	156	3758
14	Water	150	2917
15	Nature	130	3940

Cluster analysis divided a group of heterogeneous populations into subgroups with superior homologous characteristics. As a result, Figure 10 shows each journal's joint citation map, which is represented by three clusters, 78 items, and 2609 links, with a total link strength of 104,173.

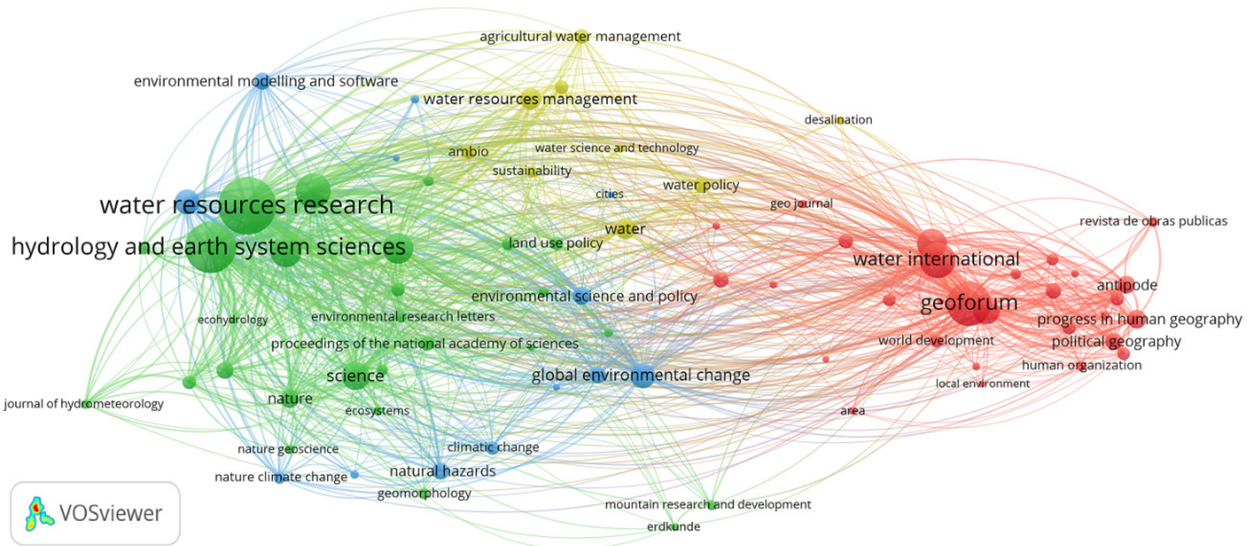

Figure 10. Scientific source co-citation network of socio-hydrology.

Cluster 1 (red), governance and water management, is made up of 29 nodes, where the main journals are as follows: Geoforum (584) is a quartile one (Q1) journal from the United Kingdom, with an h-index of 107, related to 77 journals, a total link strength of 10,769, and publishing in global political economy, political ecology, national systems of regulation and governance, urban and regional development, feminism, economic and urban geographies, environmental justice, and resource management. In second place is Water International (395), a Q1 journal from the United Kingdom, with an h-index of 46, also related to 77 journals, a total link strength of 7377, and publishing topics related to sustainable water management worldwide. In third place is Water Alternatives (288), a Q1 journal from the United States of America, with an h-index of 39, also linked to 77 journals, a total link strength of 5214, and covering topics such as the importance of water for the environment and its demand management, economic efficiency, and access to water as a human right.

Next, cluster 2 (green), hydrology and hydrological systems, includes 27 nodes directed by the Water Resources Research journal (951), a Q1 journal from the United States of America of America, with an h-index of 203, related to 76 journals, a total link strength of 23,629, and focussing on publications on hydrology and water resources, and the natural and social sciences of water. Second is Hydrology and Earth System Sciences (762), a Q1 journal from Germany, with an h-index of 123, related to 74 journals, a total link strength of 18,919, and publishing on relevant topics in hydrology, such as hydrological systems, the water cycle, and the supply of water for ecosystems and society. Third is the Journal of Hydrology (379), a Q1 journal from the Netherlands, with an h-index of 208, related to 76 journals, a total link strength of 9943, and publishing in all sub-fields of hydrological sciences, including water management and political issues that have an impact on the economy and society.

Cluster 3 (blue), water resources and environmental issues, contains 13 nodes led by the Global Environmental Change journal (205), a Q1 journal from the Netherlands, with an h-index of 162, related to 76 journals, a total link strength of 5518, and publishing on topics that include drivers, consequences, and management of changes in biodiversity and ecosystem services, climate, coasts, food systems, land use and cover, oceans, urban areas, and water resources mainly. In second place is Hydrological Sciences Journal (205), a Q1 journal from the United Kingdom, with an h-index of 90, related to 74 journals, a total link strength of 5982, and focussing on hydrology and the relationship of water with atmospheric processes and the climate. In third place is Environmental Science and Policy (112), a Q1 journal from the Netherlands, with an h-index of 105, related to 76 journals, a total link strength of 2740, and publishing on environmental issues such as climate change, biodiversity, pollution, environmental waste, renewable and non-renewable natural resources, and sustainability.

Finally, cluster 4 (yellow), water resources management, includes nine nodes managed by the following journals: Water Resources Management (156), a Q1 journal from the Netherlands, with an h-index of 91, related to 75 journals, a total link strength of 3758, and publishing on the management of water resources, especially on the evaluation, development, conservation, and control of water resources. Second is Water (150), a Q4 journal from Australia, with an h-index of 15, related to 76 journals, a total link strength of 2917, and publishing technical and scientific articles on water. In third place is Water Policy (98), a Q2 journal from the United Kingdom, with an h-index of 53, related to 74 journals, a total link strength of 2104, and publishing on financial, diplomatic, organisational, legal, administrative, and research areas, organised by country, region, or river basin.

4. Discussion

For 41 years, socio-hydrological relationships have been implemented, which include the water–society system. However, this study analysed this new science's formal appearance, socio-hydrology, given in 2012 [23], and its development until 2020. The analysis of future trends in this topic showed that the most interesting studies in the period 2001–2010 help to understand the scope of hydro-social contracts to establish cultural reform initiatives that allow effectively accelerating the transition to more sustainable water management, as proposed by Brown [98] and Wong [112]. Otherwise, Swyngedouw formulated the socio-hydraulic re-establishment of Spain in the context of a double scalar policy [114]. In addition, Lele states that forest cover changes in tropical regions generate transformations in hydrographic basin processes, so it is necessary to study the socio-hydrological links adequately [173]. In the second period of scientific production (2011–2020), exponential growth is already observed in the development of socio-hydrology, highlighting the publications of Sivapalan [23], Linton [66,113,115], and Lane [121], evidencing the co-evolution of hydrological systems and their applications.

As of 2014, growth in the scientific production of this topic has been observed (see Figure 5). That is why the challenge of sustainable management of the world's freshwater resources demands increased attention in understanding coupled systems of human hydrology [117]. In recent years, the water–society link has come to the fore in critical research. A hydro-social cycle is an analytical tool for investigating hydro-social relationships and undertaking critical political water ecologies [66]. The inadequate treatment of human–water systems require new approaches to study the challenges of water sustainability. Socio-hydrology is a scientific discipline that studies real-world systems through the gradients of climate, socioeconomic status, ecological degradation, and human management [24]. It is necessary to establish water control through water rights or the construction of hydro-social cycles as technical, profoundly social, and political activities [108]—likewise, the role of water infrastructure examined in the constitution and deactivation of state power [118]. Publications in 2014 related to the right to water, sustainable development, and sanitation [174], and the agreement on protection and use [175] reinforce the growth in scientific production on socio-hydrology in the past years.

The findings of the bibliographic coupling analysis by country, represented in Figure 6, showed that the countries featured in socio-hydrology are the United States of America, the Netherlands, the United Kingdom, and Australia. These representative countries for this subject also consequently position themselves within the frequently cited documents. First is a study from Sivapalan [23], which he published together with Savenije from the Netherlands and Blöschl from Australia. Second is a study by Brown [93] from Australia, which he published together with two other authors from Australia. Finally, in third place is the French author Linton [66], who published with the author Budds from the UK.

According to the co-occurrence analysis based on author keywords, represented in Figure 8, it is observed that the most relevant term socio-hydrology, be-longing to cluster 5, coincides with the analysis topic and presented 134 co-occurrences in the 490 documents in the database. Furthermore, this term is related to 34 of the 43 terms (keywords) analysed and has a strong link with cluster 4, hydro-social cycle; cluster 6, water; and cluster 1, political ecology. Even though cluster 5 intersects with clusters 2 and 3, it does not have a strong relationship, since in these clusters, there are case studies and applications related to hydrology, but they do not focus on socio-hydrological studies.

With the authors' analysis of co-citations (Figure 9), the most relevant authors in the branch of socio-hydrology were established. First is Sivapalan, with 718 citations, belonging to cluster 1 (human–water interactions). This author has published only two articles as the main author [23,110], obtaining 465 citations in one of these articles, and heads the list of the 15 most cited documents (Table 3). In addition, he has 18 documents as a co-author. In second place is Boelens, with 629 citations, from cluster 2 (water power), with 5 publications as the main author [67,101,108,157,158], of which 2 are among the 15 most important cited documents, and 14 documents as a co-author. Third is the author Bloschl (513 citations), from cluster 4 (hydrological risk management), who appears as a co-author in 14 papers. Finally, the author Swyngedouw (486 citations), also from cluster 2, who has written four publications as the main author [114,161,162,176] and one as a co-author [67]. It was shown that despite being the most representative authors of this subject, they do not have a large number of publications but a significant number of citations.

Reviewing the bibliometric map of co-citation by sources (see Figure 10), it is observed that of the 78 journals analysed, 3 are outstanding journals: Geoforum (24 documents), Water International (22 documents), and Water Alternatives (11 documents). The first two journals are from the United Kingdom and the third from the United States of America. It should be noted that some of the most cited documents in the database have been published in these journals. For example, the publication of Linton was published in the journal Geoforum, and it is the third-most cited document. In addition, the fifth-most cited document was published by Boelens in the journal Water International. However, there are other journals such as Hydrological Processes (3 papers) and Hydrology and Earth System Sciences (26 papers), in which prominent papers such as those by Sivapalan [23] and Di Baldassarre [113] have been published.

The study used an analysis of bibliographic coupling by country because there is a worldwide reach of publications related to this topic. This allows recognising the regions with the highest contribution according to the number of documents on socio-hydrology. This article also carried out an analysis of co-citation by authors and sources. This allows identifying new lines of research emerging in the subject and the journals with the most significant number of publications, reflecting the areas of interest related to socio-hydrology. This article used a triangulation method (co-occurrence, bibliographic coupling, and direct citation) to examine the intellectual structure, including an analysis that ranged from micro (keywords), meso (articles/authors), and macro (journals) [93]. Co-occurrence occurs when two elements (e.g., authors, institutes, journals, or keywords) appear in a publication. Co-occurrence networks, depending on the unit of analysis, can be co-keyword, co-author, or co-citation [80]. Triangulation produces a complete image instead of applying each method individually. The results of these three bibliometric analyses provide information on the complex multidisciplinary structure of a specific field [177]. This method combines various techniques and software programs such as VOSviewer [178,179].

5. Conclusions

This article provides a bibliometric analysis of scientific publications related to socio-hydrology, indexed in the Scopus database, from 2001 to 2020. The scientific production results show a contribution of 80.81% from articles and 6.53% from review documents. The first record in the database is from 2002, titled "Feminization as a Critical Component of the Changing Hydro-Social Contract," by the authors Turton, Schreiner, and Leestemaker [96], in the journal Water Science and Technology. The apogee of this new science has become noticeable in the past 3 years. In 2018, there were 79 documents; in 2019, there were

103 documents; and in 2020, there were 95 publications. The production focuses on the continents of North America, Europe, and Oceania, with the United States of America being the central producer, with 171 publications and 3009 citations. Additionally, this study allows us to understand socio-hydrology's intellectual structure by assessing scientific production, spatial distribution, the contribution of frequently cited journals, authors, and documents. In total, 490 documents, 71 countries, 78 journals, and 266 authors were analysed, which complied with the selected selection criteria.

To understand the intellectual structure of socio-hydrology, three analyses based on science mapping were carried out. First was the author keyword co-occurrence analysis, which includes 43 nodes (topics) and is represented by six clusters: (i) political water, (ii) water sustainability, (iii) water management, (iv) hydro-social cycle, (v) socio-hydrology, and (vi) water infrastructure. The most relevant area is made up of cluster 5 (socio-hydrology). Secondly, the network of co-citations by authors includes five clusters representing the various topics related to socio-hydrology: (i) human–water interactions, (ii) water power, (iii) resilience and socio-ecological systems, (iv) hydrological risk management, and (v) technologies of water government. Cluster 1 is the most significant; it consists of 94 nodes and is led by Sivapalan.

Third, the network of co-citations of scientific journals is represented by four clusters, which demonstrate the fields of knowledge that have been developed in the area of socio-hydrology: (i) governance and water management, (ii) hydrology and hydrological systems, (iii) water resources and environmental issues, and (iv) water resources management. The Geoforum journal is strongly linked to all the scientific journals analysed, and according to these analyses, socio-hydrology is closely linked to human–water interactions but covers aspects of policy, sustainability, management, and resilience, which denotes the projections of the research. This would serve as the lines of future research, which in this case are mainly related to the policies of the hydro-social cycle, hydro-social territories, and socio-hydrological models.

Regarding the methodological approach of this work, there is one main limitation: using a single database (Scopus), which, despite being a recognised and widely used database in academia, may exclude some significant contributions in other databases. However, researchers worldwide have found the bibliometric approach to be reliable and have used it in several studies, including [180–182]. This study demanded several descriptors related to the term socio-hydrology in order to obtain adequate information regarding the subject. These descriptors used in this study facilitate the identification of the central focus of the study and the importance that the authors give to the subject; this is complemented by using the abstract and keywords to broaden this approach, considering research related to the term. In later studies, these limitations can be integrated to broaden the topic covered in this research. In contrast, the bibliometric process presented is rigorous and demanding in selecting critical descriptors to recognise the field of study; it also requires extensive analysis that consolidates a reference point for future research in the area of socio-hydrology.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/w13091283/s1, Table S1: Results of the co-occurrence network of author keywords, Table S2: Co-citation-cited authors network.

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