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Sustainable Water Resources Management: A Bibliometric Overview

Amador Durán-Sánchez [1], José Álvarez-García [2,*] and María de la Cruz del Río-Rama [3]

1 Faculty of Business, Finance and Tourism, University of Extremadura, 10071 Cáceres, Spain; ads_1975@hotmail.com
2 Financial Economy and Accounting Department, Faculty of Business, Finance and Tourism, University of Extremadura, 10071 Cáceres, Spain
3 Business Organisation and Marketing Department, Faculty of Business Administration and Tourism, University of Vigo, 32004 Ourense, Spain; delrio@uvigo.es
* Correspondence: pepealvarez@unex.es; Tel.: +34-609-880-141

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Received: 18 July 2018; Accepted: 1 September 2018; Published: 4 September 2018

Abstract: While global water demand continues increasing, the quantity and quality of water resources is decreasing in many regions. Conflicts over competition in the use of water are likely to increase as societies face social, economic and political challenges, especially aggravated by climate change. In this scenario, sustainable management of water resources is a key priority to meet the growing demand for water and to achieve a safe and environmentally sustainable future supply. The main objective of this article was to show an image of the international scientific production related to "Sustainable Water Resources Management" by using the comparative bibliometric study of the documents indexed in the WoS(Web of Science) and Scopus databases as a tool; and to analyze relevant aspects such as their coverage, correlation, overlap, growth, citation, dispersion or concentration, among others. For this purpose, and by means of an advanced search of terms, a representative set of 160 articles in WoS and 210 in Scopus were selected (with a time limit that limited the results to anything published before 2017, including 2017), which form the ad-hoc basis of the analysis. Their significant increase in both the number of articles and citations received in the last 10 years demonstrates the growing interest of the scientific community in its study. Regarding the analysis of the databases, although WoS and Scopus differ in terms of scope, volume of data and coverage policies, both information systems are complementary and non-exclusive. Despite their similarities, Scopus performs better coverage in the specific area of Sustainable Water Resource Management by collecting a greater number of articles and receiving a greater number of citations.

Keywords: Sustainable Water Resources Management; bibliometric study; WoS; Scopus; coverage; overlap

1. Introduction

Water is a scarce natural resource, essential for life and to carry out the vast majority of economic activities; it is irreplaceable, non-expandable by the mere will of man, irregular in its way of presenting itself in time and space, easily vulnerable and susceptible of successive uses. Easily available water resources have already been widely exploited across most of the planet, and the pressures from development, population growth, and climate change exert additional tensions on this vital element [1]. The widespread recognition of the impact that human activities have on ecosystems is transforming the way in which natural resources are viewed and managed. On July 28 2010, through Resolution 64/292, the General Assembly of the United Nations explicitly recognized the human right to water and sanitation, reaffirming that clean and safe water is essential for the realization of all human rights [2].

More than 35 years have passed since the concept of "sustainable development" was introduced for the first time by the World Conservation Strategy [3]. Sustainable development balances the exploitation of natural resources, technological development and institutional change, in order to improve the potential to meet human needs and aspirations, now and in the future [4]. The main challenge facing today's society is to develop sustainable management that ensures an adequate supply of quality water and at the same time prevents the overexploitation and degradation of associated aquatic ecosystems.

Integrated Water Resources Management is a process that promotes coordinated development and management of water, land and related resources, in order to maximize economic and social well-being in an equitable manner and without compromising, in the present or future, the sustainability of vital ecosystems [5–7]. A key aim of Integrated Water Resources Management is to promote the coordination and integration as a means to achieve holistic water management and improve the sustainability of water resources [8]. Like the concept of sustainability, it is not a final state to be achieved, but a continuous process with the aim of creating a closer link and a better understanding of human and natural needs, as well as interactions between both [9].

The importance that everything related to sustainable management of water resources as a field of study has acquired in various areas of knowledge, has contributed to the development of extensive academic literature. Communication in science is carried out through publications, which are recognized as adequate sources to analyze the growth and impact of science, which constitute the body of the so-called scientific literature. Every new study needs to know about previous research that may affect the subject under study, based on past advances to create new discoveries [10]. Motivated by this fact, it is necessary to stop at this point to make an inventory of the work carried out and at the same time analyze and identify new directions and challenges for the future [11].

To achieve a good understanding of the state of the art, synthesizing existing knowledge in a reproducible way, several authors point out that bibliographic reviews are the first common step to achieve this goal [12]. Although there are limitations in this methodology, this type of review provides a reasonably detailed description of the body of the research carried out on the subject under analysis. Thus, our main objective was to show an in-depth analysis of the current state of research related to Sustainable Water Resources Management through a bibliometric-comparative study of articles indexed in WoS and Scopus, which enables to determine which of the two bases makes a greater coverage, as well as the overlap between the two. In the same way, and as secondary objectives, by means of statistical methods, bibliometric indicators and analysis of citations, the aim is to know how much, who, what, where and how it has been investigated.

For this purpose, this article is structured into four main sections. First, after the introduction, the academic literature is reviewed in order to establish the theoretical framework of the research. Then, in Section 3, both databases and the methodology of the calculations and the tracking strategy used to select the references that form the empirical basis of the study are described. In Section 4, the main results obtained in the study of the basic bibliometric indicators are detailed and discussed, as well as the analysis of overlapping and singularity between the bases, and finally, in Section 5, the final conclusions reached, and the limitations associated with the investigation are discussed.

2. Theoretical Framework

The need for water is universal, and without it, life, as we know it, would simply cease to exist. Water can be everywhere, but its use is limited in terms of availability, quantity and quality. The methodology used to measure water scarcity has evolved in the last twenty years. The initial water scarcity threshold developed by Falkenmark [13] was the basis on which the demands for water consumption were built. By recognizing that water consumption varies among social sectors, Falkenmark [14], and Gleick [15] achieved to improve the water scarcity index by incorporating specific water requirements for basic human needs. Moverover, Asheesh [16] established the link between the demand for water resources and the future growth of the population as a way to measure water availability gaps.

Water availability has been identified as an important environmental limitation for economic growth and development [17], and conflicts in the planning and management of water resources arise when people and institutions do not agree on the quantity and quality of water that is needed or required in a specific place for a precise purpose and at a specific time [18]. Readily available water resources have already been widely exploited in most of the planet, and pressures from development, population growth and climate change exert additional stress on this vital resource [1]. Many water problems have become so complex and interconnected to be managed by a single institution, regardless of the authority and resources granted, the technical expertise and management capacity available, the level of political support and all the good intentions [19]. The solution to these problems, therefore, depends not only on the availability of water, but also on its correct management and planning [20].

Integrated Water Resources Management (IWRM) is a process that promotes the development and coordinated management of water, land and related resources in order to maximize economic outcomes and social well-being, in an equitable manner, and without compromising the sustainability of vital ecosystems [6]. Although some authors found the roots of this "new" paradigm in the United States in the first decades of the 20th century [7,21], its relevance at international level began with the Silver Sea Conference in 1977 [22] and the subsequent summits in Rio de Janeiro and the Dublin Conference in 1992. The ideas presented at these two international meetings laid the foundations for the concept and principles of IWRM, in the way they currently exist.

In general terms, IWRM can be interpreted as an approach to water development and management that seeks balanced results among the three dimensions of sustainable development: Economic efficiency, social equity and environmental sustainability [23]. Since then, IWRM has been followed internationally as a mantra in the management of water resources in both the political and academic spheres [24]. In the political arena, most developed and developing countries have decided to align their water development and management policy frameworks with the general principles of IWRM in order to address the challenges in a more comprehensive and consistent way, which climate change poses among other threats [25]. Jouravlev [26] states that integrated management should promote economic growth, equity and environmental sustainability simultaneously, through productive transformation, the provision of social services and the conservation of natural resources.

However, these three short-term objectives are very conflicting with each other, since they seek to achieve the global optimum, by each of them sacrificing their partial optimum, and this is only possible through a lot of negotiation. Despite the international recognition of IWRM, there is an increasing criticism of this paradigm [22] focused to a great extent on the concern about its possible implementation in real life [27], considering that it is still a predominantly theoretical concept [28].

At academic level, the impact of the IWRM approach can be seen in the growth of specific research networks, as well as in educational programs focused mainly on creating skills for new water managers in IWRM [29]. Although biophysical sciences such as civil engineering and hydrology have paid a lot of attention to IWRM [30], from the point of view of the social sciences (economics, political science, public administration, etc.) it must still be strengthened [31]. Current research has four fundamental subjects as its object of study: Institutional framework; equitable allocation of water; implementation of IWRM; and stakeholder participation [23], offering new opportunities for research, both in theoretical-methodological and empirical applications that explain, thanks to its strong multidisciplinary nature, the subsequent advances achieved in the field of water resources management [32].

On the other hand, and as can be seen from its definition, the concept of IWRM is closely related to the idea of sustainability, with the definition of the term sustainability in the context of water resources being an important subject in hydrological literature [33,34].

The application of sustainability principles requires important changes in the objectives which decisions are based on and an understanding of the interrelationships between existing ecological, economic and social factors. The general objectives to achieve sustainability are: (a) Environmental integrity; (b) economic efficiency; and (c) equity [35]. Together, with these objectives, the challenge of time (long-term consequences) is another aspect of utmost importance for making sustainable decisions, since sustainable development requires forms of progress that meet current needs without compromising the needs of future generations [4].

To quantify the sustainability of water resources systems, Loucks [34] proposed the so-called Sustainability Index with the aim of facilitating the evaluation and comparison between several proposed water management policies. Indices are frequently criticized because they are seen as a sum of different items [36] and in practice, researchers in the water sector are sometimes reluctant to use them [37]. However, the index proposed by Loucks summarizes the essential performance parameters of water management in a meaningful way, instead of adding broad factors and they have been widely used by the scientific community [38].

In this context, the principles of sustainability seem to be in particular, suitable for responding to the problems posed in water management. The sustainability of water resources is therefore, the ability to use water in sufficient quantity and quality, both locally and globally, to meet the needs of human beings and ecosystems, in the present and in the future, with the objective of maintaining and protecting life from the dangers caused by natural disasters and those caused by the hand of man [39]. Or in other words "sustainable water resources systems are those designed and managed to fully contribute to the objectives of society, now and in the future, while maintaining their ecological, environmental and hydrological integrity" [34] (p. 518).

Research regarding water resources management models that incorporate the idea of sustainability as part of the optimization objective has been limited [40]. Cai [41], in a holistic management model of the Syr Darya River Basin in Central Asia, defined sustainability as a guarantee of a durable, stable and flexible water supply capacity to meet the demands, as well as the environmental maintenance associated with irrigation practices. The methods for measuring sustainability included criteria such as: Reliability, reversibility, and vulnerability of the water supply system; integrity of the environmental system by considering the water quantity and quality; spatial and temporal equity or; "socioeconomic acceptability", directly related to the comparison of the marginal costs associated with the depletion of natural capital and marginal benefits, that is, when environmental costs exceed the marginal benefits associated with the use of the resource, the system becomes unsustainable.

3. Methodology

This section details the process followed to develop the bibliometric and overlapping study between the multidisciplinary databases WoS and Scopus in relation to the scientific production on Sustainable Water Resources Management—which is an ideal way to organize and know about academic information, guiding the researcher towards bibliographical sources of interest [42].

The bibliometric analysis provides, in this way, useful information for both academics and professionals by providing a series of significant indicators to assess the bibliographic material: Number of publications, most prolific authors, countries where this field is most popular or journals that devote more attention to it. Others, such as the number of citations or the h index, are a good measure of the researcher's influence [43].

3.1. Databases

Since access to the whole scientific production is an unreachable objective, any bibliometric analysis is limited by the availability, relevance and reliability of information [44]. Therefore, the first step that must be taken is to identify which database would be the most useful for the study [45]. Bibliographic databases play a fundamental role in bibliometric research, since they allow to analyze the scientific activity carried out by researchers, centers, regions and countries; to detect their strengths and weaknesses and to identify trends in research. The validity of the results obtained will depend to a large extent on their adequate selection and the coverage they make of the study area [46]. It is precisely this fact that leads us to choose WoS and Scopus as the basis of our study on Sustainable

Water Resources Management, since they both appear frequently as documentation sources in the scientific literature.

Web of Science, is a web technology-based platform created in 1960, owned by the Thomson Reuters company, and which includes a number of bibliographic databases and information analysis instruments that allow to evaluate and analyze the performance of scientific research. It collects citations and references of publications of all the disciplines of knowledge, scientific, technological, humanistic and sociological since 1945. It is also a widely used database for carrying out bibliometric studies, with a selective coverage of the most prestigious and visible publications [47]. On the other hand, Scopus was created by the publishers Elsevier in November 2004. Its ability to manage bibliographic references and quantify citations referred to each of them, makes Scopus an essential instrument for the analysis of any discipline. In addition, as a bibliographic database of peer-reviewed scientific literature, it provides an overview of global research production in the fields of science, technology, medicine, social sciences, arts and humanities and whose characteristics have been deeply analyzed in studies such as Goodman and Deis [48], or Bar-Ilan [49], among others.

Archambault et al. [50] have shown a high correlation between WoS and Scopus in the number of articles and the number of citations, so they concluded that both databases are an adequate tool for scientometric analysis, with a variety of articles that compare both their general characteristics, as well as their coverage. Gavel and Iselid [51] analyzed the overlap of journal coverage between Scopus and WoS. At that time, 54% of active titles in Scopus were also in WoS, while 84% of active titles in WoS were in Scopus.

3.2. Tracking Methodology

One of the main drawbacks in the compilation of bibliometric data is the choice of the types of documents to be included. In the past, bibliometricians used to use articles, research notes and review articles generally considered as original contributions to the advancement of science [52]. However, since the two databases do not cover and classify the documents symmetrically, it was not possible to reproduce this selection in both. The classification of the documents located in both bases is shown in Figure 1.

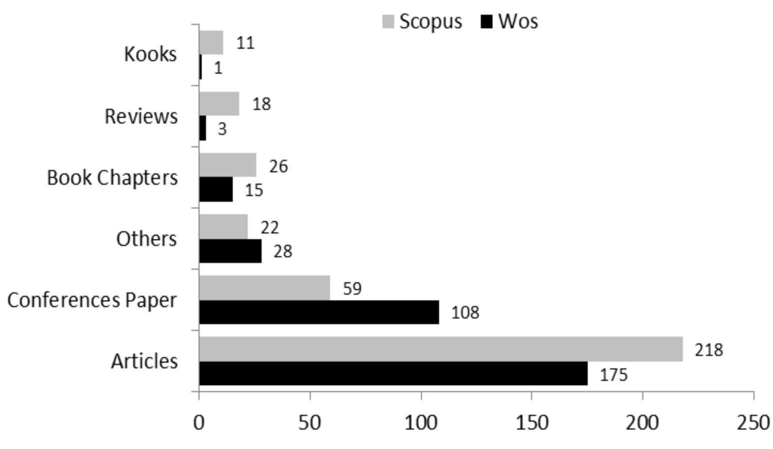

Figure 1. Classification of the documents located in WoS and Scopus on Sustainable Water Resources Management. Source: The authors' own elaboration.

Therefore, and following the outline of similar studies, only articles published in scientific journals are analyzed in order to develop bibliometric indicators because they constitute a representative sample of international scientific activity [53], and it are the main means of transmission of the results of an investigation [54], excluding papers from congresses, books and chapters, comments, press articles, editorials, notes, letters or errata contained in WoS or Scopus. The process followed to obtain them is shown in Figure 2.

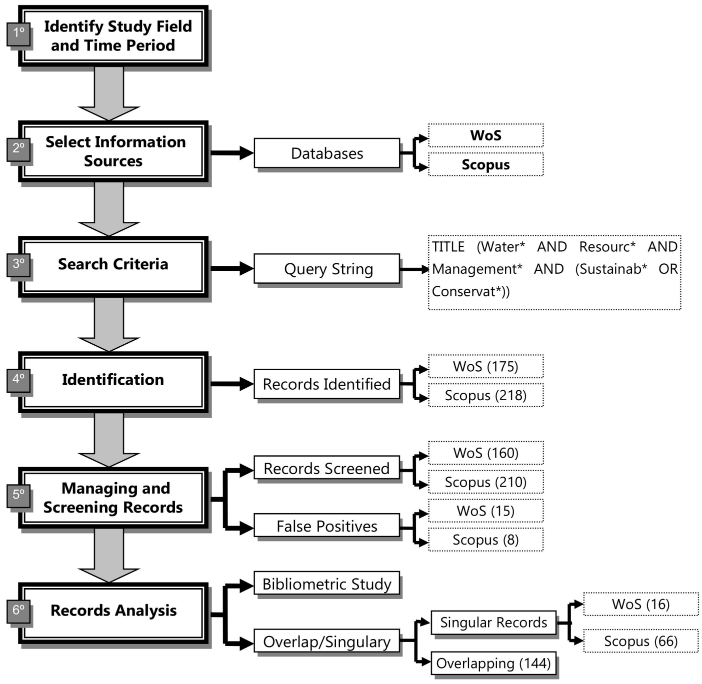

Figure 2. Bibliometric Methodological Procedure. Source: The authors' own elaboration.

In order to delimit the results to the Sustainable Water Resources Management area, a document tracking strategy was chosen by means of search terms whose equation is shown in Table 1. This form has the advantage of enabling to reach classified journals within all the thematic areas, being, therefore, more thorough [55].

Table 1. Search strategy.

Search Word	Water Resources; Management; Sustainability; Conservation
Category	Title
Subject area	ALL
Document type	Journal article
Period time	Year of publication $\leq$ 2017
Language	English
Query String	WoS: TI = (Water * AND Resourc * AND Management * AND (Sustainab * OR Conservat *)) AND Idioma: (English) AND Tipos de documento: (Article) Refined by: Base de datos = (WOS) Período de tiempo = 1900–2017Scopus: TITLE (Water * AND Resourc * AND Management * AND (Sustainab * OR Conservat *)) AND DOCTYPE (ar) AND PUBYEAR < 2018 LIMIT-TO (LANGUAGE, "English")
Search Date	February 2018

Source: The authors' own elaboration.

Another major problem in the bibliometric analysis of the documents indexed in the different databases is the lack of consistency of records, which is why it is essential to carry out a standardization process. For the specific case of authors' names, the fundamental criterion used for their standardization was the coincidence in the affiliation of the institutional signature associated with the different variants of the names and surnames [56].

Once the documents were selected, the ad hoc database needed to analyze each of the basic variables of the bibliometric and overlapping indicators was analyzed. After deleting those articles considered irrelevant for our study, the final result was 160 articles published in WoS and 210 in Scopus, all processed with the bibliographic reference manager Refworks.

3.3. Methodology of Calculations

There is a wide range of useful bibliometric methods to analyze the bibliographic data of a set of documents [57]. This work focuses mainly on the total number of articles and citations received as indicators capable of measuring an author's productivity and influence [58]. The study also uses the h index to combine both concepts [59].

There are two main procedures for carrying out overlap calculations; the first based on the primary sources that cover the secondary sources, and the second using the documents (articles) that these sources contain. The disadvantage of the former method is the different document indexing policies used by each database; while some transfer all the sources, others do so selectively [60], and the latter requires more effort when comparing databases. This paper analyses the overlap between WoS and Scopus bases in the research area of Sustainable Water Resources Management following both procedures.

3.3.1. Meyer's Index

It is also called the relative index of singularity or peculiarity. It was developed by Meyer et al. [61] and it evaluates the monitoring or coverage that a database performs on a given topic. The result is interpreted as the degree to which the database covers a specialty or subject [62]. In this indicator, single documents, contained in a single database, are those of greater weight or value, weight that will progressively be reduced by duplicate documents (weight = 0.5), triplicates (weight = 0.3), etc., depending on the number of databases to be compared. The higher the value of the index, the greater the singularity of the database, that is, it will collect a greater number of single documents [63].

$$\textit{Meyer's Index} = \sum \text{Sources} * \text{Weight} \ / \ \text{Total Sources} \tag{1}$$

3.3.2. Traditional Overlap (TO)

To measure the overlap %, or degree of similarity between two bases, traditional overlapping (TO), defined by Gluck [64], is usually used and it is calculated using the following expression:

$$\%\ \text{TO} = 100 * (|A \cap B| \ / \ |A \cup B|) \tag{2}$$

The higher the TO value, the greater the degree of similarity between the bases, that is, a coefficient of 0.15 shows a similarity of 15%, or interpreted from the opposite point of view, a difference of 85%, which would imply that if an adequate selection of the database is not made, 85% of the relevant documents for the investigation could be lost.

3.3.3. Relative Overlap

It was originally developed by Bearman and Kunberger [65]. It measures the coverage % of a database, A, with respect to another, B.

$$\%\ \text{Overlap in A} = 100 * (|A \cap B| \ / \ |A|) \tag{3}$$

The result would be interpreted as the percentage of documents that base A covers of base B.

4. Results and Discussion

4.1. Production

In Table 2, the temporary distribution of the articles related to Sustainable Water Resources Management selected through the search equations seen in the previous section, the years 2008–2009 stand out as those with the highest production of articles and the highest number of total citations received. Despite showing a similar number of articles in 2016 and 2017, their maximum number of citations has not been reached yet. It is interesting to note that in the period between 2008 and 2017, the total number of published articles is 67.5% of the total of WoS articles and 63.3% of Scopus, which would show the interest that has been given to the need to manage water resources in a sustainable way in the last 10 years.

Table 2. Number of articles and citations per year on Sustainable Water Resources Management in the WoS and Scopus databases.

Year	WoS					Scopus				
	f	hi%	TC	$\bar{x}$	h-Index	f	hi%	TC	$\bar{x}$	h-Index
1964	1	0.63%	0	0.00	0	0	0.00%	0	0.00	0
1972	0	0.00%	0	0.00	0	1	0.48%	1	1.00	1
1988	0	0.00%	0	0.00	0	2	0.95%	3	1.50	1
1990	2	1.25%	12	6.00	1	3	1.43%	20	6.67	2
1991	0	0.00%	0	0.00	0	1	0.48%	0	0.00	0
1993	2	1.25%	6	3.00	1	0	0.00%	0	0.00	0
1994	2	1.25%	28	14.00	2	2	0.95%	31	15.50	2
1995	5	3.13%	50	10.00	4	6	2.86%	83	13.83	5
1996	2	1.25%	61	30.50	2	4	1.90%	103	25.75	3
1997	0	0.00%	0	0.00	0	2	0.95%	19	9.50	1
1998	4	2.50%	34	8.50	3	4	1.90%	41	10.25	2
1999	6	3.75%	48	8.00	4	9	4.29%	53	5.89	4
2000	4	2.50%	101	25.25	3	4	1.90%	133	33.25	3
2001	4	2.50%	49	12.25	3	10	4.76%	79	7.90	4
2002	6	3.75%	127	21.17	4	6	2.86%	240	40.00	4
2003	1	0.63%	3	3.00	1	8	3.81%	55	6.88	4
2004	1	0.63%	1	1.00	1	2	0.95%	13	6.50	2
2005	3	1.88%	30	10.00	3	3	1.43%	39	13.00	3
2006	3	1.88%	18	6.00	2	4	1.90%	25	6.25	2
2007	6	3.75%	58	9.67	2	6	2.86%	77	12.83	3
2008	17	10.63%	324	19.06	9	15	7.14%	360	24	9
2009	13	8.13%	263	20.23	8	18	8.57%	332	18.44	9
2010	6	3.75%	77	12.83	4	9	4.29%	96	10.67	4
2011	4	2.50%	94	23.50	3	7	3.33%	121	17.29	3
2012	7	4.38%	21	3.00	3	10	4.76%	35	3.50	3
2013	8	5.00%	64	8.00	4	15	7.14%	70	4.67	4
2014	7	4.38%	75	10.71	5	11	5.24%	91	8.27	6
2015	11	6.88%	68	6.18	6	11	5.24%	74	6.73	6
2016	17	10.63%	81	4.76	5	18	8.57%	59	3.28	5
2017	18	11.25%	17	0.94	3	19	9.05%	13	0.68	3
∑	160	100.00%	1710	10.69	21	210	100.00%	2266	10.79	24

f = frequency (number of articles published); hi% = relative frequency; TC = total number of citations received for published articles; $\bar{x}$ = Average; h-index = Hirsch's index. Source: The authors' own elaboration.

Regarding production growth, after a first period in which publications are scarce (generically, and according to the law of exponential growth of Price [66], they are the so-called Precursors), a second stage of Exponential Growth begins in 2008, in which work on Sustainable Water Resources Management becomes a research front (Figure 3). Given that both bases have experienced an upturn in the number of articles in the last two years, this trend is expected to continue for at least the next few years before moving on to the last phase called linear growth, where growth slows down, and the main objective of publications is reviewing.

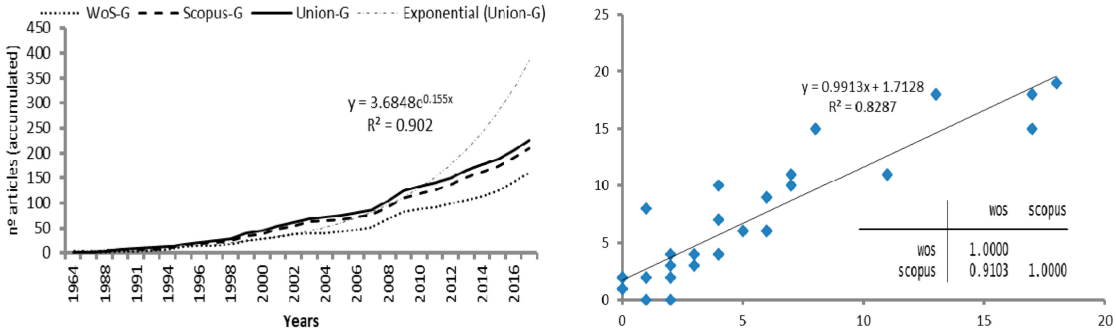

Figure 3. Growth and Correlation of articles published in WoS and Scopus on Sustainable Water Resources Management. Source: The authors' own elaboration.

On the other hand, and as shown in Figure 3, there is a strong correlation between WoS and Scopus regarding the number of articles collected per year with R^2 = 0.8287, although the growth curves start to separate from the year 1994.

4.2. Citations

The 160 WoS articles received a total of 1710 citations, which leads to an average ratio of 10.69 citations/article. Expressed in terms of the h-index = 21, of the total number of studies, 21 received 21 citations or more. In addition, the 210 articles of the Scopus database obtained a total of 2266 citations, and an average of 10.79 citations/article with an h-index = 24.

As with the number of articles published, the growth in the number of citations that publications received in both WoS and Scopus is constant throughout the analyzed period (Figure 4), reaching its highest level in 2017 (316 and 338 citations respectively). Only 1.25% (2) of WoS articles and 1.90% (4) of Scopus get more than 100 citations, 2.5% (4) and 2.86% (6) respectively, between 50–100 citations, 28.75% (46) and 26.19 (55) between 10–49 and 50.63% (81) and 45.24% (95) between 1–9. Only 18.88% (27) of WoS articles and 23.81% (50) of Scopus do not receive any citation. It must be taken into account that articles published during the last 10 years have not yet shown their maximum level of citations and that access to the first studies is not always available to everybody [67].

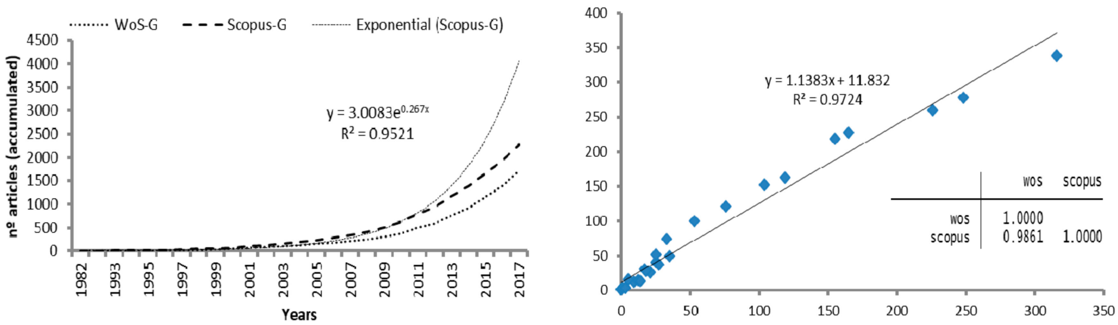

Figure 4. Growth and Correlation of citations received per year. Source: The authors' own elaboration.

The following stand out from the total of selected references, due to the number of citations received (Table 3)—Linking science with environmental decision making: Experiences from an integrated modeling approach to supporting sustainable water resources management [68] with 133 citations in WoS and 162 in Scopus, A multistage fuzzy-stochastic programming model for supporting sustainable water allocation resources and management [69] with 105 and 113 citations respectively and Sustainable water resources management [70] with 93 and 119.

Table 3. Ranking of articles on Sustainable Water Resources Management most cited in WoS/Scopus.

Author/s	Year	Title	WoS			Scopus		
			R.	TC	R.	TC	R.	TC
Liu, Y.; Gupta, H.; Springer, E.; Wagener, T. [68]	2008	Linking science with environmental decision making: Experiences from an integrated modeling approach to supporting sustainable water resources management	1	133	14.8	1	162	18
Li, Y.P.; Huang, Y.F.; Huang, Y.F.; Zhou, H.D. [69]	2009	A multistage fuzzy-stochastic programming model for supporting sustainable water-resources allocation and management	2	105	13.1	4	113	14.1
Loucks, D.P. [70]	2000	Sustainable water resources management	3	93	5.5	3	119	7
Zalewski, M. [71]	2002	Ecohydrology—the use of ecological and hydrological processes for sustainable management of water resources	4	70	4.7	2	136	9.1
Sandoval, S.; McKinnney, D.V.; Loucks, D.P. [72]	2011	Sustainability Index for Water Resources Planning and Management	5	63	10.5	5	87	14.5
Archer, D.R.; Forsythe, N.; Fowler, H.J. [73]	2010	Sustainability of water resources management in the Indus Basin under changing climatic and socio-economic conditions	6	52	7.4	9	52	7.4
Chowdary, V.M.; Ramakrishnan, D.; Srivastava, Y.K.; Chandran, V.; Jeyaram, A. [74]	2009	Integrated Water Resource Development Plan for Sustainable Management of Mayurakshi Watershed, India using Remote Sensing and GIS	7	48	6	8	57	7.1
Ajami, N.K.Hornberger, G.M.Sunding, D.L. [75]	2008	Sustainable water resource management under hydrological uncertainty	8	47	5.2	10	54	6
Simonovic, S.P. [76]	1996	Decision support systems for sustainable management of water resources. 1. General principles	9	43	2.1	7	72	3.4
Jacobs, K.; Lebel, L.; Buizer, J.; Addams, L.; Matson, P.; McCullough, E.; Garden, P.; Saliba, G.; Finan, T. [77]	2016	Linking knowledge with action in the pursuit of sustainable water-resources management	10	36	36	45	11	11

R. = rank; TC = the total number of citations received by the published articles; C/Y = average citations received by years. Source: The authors' own elaboration.

A framework for sustainability analysis in water resources management and application to the Syr Darya Basin [78] with 79 citations in Scopus is ranked 6th, in WoS it is in the 11th position with 37 citations.

4.3. Overlap and Singularity

As mentioned throughout this article, a total of 160 articles were identified in WoS compared to 210 in Scopus, of which 144 are overlapping, that is, they are common to both databases, representing 90% of WoS documents and 68.57% of Scopus. The remaining articles, 16 (10%) and 66 (31.43%) respectively, are single documents collected in only one of them (Figure 5 and Table 4).

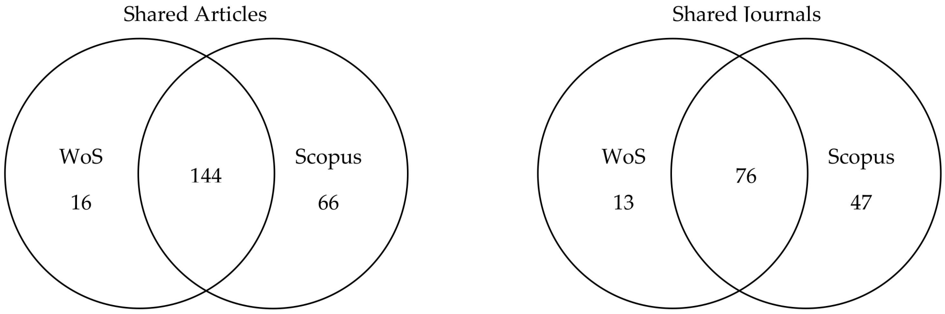

Figure 5. Overlap data between WoS and Scopus. Source: The authors' own elaboration.

Table 4. Singularity of the databases.

Databases	% Single Documents		Meyer's Index	
	Articles	Journals	Articles	Journals
WoS	10.00%	14.61%	0.55	0.57
Scopus	31.43%	38.21%	0.66	0.69

Source: The authors' own elaboration.

The calculation of the traditional overlap (TO) % of the articles between WoS and Scopus, developed by Gluck [64] and whose formulation is shown below, was 63.72%:

$$\%\mathrm{TO} = 100 * \left(\frac{|WoS \cap Scopus|}{|WoS \cup Scopus|}\right) => \%\mathrm{TO} = 100 * \frac{144}{160 + 210 - 144} => \%\mathrm{TO} = 63.72\% \quad (4)$$

This result expresses that between WoS and Scopus there is a 63.72% similarity, or in other words, a 36.28% disparity in relation to indexed articles on Sustainable Water Resources Management.

To measure the percentage of coverage of WoS with respect to Scopus and vice versa, relative overlap is used [65], calculated by the expression:

$$\%\mathrm{TO\ WoS} = 100 * \left(\frac{|WoS \cap Scopus|}{WoS}\right) \quad (5)$$

That is, Scopus covers 90% of WoS articles on Sustainable Water Resources Management. The % TO Scopus = 68.57%, that is, 21% less compared to the WoS overlap.

The differences between the overlapping of articles can be explained, in addition to the number of journals that both databases collect, by the different indexing policies followed. Although some journals are included in the two databases, it is possible that not all of their documents are transferred to each of them [63].

The singularity analysis of the databases was done through Meyer's index [61], which includes the degree of overlap between the bases, and the percentage of single documents present in each of them. The results observed in Table 4 show a greater singularity of Scopus with 31.43% of single articles and a 38.21% of single journals, and Meyer's index is 0.66 and 0.69 respectively.

4.4. Authors

As shown in Table 5, the ranking of the most productive authors in the area of Sustainable Water Resources Management, with a presence in the WoS and Scopus databases, is led by Ommani, A.R., with a total of four different articles between both bases, followed by six authors with 3 authorships, including Simonovic S.I. or Serageldin I. However, Loucks, D.P. has a better citations/articles average, his three articles receive an average of 53.7 citations in Wos, and 71 in Scopus. According to the criteria proposed by Lotka [79], no author is considered a large producer, with 10 or more articles. 4.51% (29)

are medium producers and the rest, 95.49% (614), are temporary, that is, with a single authorship. As a result of the above, the Productivity Index remains 1.06.

Table 5. Ranking of the most productive authors.

R.	Name	Country	University	f	WoS				Scopus			
					f	TC	C/f	h-Index	f	TC	C/f	h-Index
1	Ommani, A.R.	Iran	Islamic Azad University	4	3	4	1.3	1	4	14	3.5	2
2	Simonovic, S.I	Canada	Western University	3	2	61	30.5	2	2	98	49	2
3	Serageldin, I.	Egypt	New Library of Alexandría	3	1	18	18	1	3	46	15.3	2
4	Loucks, D.P.	United States	Cornell University	3	3	161	53.7	3	3	213	71	3
5	Huang, G.H.	Canada	University of Regina	3	3	111	37	2	3	119	40	2
6	Chizari, M.	Iran	Tarbiat Modares University	3	2	4	2	1	3	14	4.7	2
7	Cai, X.	United States	University of Illinois	3	2	59	29.5	2	3	104	34.7	2

* R. = rank; f = frequency (number of articles published); TC = the total number of citations received by the published articles; C/f = average citations received by the published articles; h-index = Hirsch's index. Source: The authors' own elaboration.

The collaboration index, which is the number of authorships per articles (Table 6), stands out from the indicators associated with authorship, with a value of 3.01, which indicates that the average number of authors who sign the articles is 3. Only 31% (69) of the articles are signed by one author, so the majority of articles have multiple authorship.

Table 6. Some indicators associated with authorship.

Index	Calculation	Result
Transiency Index	(Number of authors with a single article published/ Total number of authors) * 100	95.49
Collaboration Index	Number of authorships/Number of articles	3.01
Degree of Collaboration (I. Subramanyan [80])	(Number of articles with multiple authorship/Total number of articles) *100	69.47
Productivity Index	Number of authorships/Number of authors	1.06

Source: The authors' own elaboration.

Together with the authorship indicators, the affiliation, both of articles and authors, is one of the determining aspects for the correct identification and recovery of intellectual production in the different databases (Table 7). In this regard, by countries and within the scientific production of articles related to Sustainable Water Resources management, the United States stands out with 21.9% (35) of WoS articles and 20.5% (43) of Scopus affiliated to some of its centers. This country also receives the highest number of citations (711, 867) and has the highest h index (14, 15). It is followed by China, Italy and India as the countries with the highest number of authorships.

Table 7. Top 10 countries of affiliation of the authors by the number of authors.

R.	Country	WoS ∪ Scopus			WoS				Scopus			
		Centers	Authors	Authorships	f	hi%	TC	h-Index	f	hi%	TC	h-Index
1	United States	59	92	101	35	21.9	711	14	43	20.5	867	15
2	China	48	94	96	19	11.9	203	7	20	9.5	208	7
3	Italy	22	41	41	8	5.0	60	4	9	4.3	58	4
4	India	27	38	38	9	5.6	100	5	13	6.2	119	4
5	Australia	17	34	37	9	5.6	84	5	16	7.6	114	7
6	Spain	13	34	34	9	5.6	46	5	9	4.3	32	4
7	United Kingdom	17	28	28	9	5.6	133	6	11	5.2	145	6
8	Canada	15	21	27	14	8.8	237	7	14	6.7	287	8
9	Iran	8	14	22	7	4.4	50	3	10	4.8	77	4
10	Romania	3	13	16	3	1.9	7	2	4	1.9	20	2

* R. = rank; f = frequency (number of articles published); hi% = relative frequency; TC = the total number of citations received by the published articles; h-index = Hirsch's index. Source: The authors' own elaboration.

4.5. Journals

Of the total of 133 journals indexed, between WoS and Scopus that collect articles on Sustainable Water Resources Management, 98 publish a single article and only eight publications publish five or more (Table 8).

Table 8. Ranking of the most productive journals.

R.	Title	f	%	WoS (JCR) [1]				Scopus (SJR) [2]			
				f	TC	h-Index	Q	f	TC	h-Index	Q
1	IAHS-AISH Publication	9	3.98	-	-	-	-	9	33	3	-
2	International Journal of Water Resources Development	9	3.98	5	38	4	Q2	9	73	5	Q2
3	Water International	9	3.98	9	191	5	Q3	9	269	5	Q2
4	Water Resources Management	9	3.98	9	89	5	Q1	9	108	5	Q1
5	Water Science and Technology	7	3.1	7	46	4	Q3	4	38	3	Q2
6	Desalination	5	2.21	5	43	4	Q1	5	61	4	Q1
7	International Journal of Sustainable Development and World Ecology	5	2.21	5	19	3	Q3	5	25	3	Q2
8	Journal of the American Water Resources Association	5	2.21	5	70	5	Q2	5	82	5	Q1

* R. = rank; f = frequency (number of articles published); TC = the total number of citations received by the published articles; h-index = Hirsch's index; Q = quartile. [1] Category considered for the JCR Impact Factor: Water Resources except International Journal of Sustainable Development and World Ecology included in the category Green and Sustainable Science and Technology. [2] Category considered for the SJR Impact Factor: Water Science and Technology except International Journal of Sustainable Development and World Ecology included in the category Management, Monitoring, Policy and Law. Source: The authors' own elaboration.

According to Bradford's Law [81], most of the articles published around an area are grouped in a small number of journals, a fact that helps to identify the most used journals by researchers for the dissemination of their articles (Figure 6). The denomination of Minimum Zone (MBZ) is given to the number of articles equal to half the number of journals that produce a single article [82]. Once the value of MBZ (49) was calculated and from the ranking of journals ordered in descending order of productivity, the Bradford Core is made up of those journals whose sum of articles was equal to the MBZ (49). In our bibliometric analysis, the MBZ is made up of the top seven journals with a total of 53 articles published, with nine articles that stand out: International Journal of Water Resources Development, Water International, Water Resources Management and IAHS-AISH Publication, this last one present exclusively in Scopus.

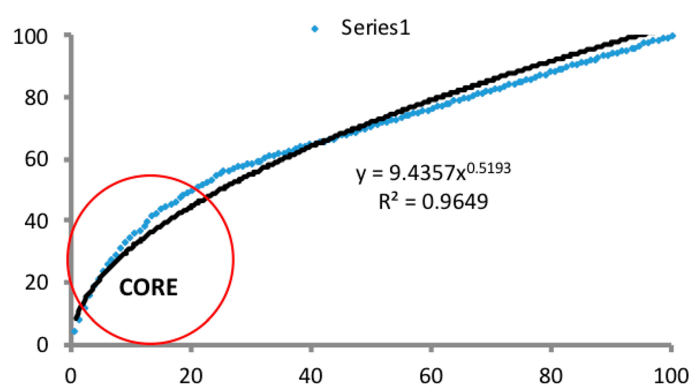

Figure 6. Lorenz curve. Bradford's core of the most productive magazines Source: The authors' own elaboration.

As shown in Table 9, there is no clear correspondence between the thematic areas in which journals are classified, which include articles on Sustainable Water Resources Management in WoS and in Scopus. Environmental Sciences stands out in both bases, with the first position in the ranking of the most productive in Scopus, with 76% (160) of the articles and in the second position in WoS with 40% (64). In the latter base, Water Resources ranks first with 50% of the articles. Note at this point that journals can belong to one or more Subject Area fields. By bases, in WoS, it must be mentioned that the area of Engineering with 60 articles (37.5%) receives 853 citations, occupying the second position in the ranking of the most cited articles, only behind Water Resources. On the other hand, Social Science with 49 articles (23%) and 380 citations is in the second position in the ranking, far from the 160 and 1902 citations, respectively, of Environmental Science.

Table 9. Classification of articles by subject area.

WoS						Scopus					
Area	**J.**	**f**	**TC**	**C/f**	**h-Index**	**Area**	**J.**	**f**	**TC**	**C/f**	**h-Index**
Water Resources	29	80	945	11.8	15	Environmental Science	80	160	1902	11.9	22
Environmental Sciences Ecology	37	64	768	12	13	Social Science	31	49	380	9.4	10
Engineering	22	60	853	14.2	14	Earth and Planetary Sciences	24	43	336	7.8	13
Science Technology	11	20	220	11	8	Agricultural and Biological Sciences	28	35	268	7.7	11
Geology	9	18	203	11.3	10	Engineering	14	29	306	10.6	9
Agriculture	9	12	68	5.7	5	Energy	10	12	157	13.1	6
Marine Freshwater Biology	5	7	125	17.9	5	Chemical Engineering	6	10	74	7.4	4
Meteorology Atmospheric Science	2	5	81	16.2	5	Business, Management, and Accounting	6	8	67	8.4	3

* J. = journal; f = frequency (number of articles published); TC = the total number of citations received by the published articles; C/f = average citations received by the published articles; h-index = Hirsch's index. Source: The authors' own elaboration.

5. Conclusions

The analysis of scientific publications through bibliometric reviews is a key element in the research process, not only as a tool capable of examining existing information in order to show trends, but also as a measure of its impact on the environment. In this process, bibliographic databases play a key role in allowing access to most of the information. However, the existence of differences in coverage, information provided and downloading of documents makes the selection of the most appropriate basis for each area of knowledge be an essential phase. Based on the results obtained, and as a conclusion, this section provides a series of ideas on research related to the area of Sustainable Water Resources Management (its volume, evolution, visibility and structure) that may be useful for future studies, at the same time as comparing the coverage and overlap that on this particular field is made by two of the main existing databases in the market, WoS and Scopus.

After a first period of uncertainty in which there are few publications, a second phase of exponential growth began in 2008, where the area of Sustainable Water Resources Management becomes the subject of study, concentrating two thirds of the articles in the period between 2008 and 2017, which would show the interest that has been given to the need to manage water resources in a sustainable way in the last 10 years. In addition, the growth in the number of citations that publications received during these years is constant, reaching its highest level in 2017. Throughout the period, the two databases analyzed, WoS and Scopus, show a strong correlation both in the number of articles published annually and in the number of citations received. However, as with other fields of research [83], Scopus is the base that as a whole collects a greater number of articles and receives a greater number of citations.

However, despite these and other similarities, there are also differences such as those related to the coverage of both databases by the Sustainable Water Resources Management area. With almost a third of single articles, Scopus is shown to be the base that covers overlapping the best, at the same time, to almost 90% of WoS articles. 10% in the degree of singularity of WoS is the measure of the amount of information that would be lost if Scopus were chosen as the only bibliographic base.

Based on the results obtained and following the criteria proposed by Lotka [79] for the classification of authors based on their productivity, there are no authors considered large producers and more than 95% of them are temporary authors, having a single authorship, causing the average productivity index per author to be very close to one. The ranking of the most productive authors is led by Simonovic S.I. with four articles. Although there is a wide variety of countries with author affiliation, which shows how geographically widespread this field is, two countries stand out at the forefront of research on Sustainable Water Resources Management, the United States and China. Canada is included in the countries with the best rated authors, by obtaining the second highest h index value (8). If the authorship (collaboration index) is observed in greater detail, the articles with multiple signatures represent more than two thirds of the total. Within these, articles with five or more authors represent 20%, which places the collaboration index, expressed as the average number of authors per article, above three.

Finally, and in relation to the journals where the articles are published, seven are the core of the main journals that collect articles on Sustainable Water Resources Management (Bradford's core), with Water International standing out, due to the number of citations received. With regard to the thematic classification of documents that the databases make according to the areas to which the journals where they are published belong, there is a common main research field for WoS and Scopus that includes the highest percentage of articles: Environmental Sciences, but given the multidisciplinary nature of water management, other areas such as Water Resources (Wos), Social Science (Scopus) or Agriculture (both) must also be mentioned.

Although bibliometric studies are instruments capable of representing the main trends in a field of study, due to the specific characteristics of this type of research, it is worth mentioning some limitations such as the one that involves, when analyzing the results, the choice of a certain database and a particular search equation. On the other hand, the aim was not to evaluate the content quality of the selected articles, objective that can be considered in a later investigation, but a descriptive-comparative analysis of the articles and citations related to Sustainable Water Resources Management present in Wos and Scopus. In order to broaden the research, it would be interesting to extend the comparative study to other databases such as Scielo, Latindex, Emerald among others, where you can get more coverage per continent of studies in relation to IWRM, and carry out a collaboration analysis such as those carried out in other areas of knowledge.

Author Contributions: All authors contributed equally to this work. All authors wrote, reviewed and commented on the manuscript. All authors have read and approved the final manuscript.

Funding: This research received no external funding.

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

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