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Water Markets: Mapping Scientific Knowledge

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Abstract: Water is a vital resource for citizens' economic and social development. However, the uses to which it can be put often conflict. Possible solutions to mitigate disputes involve political options, scarce economic resources, and the search for mechanisms to ensure its adequate allocation. For over half a century, countries such as Australia, Spain, Chile, and the western states of the United States have been considering the possibility of using markets for rights of use. They are defined as formal or informal trading exchanges of rights, whose aim is to improve efficiency, ensure security of supply, and make allocations more flexible. In this context, the aim of this article is to show a current picture of the scientific production related to Water Markets using the comparative bibliometric study of the documents indexed in the Web of Science (WoS) and Scopus databases as a tool. The advanced search of relevant terms resulted in the retrieval of 261 papers from WoS and 305 from Scopus, with a time limit of 2020, which make up the ad hoc basis of the analysis. From this basis, it can be deduced that the subject of the Water Market has been present in the scientific literature on a more or less regular basis since the beginning of the 1990s. However, it has emerged as a topical issue in recent years, being in a phase of exponential growth, which means that interest in the area is likely to continue in the coming years.

Keywords: water market; bibliometric study; WoS; Scopus; coverage; overlap

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1. Introduction

Growing demand for water is depleting the water availability in many regions and water scarcity has become one of the major challenges of the 21st century [1]. Water governance systems are proving ineffective in managing such scarcity, putting societies and economies at serious risk. Th overexploitation of water resources is being allowed to occur, making it impossible to sufficiently reduce water demands during periods of drought in order to avoid a supply crisis, resulting in social conflicts and political instability [2].

However, despite this crisis, freshwater is not running out [3]. Water is a global resource that is sufficient to satisfy human needs. The main problem is that the availability and needs do not coincide in space and time, and rearranging availability and needs can be costly and environmentally damaging. For this reason, for the last decade, the United Nations has been calling for improvements in water management to help alleviate this situation [4].

Traditionally, the answer focused on the construction of reservoirs and infrastructure. However, in recent years, due to growing environmental concerns, it is no longer possible to solve scarcity problems solely through an engineering approach. The use of market mechanisms to manage water efficiently, fairly and sustainably has become a solution [5] and economic instruments must find their way into governance policies [6]. It is in this context that water markets are increasingly being promoted and applied [7].

The market for concessions of rights to use water resources has been boosted since Roman times. Scott and Coustalin [8] show that "the idea arose several times throughout history, motivated by very different causes, but always to balance different uses during dry periods" (p. 822). In many regions of the world, including the United States, China, Australia, and Chile, a large number of different water market schemes for surface and groundwater management have been proposed and/or implemented [9].

A water market constitutes a system of formal regulations governing the purchase, sale, and lease of rights for use of water (water rights) that are ideally traded independently of property titles. Existing water supplies are allocated more productively and flexibly under the supervision of regulatory institutions that limit unwanted or negative externalities [10]. However, water markets do not always work in the real world as expected [11], so incentives are often included in order to align individual desires with public objectives [12].

Despite the fact that economic theory grants it certain advantages, the implementation of this allocation system has often not been well received. However, it should be noted that the volume of papers defending the market option is considerable [13] and there are plenty of articles that analytically argue the pros and cons of water markets, or that calculate the potential economic gains that market-like transactions could generate [14,15]. Following this line of research, Grafton et al. [16] carried out a classification and a comparison of the functioning of the water markets that are operative in several countries and what this implies for efficiency, equity, and sustainability. It must be taken into account that their operation is regulated by different legal and institutional frameworks.

For all of these reasons, the study of water markets arouses great interest among researchers around the world at an academic level, generating a large number of papers. Due to this increase in the amount of research, it is important and necessary to analyse the academic literature in a structured and systematic way to provide a good understanding of the state of the art. In this sense, several authors show that the use of bibliometrics is the first step to achieving this goal [17] and predicting research trends [18,19].

The main objective is to present a current in-depth analysis of the published scientific literature on the *Water Market* through a bibliometric comparative study of the articles indexed in the two main international databases: Web of Science (WoS), owned by Clarivate Analytics, and Scopus, owned by the publisher Elsevier. This analysis allows, through metrics (productivity measures, impact metrics, and hybrid metrics) [20] the evaluation of the performance of research and analysis of the publications, citations, and sources of information. In this regard, evaluative techniques will be used considering articles, journals, authors, institutions, and countries. Citation and co-citation analysis and co-authorship analysis will also be used to map the structure and science dynamics [21]. The purpose of this research is merely informative, providing information of interest to researchers in order to guide them in the process of planning their future research on the subject.

In order to achieve these objectives, this article is structured as four main sections. After the introduction, in which the research is contextualised and the objective is presented in Section 2, a review of the academic literature is carried out in order to establish the theoretical framework of the research. Section 3 describes both the methodology and tracking strategy used to select the documents that make up the empirical basis of the study. Section 4 details and discusses the main results obtained, and ends, in Section 5, with the presentation of the conclusions and the limitations of the research.

2. Theoretical Framework

Most developed countries are in a context of maturity of their water economy [22], characterised by a growing demand for this resource, its limited supply, rising infrastructure costs, increasing competition between areas and uses, the problem of negative externalities caused by inappropriate use, and the growing social cost derived from subsidising some uses. As a consumer product, water has a unique set of characteristics determined largely by its location as well as by its use: its high mobility, which affects the commercialisation of rights; uncertain quality, quantity, and location; high costs of transporting water to where it is consumed; and decisions regarding its extraction, use, and reuse that affect all users of a hydrological system [23]. Supply and demand change over time due to seasonality, sociodemographic factors, climate change, and socioeconomic dynamics, so water management requires some flexibility in order to encourage the rational use of water.

As a management tool, markets have long been proposed as the most efficient solution to manage both environmental problems and natural resources, including water [24]. These water markets do not have to imply the transfer of water, but rather the right to use or access this resource in a given quantity to be used in specific places and at specific times. Thus, we can define water markets as trading exchanges of formal or informal water rights [25]: (i) formal water rights are those that have been regularised by recognising private property rights over them and their free transferability between users [26]. In theory, this allocation of water rights by the market should provide incentives to improve efficiency in its use; (ii) informal exchanges consist of selling volumes of water, also known as water rights rentals, and arise mainly in places where the government is unable to manage water demand during scarcity [27]. In general, water markets can be classified as "(i) short-term or temporary markets, (ii) medium-term leases of water allocations, and (iii) permanent transfers of water rights" [28] (p. 808).

Market mechanisms to allocate and reallocate water among competitive uses may be more conductive to increased efficiency than a process that does not depend on a pricing system [7], since without prices that adequately indicate how scarce water is, extraction and consumption rates tend to be higher than desired for long periods of time. When the jurisdiction moves from the centralised allocation of water resources to market-based instruments, power is transferred from regulators to users, and governments are often relieved of the need for large infrastructure investments [29]. This does not imply that they do not have an important role to play in ensuring that rights are well defined, secure, and reflect real uses and that no third party is negatively affected without adequate compensation [7].

There are many countries that, over time, have established this figure in their water governance. Among these countries, the case of the United States is probably the oldest and best documented [30]. As reported by Anderson and Hill [31], the modern idea of the water market began in the 1850s with the California gold rush, where the miners themselves assigned their own sections of rivers, something similar to today's "water rights". After the end of gold mining, it was farmers who acquired these rights, initiating a primitive market among settlers. Throughout the 20th century, this market was reduced by the exploitation of groundwater as a substitute source. However, in recent years, its use has been reactivated due to the lack of water supply options in the American West.

It is in the 1980s when academic literature—especially economic literature—begins to pay attention to the market, with a consensus that it is a good way to manage the efficient use of water in a situation of scarcity, provided that it is possible to reduce transaction costs and negative externalities [32]. Many papers adopt an economic approach to analyse its efficiency and evaluate its prices and the importance of reducing transaction costs [33]. Other researchers consider water markets as a social and historical institution [34] arising from an overlapping of social practices, political decisions, and rules that are reproduced over time. These institutions are essential to reduce transaction costs and to ensure that supply and demand are satisfied, especially at the local level [35].

The correct implementation of a water market requires establishing a series of legal conditions, i.e., a legal framework to support it [36], with laws that can promote or hinder its creation. Three of the most important legal conditions when establishing a water market [37] are: the existence of a rule that allows for the reallocation of water [35]; the separation of water rights and land ownership [13]; and the modification of the non-use cancellation rule [38].

This economic instrument can achieve resource allocation efficiency better than any of its alternatives, improving the overall welfare of society [32], and has been chosen as the preferred water demand policy, especially in regions characterised by the maturity of their water economy, such as the western United States, Chile [16], Australia [39], and India [40].

Market-based approaches seem to be useful tools for water management [41], but institutions do not always evolve to be efficient and effective in allocating resources [42] or to reduce transaction costs [43], which may have negative effects on wellbeing [44]. Thus, in other countries, the legal framework of water rights does not allow for formal water trading between users. In Brazil, water is considered a common public good; therefore, establishing a market considering water as the property of private owners would be unconstitutional [45].

There are only a few successful experiences of water markets around the world [16] and it seems unclear how they influence incentives for users to use water efficiently given the limited literature on this subject [46]. There is also some resistance based on ideology or previous failed efforts, giving rise to stakeholders who may have divergent views on how to regulate access to water [47].

Although we have seen that water markets are a positive strategy, there are studies that point to adverse impacts. According to Skurray et al. [48], "[t]he impacts of groundwater pumping can range from relatively simple and compensable third-party financial effects (such as a neighbour's altered pumping costs as a result of a nearby pumping transfer) to much more complex, spatially—and temporally—distributed impacts" (p. 261). They can cause agricultural job losses [49], undermine means of living due to political pressure to transfer water [50], and reduce environmental flows [51]. Young and Haveman [52] name those specific water factors that make it difficult to use water markets as an allocation method: mobility, large-scale economy, supply variety, absorption of pollutants, sequential uses, complementary uses, value/volume relationship, and conflicting cultural and social values.

If strictly economic criteria are considered, there are numerous arguments questioning the feasibility of establishing water rights markets. In general, these arguments can be classified into three main groups: (i) transaction costs—Colby et al. [53] showed that prices in the rights market differ significantly from the economic value generated by the resource at the destination. Factors such as the number and size of participants, information and search costs, and heterogeneity of resources would explain these differences; (ii) definition of property rights—since water is a resource whose quality and quantity respond, at least partly, to random phenomena, the definition of property rights is complex. Howe et al. [32] define and conceptualise two types of property rights. They are proportional rights that allow for an equitable distribution of resources according to availability, and priority rights that establish the order in which each right can be used according to the pre-set priority; (iii) negative externalities—Cummings and Nercessiantz [54] argue that water markets can erode the natural habitats of river basins, their aesthetic values, and the maintenance of ecological flows. However, for Howe et al. [32], a correct definition of property rights can mitigate this problem.

3. Methodology

This paper uses bibliometric analysis to classify and analyse documents published in the WoS and Scopus databases related to the *Water Market* subject. Broadus [55] (p. 376) defines this technique as "the quantitative study of published physical units, or bibliographic units, or substitutes for any of them". In this regard, bibliometrics studies bibliographic material by using quantitative methods and statistical–mathematical tools [56], with the aim of mapping the structure, development, and evolution of scientific disciplines [57,58].

In order to carry out this analysis, the first step is to consider a mental map with which to outline the most important steps to follow in the process of systematically searching for the bibliography required to carry out the analysis [59]. Following this line of thought, Figure 1 shows the phases followed for the systematic development of the bibliometric analysis focused on the *Water Market*. The general description and guidelines provided by Donthu et al. [60] were followed.

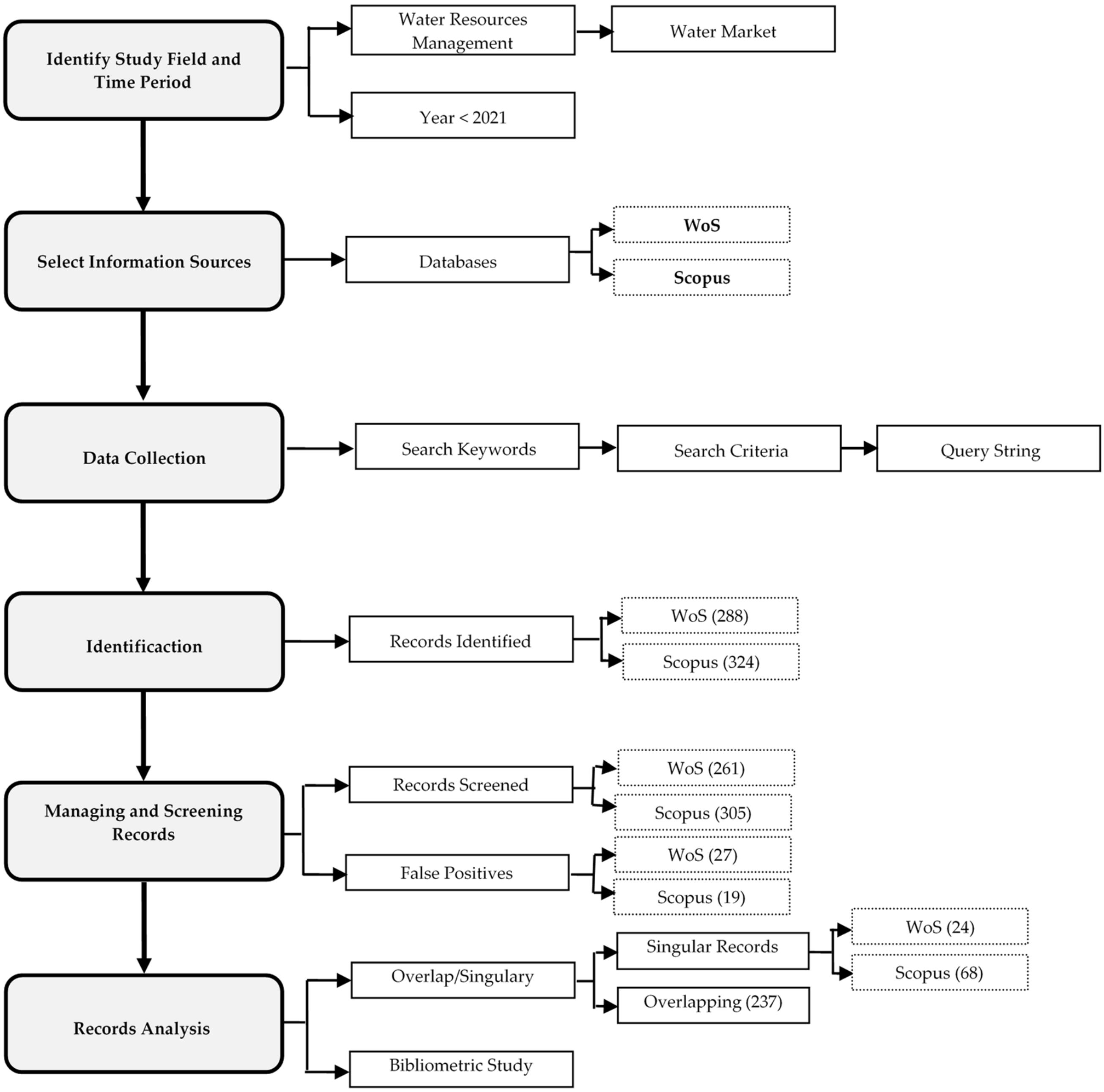

Figure 1. Methodological scheme. Source: own elaboration.

Following the methodological scheme, the next step, once the subject of study has been determined, is the choice of the most appropriate databases to obtain the information under analysis. WoS and Scopus were selected as the primary source of information, both of which are worldwide reference sources. Bearing in mind that the validity of the results of this research will depend on whether or not the choice is correct [61], a comparative analysis of both databases will be carried out in order to evaluate their greater or lesser coverage or suitability for the scientific area under study. In this regard, there are already other studies that carried out such analyses by considering the articles collected, journal titles, subject and geographical areas, affiliation, languages, and citation analysis [62,63].

The next stage is to set the search criteria and search equations for each of the databases that include the terms used to search for documents related to the *Water Market* area (Table 1). This strategy makes it possible to search for documents in journals classified within all subject areas, thus making the search very comprehensive [64].

Table 1. Characteristics of the document search.

Search Word	"Water Market" OR "Water Trading"
Category	Title
Subject area	ALL
Document type	Journal article or review articles
Period time	Year of publication ≤ 2020
Language	English
Query String	WoS: (Main Collection) TÍTULO: ("Water Market" OR "Water Markets" OR "Water Trading") Refined by: [excluding] YEARS OF PUBLICATION: (> 2020) AND TYPES OF DOCUMENTS: (ARTICLE AND REVIEW ARTICLE) AND LANGUAGES: (ENGLISH) Scopus: TITLE ("Water Market" OR "Water Markets" OR "Water Trading") AND PUBYEAR < 2021 AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "re") OR LIMIT TO (LANGUAJE, "English"))
Search Date	September 2021

Source: own elaboration.

Once the documents have been identified, the PRISMA (identification, screening, eligibility, and included) method will be followed and the exclusion criteria will be applied to refine and standardise the metadata, eliminate duplicate documents, and assess eligibility by discarding those with unidentified bibliometrics and those unrelated to the thematic focus of the object of study.

The next step is to define the bibliometric indicators that will be used in the analysis to carry out the performance analysis (contributions of the research components) and the scientific mapping (relationships between research components) [60]. This paper uses publications (related metrics), citation (related metrics), citation and publication (related metrics), citation and co-citation analysis, co-word analysis, and co-authorship analysis.

4. Results

4.1. Database Overlap and Singularity

After applying the tracking methodology, a total of 261 articles in WoS and 305 in Scopus focusing on the *Water Market* were selected. A total of 237 of these documents overlap, i.e., they are present in both databases, which represents 90.80% of the total number of documents in WoS and 77.70% of those in Scopus. The remaining papers, 24 (9.20%) and 68 (22.30%), respectively, are single articles, present in only one database. When taking journals as the variable analysed, the percentage of overlap is still higher in WoS, as the 90 common journals account for 87.38% of the total in WoS and 67.67% in Scopus, which is almost 20 points lower (Figure 2).

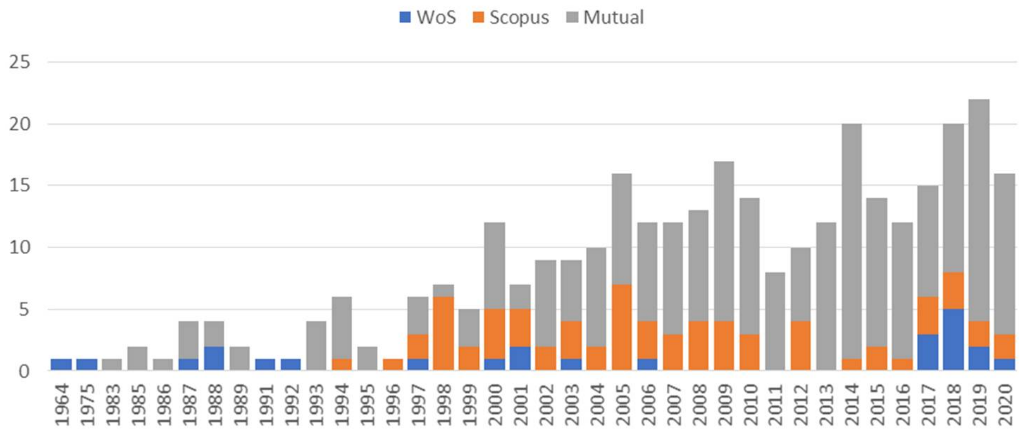

Figure 2. Chronology of the overlapping of articles indexed in WoS and Scopus on the Water Market.

As a measure of the overlap between bases, the so-called traditional overlap (TO) [65] is used academically, whose mathematical expression is:

$$\%\text{TO} = 100 * \left(\frac{|WoS\ \cap\ Scopus|}{|WoS\ \cup\ Scopus|}\right) => \ \%\text{TO} = 72.04\% \quad (1)$$

The result can be interpreted by saying that there is a 72.04% similarity or resemblance between WoS and Scopus in relation to the indexing of articles on the *Water Market*, or analysed from the opposite point of view, we find a disparity between both bases of 27.96%.

More specifically, if the aim is to determine the coverage percentage of WoS with respect to Scopus and/or vice versa, then relative overlap is used [66], whose calculation is as follows:

$$\%\text{TO WoS} = 100 * \left(\frac{|WoS\ \cap\ Scopus|}{WoS}\right) => \ \%\text{TO WoS} = 100 * \frac{237}{261} = 90.80\% \quad (2)$$

That is, Scopus overlaps or covers 90.80% of WoS articles in the area of the *Water Market*. The %TO Scopus = 77.70%, i.e., Scopus exceeds WoS by more than 13%.

This difference in the overlap of articles is mainly due to the different indexing policies and the discrepancy in the number of journals included in both databases.

Another of the most widely used indices to measure the singularity of databases is the so-called Meyer index [67], which includes, in addition to the degree of overlap between the databases, the percentage of single documents present in each of them. Scopus shows a greater singularity, with 22.30% of articles and 32.33% of single journals and a Meyer index of 0.61 and 0.66, respectively.

4.2. Open Access

Nowadays, the internet allows us to access publications and scientific and academic works free of charge and without restrictions, thanks to open access (OA), whose main objective is to allow such information to be accessible to the public. In general, the number of OA documents is increasing every year. However, the number of articles indexed in both WoS and Scopus through OA is still about 25% of the total.

WoS

WoS offers OA status as a result of a partnership with OurResearch, a non-profit organisation that publishes a knowledge base with OA content. Thanks to this, free legal content can be accessed on the publisher's website or archived by the author in a repository. This improves visibility not only by adding more links to content, but also by prioritising links to the best versions of OA content when several versions of the article exist.

There are several types of OA. Table 2 shows the WoS classification of OA documents.

Table 2. Descriptions of open access types in WoS.

Open Access Type		Descriptions
Gold	Gold	"Identified as having a Creative Commons (CC) license by OurResearch Unpaywall Database. All articles in these journals must have a license in accordance with the Budapest Open Access Initiative to be called Gold."
	Hybrid	"Items identified as having a Creative Commons (CC) license by OurResearch but that are not in journals where all content is Gold. Hybrid Gold open access status is at varying levels of completeness, especially for newly published articles."
Free to Read	"The licensing for these articles is either unclear or identified by OurResearch as non-CC license articles. These are free-to-read or public access articles located on a publisher's site. A publisher may, as a promotion, grant free access to an article for a limited time. At the end of the promotional period, access to the article may require a fee, which can lead to temporary errors in our data. You may find content that is incomplete, especially new content."	
Green	Published	"Final published versions of articles hosted on an institutional or subject-based repository."
	Accepted	"Accepted manuscripts hosted on a repository. Content is peer reviewed and final, but may not have been through the publisher's copy-editing or typesetting."
	Submitted	"Original manuscripts submitted for publication, but that have not been through a peer review process."

Source: https://webofscience.help.clarivate.com/en-us/Content/open-access.html (accessed on 2 March 2022).

Only 28.74% (76) of the 261 documents indexed in WoS relating to the *Water Market* are of OA. Of these, 9.2% (23) are in the Free to Read category and 10.73% (28) in the Green Submitted category, which means that they have not undergone a peer review process (Table 3).

Table 3. Classification of open access articles in WoS.

WoS	Frequency (Number of Articles Published)	Relative Frequency (of 261)
All Open Access	76	28.74%
Gold	17	6.51%
Gold-Hybrid	9	3.45%
Free to Read	23	9.20%
Green Published	24	8.81%
Green Accepted	5	1.92%
Green Submitted	28	10.73%

Scopus

There are currently approximately 17 million articles in Scopus using this OA classification system and there are plans to expand its definition to include those available in open repositories. The Scopus source for open access documents is the Unpaywall database managed by Impactstory, a non-profit organisation. It collects open access content from over 50,000 publishers and repositories. The description of the different categories in which Scopus classifies OA documents is shown in Table 4.

Table 4. Descriptions of open access types in Scopus.

Scopus Filter		Information Lebel	Definition
Gold	Gold	OA-only journal	"Published version with Creative Commons license, available on publisher platform. Documents are in journals which only publish open access."
	Gold Hybrid	Hybrid journal	"Published version with Creative Commons license, available on publisher platform. Documents are in journals which provide authors the choice of publishing open access."
Bronze		Other free-to-read from publisher	"Published version of record or manuscript accepted for publication, for which the publisher has chosen to provide temporary or permanent free access. Bronze status is assigned to a document if there is another (publisher-specific) license other than a Creative Commons license (e.g., Elsevier's publisher license for Open Archive), or no license at all."
Green		Free-to-read from repository	"Published version or manuscript accepted for publication, available at repository. Documents may also be available gold or other free-to-read on the publisher platform."

Source: https://service.elsevier.com/app/answers/detail/a_id/11268/supporthub/scopus/OA/ (accessed on 2 March 2022).

In Table 5, it can be seen that in the *Water Market* subject, the percentage of the total number of OA documents within the Scopus database (26.23%) is very similar to that found in WoS (28.74%). In Scopus, the OA documents classified within the Green category (documents that can be located in repositories and are free to read) stand out with 17.38% of the total number of selected articles and 65.85% of the total number of OA documents.

Table 5. Classification of open access articles in Scopus.

Scopus	Frequency (Number of Articles Published)	Relative Frequency (of 305)
All Open Access	82	26.23%
Gold	17	5.57%
Gold-Hybrid	9	2.95%
Bronze	23	7.87%
Green	54	17.38%

4.3. Production

Table 6, a comparison of the articles indexed in WoS and Scopus on the *Water Market* by year, shows the set of papers selected from the WoS and Scopus databases in an orderly manner. It can be seen that the first article appeared in Scopus in 1969, although it has not had a great impact and it does not have any citations. The subject "Water Market" has been present in the scientific literature more or less regularly since the beginning of the 1990s, with two years standing out from the rest in terms of total publications (TP), 2014 and 2020, with 20 papers in each database.

Considering the number of citations received, in WoS, the years 2014, with 405 citations and an average of 20.3 citations/year, and 2009, with a total of 383 citations and an average of 29.5, stand out. Regarding Scopus, 2009 and 2005 are the most outstanding years, with 418 citations (24.26 citations/year) and 402 citations (25.1 citations/year), respectively. At this point, it is necessary to remember that the papers after 2016 have not yet reached their full potential in terms of their ability to be cited. A good proof of this is that in the last 5 years, 28.35% (74) of the articles have been published in WoS and they have only received 6.42% (341) of the citations and in Scopus, 24.62% (74) of the articles have only received 5.39% (314) of the citations.

Table 6. Comparison of articles indexed in WoS and Scopus on the Water Market by year.

Year	WoS										Scopus									
	fi	%hi	Fi	%Hi	C	∑C	$\bar{X}$	h-ind	OP	%OP	fi	%hi	Fi	%Hi	C	∑C	$\bar{X}$	h-ind	OA	%OA
1969	1	0.4	1	0.4	0	0	0.0	0	0	0.0	-	-	-	-	-	-	-	-	-	-
1975	1	0.4	2	0.8	0	0	0.0	0	0	0.0	-	-	-	-	-	-	-	-	-	-
1983	1	0.4	3	1.1	23	23	23.0	1	0	0.0	1	0.33	1	0.33	24	24	24.0	1	0	0.0
1985	2	0.8	5	1.9	18	41	9.0	2	0	0.0	2	0.66	3	0.98	16	40	8.0	2	0	0.0
1986	1	0.4	6	2.3	207	248	207.0	1	1	100.0	1	0.33	4	1.31	89	129	89.0	1	1	100.0
1987	4	1.5	10	3.8	71	319	17.8	1	0	0.0	3	0.98	7	2.30	81	210	27.0	3	0	0.0
1988	4	1.5	14	5.4	41	360	10.3	3	0	0.0	2	0.66	9	2.95	35	245	17.5	2	0	0.0
1989	2	0.8	16	6.1	77	437	38.5	2	0	0.0	2	0.66	11	3.61	86	331	43.0	2	0	0.0
1991	1	0.4	17	6.5	23	460	23.0	1	0	0.0	-	-	11	3.61	-	331	-	-	-	-
1992	1	0.4	18	6.9	1	461	1.0	1	0	0.0	-	-	11	3.61	-	331	-	-	-	-
1993	4	1.5	22	8.4	169	630	42.3	4	1	25.0	4	1.31	15	4.92	199	530	49.8	4	1	25.0
1994	5	1.9	27	10.3	142	772	28.4	4	0	0.0	6	1.97	21	6.89	205	735	34.2	5	0	0.0
1995	2	0.8	29	11.1	29	801	14.5	1	0	0.0	2	0.66	23	7.54	43	778	21.5	1	0	0.0
1996	-	-	29	11.1	-	800	-	-	-	-	1	0.33	24	7.87	0	778	0.0	0	0	0.0
1997	4	1.5	33	12.6	307	1107	76.8	4	1	25.0	6	1.97	30	9.84	380	1158	63.3	5	1	16.7
1998	1	0.4	34	13.0	36	1143	36.0	1	0	0.0	7	2.30	37	12.13	59	1217	8.4	2	0	0.0
1999	3	1.1	37	14.2	144	1287	48.0	3	2	66.7	5	1.64	42	13.77	153	1370	30.6	5	2	40.0
2000	8	3.1	45	17.2	172	1459	21.5	5	3	37.5	10	3.28	52	17.05	197	1567	19.7	5	5	50.0
2001	4	1.5	49	18.8	47	1506	11.8	2	0	0.0	6	1.97	58	19.02	58	1625	9.7	2	0	0.0
2002	7	2.7	56	21.4	232	1738	33.1	6	2	28.6	9	2.95	67	21.97	325	1950	36.1	8	2	22.2
2003	6	2.3	62	23.7	271	2009	45.2	5	2	33.3	8	2.62	75	24.59	244	2194	30.5	5	1	12.5
2004	8	3.1	70	26.8	246	2255	30.8	8	4	50.0	9	2.95	84	27.54	273	2467	30.3	8	4	44.4
2005	9	3.4	79	30.3	332	2587	36.9	9	1	11.1	16	5.25	100	32.79	402	2869	25.1	10	2	12.5
2006	9	3.4	88	33.7	355	2942	39.4	8	4	44.4	11	3.61	111	36.39	348	3217	31.6	9	3	27.3
2007	9	3.4	97	37.2	207	3149	23.0	7	0	0.0	12	3.93	123	40.33	220	3437	18.3	6	1	8.3
2008	9	3.4	106	40.6	241	3390	26.8	7	2	22.2	13	4.26	136	44.59	304	3741	23.4	8	4	30.8
2009	13	5.0	119	45.6	383	3773	29.5	10	2	15.4	17	5.57	153	50.16	418	4159	24.6	10	2	11.8
2010	11	4.2	130	49.8	99	3872	9.0	6	1	9.1	15	4.92	168	55.08	119	4278	7.9	7	1	6.7
2011	8	3.1	138	52.9	163	4035	20.4	5	1	12.5	8	2.62	176	57.70	199	4477	24.9	6	2	25.0
2012	6	2.3	144	55.2	113	4148	18.8	5	4	66.7	9	2.95	185	60.66	138	4615	15.3	6	5	55.6
2013	11	4.2	155	59.4	262	4410	23.8	8	2	18.2	12	3.93	197	64.59	380	4995	31.7	8	2	16.7
2014	20	7.7	175	67.0	405	4815	20.3	11	7	35.0	20	6.56	217	71.15	353	5348	17.7	12	7	35.0
2015	12	4.6	187	71.6	156	4971	13.0	8	5	41.7	14	4.59	231	75.74	165	5513	11.8	7	5	35.7
2016	11	4.2	198	75.9	81	5052	7.4	7	1	9.1	13	4.26	244	80.00	90	5603	6.9	6	1	7.7
2017	11	4.2	209	80.1	110	5162	10.0	6	8	72.7	11	3.61	255	83.61	84	5687	7.6	5	6	54.5
2018	18	6.9	227	87.0	55	5217	3.1	5	10	55.6	15	4.92	270	88.52	50	5737	3.3	5	11	73.3
2019	20	7.7	247	94.6	59	5276	3.0	5	8	40.0	20	6.56	290	95.08	59	5796	3.0	5	8	40.0
2020	14	5.4	261	100.0	36	5312	2.6	4	3	21.4	15	4.92	305	100.00	31	5827	2.1	3	3	20.0
	261	100			5313		20.36	44	75	28.7	305	100			5827		19.11	46	80	26.2

Note: fi, frequency (number of articles published); %hi, relative frequency; Fi, accumulated absolute frequency; %Hi, accumulated relative frequency; C, citations received; ∑C, accumulated citations received; $\overline{X}$, average; h-ind, Hirsch's index; OA, open access. Source: own elaboration.

Price [68] enunciated "Price's Law of Exponential Growth" in which he states that the growth of scientific information has the form of a "logistic curve", so that every 10–15 years, it doubles until it reaches its saturation limit (Price's law). In that period, it will go through several stages: precursors (first publications); exponential growth (becomes the focus of research); and linear growth (growth slows down, knowledge review and file).

Expressed mathematically [68]:

$$N = N_0 * e^{x*b} \tag{3}$$

where:

N—measured magnitude related to size,
N_0—magnitude measured at time t = 0,
b—constant relating the growth speed to the size already acquired.

For the specific case of the study of the scientific production of articles on the *Water Market*, the graphical representation of the curve and the growth equation is shown in Figure 3.

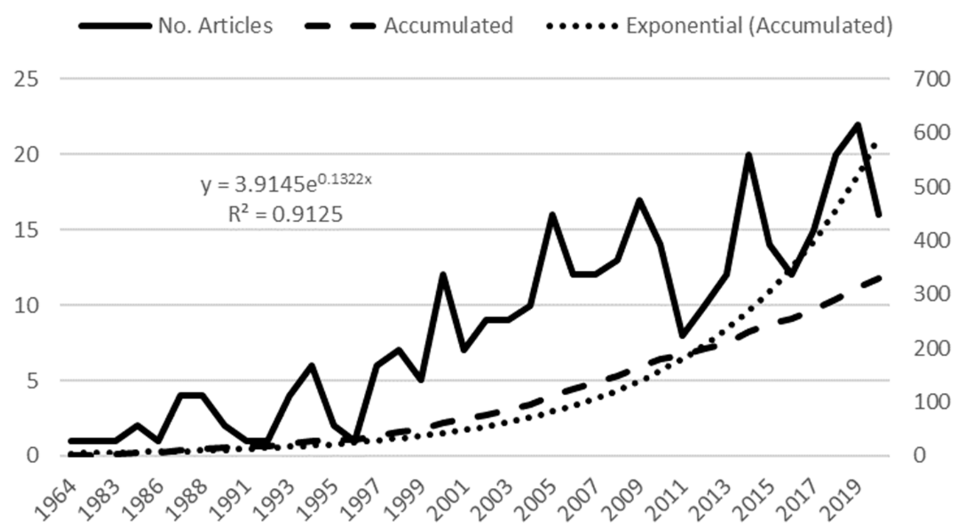

Figure 3. Growth curve and equation for the production of articles on the Water Market. Source: own elaboration.

Two other parameters associated with exponential growth are:

1. Doubling Time (D): equal periods of time between which the magnitude studied grows twice.

$$D = \frac{Ln2}{b} \rightarrow D = \frac{Ln2}{0.1322} = 5.24\ years \tag{4}$$

The result of 5.24 years is the time it has taken for the number of articles on the *Water Market* to double in the analysed period (1964–2020).

2. Annual Growth Rate (R) represents how much the magnitude has grown with respect to the previous year, expressed as a percentage.

$$R = 100 * \left(e^b - 1\right) \rightarrow R = 100 * \left(e^{0.1322} - 1\right) \rightarrow R = 14.13\% \tag{5}$$

In other words, the annual growth rate is 14.13%.

Figure 4 shows the existence of a strong connection between both databases, this correlation, and its fit to a straight line with a coefficient equal to 0.94 (R^2 = 0.8882), i.e., this straight line explains 89% of the relationship between the number of articles published per year.

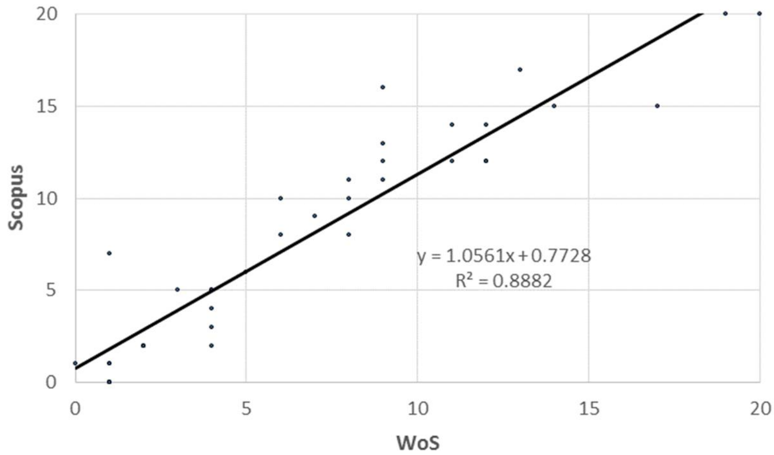

Figure 4. Correlation between the number of articles published per year in WoS and Scopus. Source: own elaboration.

4.4. Citation Analysis

In the period between 1969 and 2020, the 261 papers collected in WoS received a total of 5313 citations, with an average of 20.36 citations/article and an h-index of 44, while the 5827 documents indexed in Scopus were cited on a total of 5827 occasions, with an average of 19.11 citations/article and an h-index of 46. It should be noted that no article will achieve its maximum average citation until a period of 10 years has elapsed [69].

Focusing on the evolution of the number of citations that the documents receive each year, Figure 5 shows a steady growth from 2009 onwards in the number of citations received, with 1569 (29.53%) and 1534 (26.33%) citations in WoS and Scopus, respectively, in the last three years (2018–2020). As with the study of production, there is a strong correlation between WoS and Scopus regarding the number of citations received per year with $R^2 = 0.9684$.

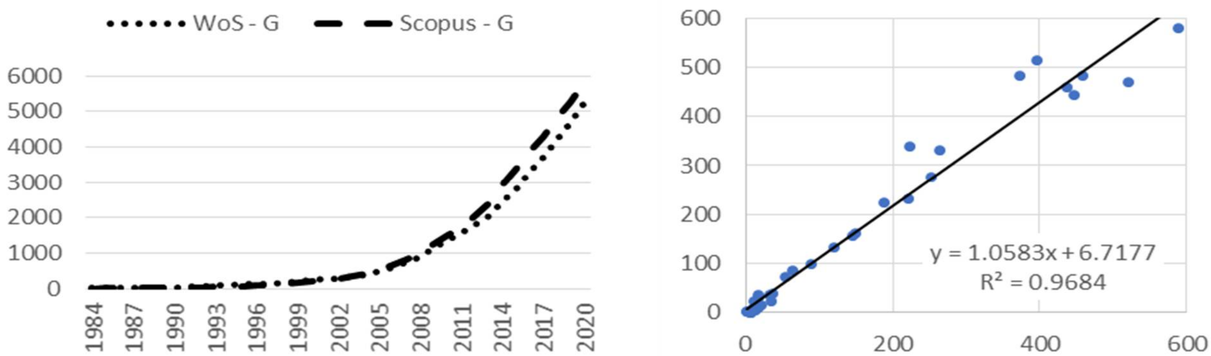

Figure 5. Growth and correlation of citations received by articles on the Water Market. Source: own elaboration.

It is observed that only 1.15% (3) of WoS articles and 0.98% (3) of Scopus articles received more than 100 citations; 9.58% (25) and 12.13% (37), respectively, between 50 and 100 citations; 40.23% (105) and 35.41% (108) between 10 and 49 citations; and 39.46% (103) and 118 (38.69) between 1 and 9 citations. Additionally, 9.58% (25) of WoS articles and 12.79% (39) of Scopus articles did not receive any citations.

The ranking of the articles according to the number of citations received (Table 7) shows that there are three papers that stand out from the rest in both WoS and Scopus due to exceeding the figure of 100 citations received in both databases: Innovative Approaches to Water Allocation: The Potential for Water Markets [32] with 207 and 243 citations, respectively, followed by Bringing Water Markets Down to Earth: The Political Economy of Water Rights in Chile, 1976–1995 [23] with 146 and 182 citations, and An Integrated Assessment of Water Markets: A Cross-Country Comparison [9] with 112–134 citations; this last one is also the best average, with 12.44 and 14.89 citations/year (Table 7).

Table 7. Ranking of the most-cited articles on the Water Market in the WoS and Scopus databases.

Author/s	Year	Age	Title	WoS			Scopus		
				R	C	C/Age	R	C	C/Age
Howe, C.W. Schurmeier, D.R. Shaw, W.D. [32]	1986	34	Innovative Approaches to Water Allocation: The Potential for Water Markets	1	207	6.09	1	243	7.15
Bauer, C.J. [70]	1997	23	Bringing Water Markets Down to Earth: The Political Economy of Water Rights in Chile, 1976–1995	2	146	6.35	2	182	7.91
Grafton, R.Q. Libecap, G. McGlennon, S. Landry, C. O'Brien, B. [16]	2011	9	An Integrated Assessment of Water Markets: A Cross-Country Comparison	3	112	12.44	3	134	14.89
Chong, H. Sunding, D. [13]	2006	14	Water Markets and Trading	4	94	6.71	-	-	-
Garrick, D. Siebentritt, M.A. Aylward, B. Bauer, C.J. Purkey, A. [6]	2009	11	Water Markets and Freshwater Ecosystem Services: Policy Reform and Implementation in the Columbia and Murray-Darling Basins	5	85	7.73	7	89	8.09
Wheeler, S. Loch, A. Zuo, A. Bjornlund, H. [71]	2013	7	Reviewing the Adoption and Impact of Water Markets in the Murray-Darling Basin, Australia	6	82	11.71	6	92	13.14
Hearne, R.R. Easter, K.W. [72]	1997	23	The Economic and Financial Gains from Water Markets in Chile	7	80	3.48	4	96	4.17
Garrick, D. Whittern, S.M. Coggan, A. [46]	2013	7	Understanding the Evolution and Performance of Water Markets and Allocation Policy: A Transaction Costs Analysis Framework	8	80	11.43	8	87	12.43
Luo, B. Maqsood, I. Yin, Y.Y. Huang, G.H. Cohen, S.J. [73]	2003	17	Adaption to Climate Change through Water Trading under Uncertainty—An Inexact Two-Stage Nonlinear Programming Approach	9	79	4.65	-	-	-
Islam, M.S. Oki, T. Kanae, S. Hnansaki, N. Agata, Y. Yoshimura, K. [74]	2007	13	A Grid-Based Assessment of Global Water Scarcity including Virtual Water Trading	10	74	5.69	15	80	6.15
Bjornlund, H. McKay, J. [75]	2002	18	Aspects of Water Markets for Developing Countries: Experiences from Australia, Chile, and the US	13	69	3.83	9	83	4.61
Brewer, J. Glennon, R. Ker, A. Libecap, G. [76]	2008	12	2006 Presidential Address Water Markets in the West: Prices, Trading, and Contractual Forms	14	68	5.67	5	94	7.83
Weinber, M. Kling, C.L. Wilen, J.E. [77]	1993	27	Water Markets and Water Quality	15	68	2.52	10	81	3.00

4.5. Authors

According to the theory put forward by Lotka [78], two authors are considered to be large producers, as they have published more than 10 articles in the field: Bjornlund, H., with 14, and Wheeler, S.A., with 12. Following the classification made by this author, only 17.19% (99) of them are intermediate producers with between 2 and 9 authorships, while practically all of the authors, 475 (82.42%), are transient with a single authorship. This low production by authors results in a Productivity Index close to 1 (1.36). Table 8 shows the ranking of the most productive authors, whose top positions are held by Bjornlund and Wheeler, followed by Zuo, A. and Howitt, R.E., with nine and eight authorships, respectively.

Table 8. Ranking of the most productive authors in the Water Market area in WoS and Scopus with more than five authors.

R.	Name	Affiliation	Country	Tfi	WoS						Scopus					
					fi	LA	SA	C	C/fi	h	fi	LA	SA	C	C/fi	h
1	Bjornlund, H.	University of South Australia	Australia	14	9	2	3	378	42.0	7	14	4	5	525	37.5	10
2	Wheeler, S.A.	University of South Australia	Australia	12	11	5	0	236	21.5	6	12	4	0	256	21.3	6
3	Zuo, A.	University of Adelaide	Australia	9	8	3	0	137	17.1	5	9	3	0	147	16.3	4
4	Howitt, R.E.	University of California	United States	8	6	0	1	213	35.5	6	8	1	2	277	34.6	7
5	Garrick, D.E.	University of Oxford	United Kingdom	7	7	3	0	243	34.7	6	6	3	0	251	41.8	5
-	Huang, G.H.	North China Electric Power University	China	7	7	0	0	170	24.3	8	6	0	0	92	15.3	5
7	Garrido, A.	Universidad Politécnica de Madrid	Spain	6	6	0	3	202	33.7	5	6	0	3	218	36.3	5
-	Harris, E.	Monash University	Australia	6	5	0	1	105	21.0	4	6	0	1	119	19.8	4
-	Libecap, G.	University of California	United States	6	4	0	2	235	58.8	4	6	0	2	294	49	4

Note: R., rank; Tfi, frequency (number of articles published); LA, lead author; SA, second author; C, the total number of citations received by the published articles; C/fi, average citations received by the published articles; h, Hirsch's index. Source: own elaboration.

On the other hand, Table 9 presents the ranking of the countries with affiliated authors who have contributed the greatest number of articles. Here, it can be seen that the United States stands out in both databases with 41.0% (107) of the papers in WoS and 32.79% (100) in Scopus, followed by Australia with 22.99% (60) and 24.59% (75), respectively. Some distance behind are China with 8.81% (23) and 9.51% (29) and Spain with 8.43% (22) and 7.21% (22). If the ranking of countries is based on the number of citations, the top two positions are still held by the United States, with 2605 and 2291 citations, respectively, and Australia with 1640 and 1958, with a change in the third position, which would be held by the United Kingdom with 523 citations in WoS and 593 in Scopus.

Table 9. Most prominent countries in the production of articles on the Water Market.

R.	Country	WoS					R.	Country	Scopus				
		fi	hi%	C	C/fi	h			fi	hi%	C	C/fi	h
1	United States	107	41.00%	2605	24.35	30	1	United States	100	32.79%	2291	22.91	26
2	Australia	60	22.99%	1640	27.33	25	2	Australia	75	24.59%	1958	26.11	27
3	China	23	8.81%	259	11.26	8	3	China	29	9.51%	260	8.97	7
4	Spain	22	8.43%	431	19.59	11	4	Spain	22	7.21%	480	21.82	12
5	United Kingdom	15	5.75%	523	34.87	9	5	United Kingdom	19	6.23%	593	31.21	9
6	Canada	14	5.36%	370	26.43	9	6	Canada	15	4.92%	342	22.80	9
7	France	8	3.07%	61	7.63	4	7	South Africa	10	3.28%	164	16.40	6
8	Germany	5	1.92%	32	6.40	2	8	France	9	2.95%	60	6.67	4
9	South Africa	5	1.92%	132	26.40	5	9	Germany	7	2.30%	42	6.00	2
10	India	5	1.92%	44	8.80	3	10	India	6	1.97%	25	4.17	2

Note: R., rank; fi, frequency (number of articles published); hi%, relative frequency; C, the total number of citations received by the published articles; C/fi, average citations received by the published articles; h, Hirsch's index. Source: own elaboration.

The data allow us to affirm that in the water market, there is a high degree of collaboration between researchers (Collaboration Index of 2.38 together with a degree of collaboration of 67.48%). Although almost two thirds of the papers are multi-authored, 73.87% of them are written by two or three authors (49.85% of the total number of articles). The very high Transience Index of the authors (82.47%) is noteworthy, revealing that the vast majority of authors have only contributed one paper.

4.6. Journals

Bradford's scientific literature dispersion law [79] postulates as a hypothesis that most of the documents on a subject or specialised area could be published by a small number of journals dedicated to that subject (Bradford Core), together with other journals called border and others, called general or dispersion. To identify this group of journals, the Minimum Zone (*MBZ*) is used; the number of articles is equal to half the number of journals that produce a single article ($MBZ_{WoS} = 32\ y\ MBZ_{Scopus} = 44$), and the ranking of journals is arranged in descending order of productivity. The Bradford Core is made up of those journals whose sum of articles was equal to the MBZ. In the *Water Market* (Table 10), this core is made up of only two journals in the case of WoS and three in the case of Scopus.

Table 10. Classification of journals according to the number of articles they include about the Water Market.

Journals	WoS							Scopus						
	R	fi	OA	hi%	C	h	Q	R	fi	OA	hi%	C	h	Q
Water Resources Research	1	25	13	9.6	841	14	Q1	1	25	13	8.20	763	15	Q1
Water Policy	2	12	6	4.6	154	6	Q4	2	16	6	5.25	221	9	Q2
Agricultural Water Management	3	12	2	4.6	355	8	Q1	3	13	3	4.26	375	8	Q1
Water (Switzerland)	4	9	9	3.4	92	5	Q2	4	9	9	2.95	91	5	Q1
American Journal of Agricultural Economics	5	8	3	3.1	228	7	Q1	6	8	3	2.62	268	8	Q1
Australian Journal of Agricultural and Resource Economics	6	8	8	3.1	250	7	Q2	7	8	8	2.62	300	7	Q2
Water International	7	8	-	3.1	85	4	Q2	5	9	-	2.95	110	7	Q2
International Journal of Water Resources Development	8	7	3	2.7	112	5	Q1	8	7	3	2.30	136	5	Q1
Water Resources Management	9	6	1	2.3	122	6	Q2	9	6	1	1.97	128	6	Q1
Journal of the American Water Resources Association	10	6	-	2.3	102	4	Q2	10	6	-	1.97	120	5	Q1

Note: R., rank; fi, frequency (number of articles published); hi%, relative frequency; C, the total number of citations received by the published articles; h, Hirsch's index; OA, open access. Source: own elaboration.

In order to quantify the degree of inequality in the distribution of a magnitude among a given number of "units", the Lorenz Curve (Figure 6) and the Gini Concentration Index are analysed. These two indices are valid instruments for analysing the greater or lesser concentration in the distribution of articles among the different journals in which they are published.

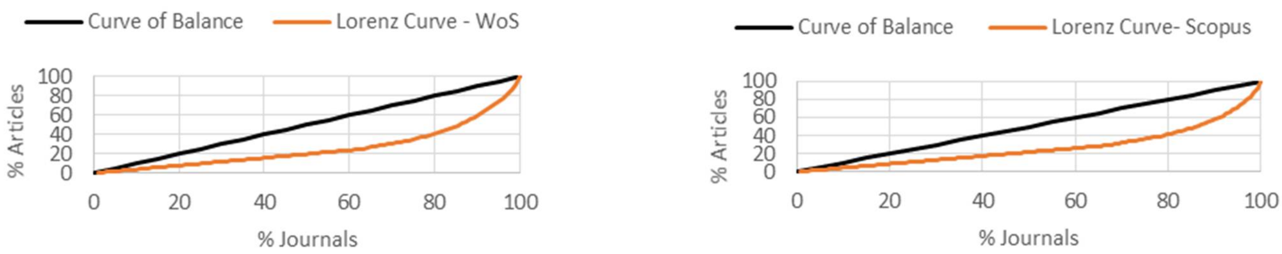

Figure 6. Lorenz curves (distribution of number of articles in journals in which they are published).

Regarding the Gini index, its value is between 0 and 1, with zero being the maximum equality (all journals publish the same number of articles) and 1 the maximum inequality (all articles belong to a single journal).

$$I_g = \sum_{i=1}^{r-1} (p_i - q_i) / \sum_{i=1}^{r-1} p_i \tag{6}$$

q_i = cumulative evolution of articles expressed in percentages,
p_i = cumulative evolution of journals expressed in percentages,
$I_g(Scopus)$ = 0.4711,
$I_g(WoS)$ = 0.4891,
As I_g (*WoS*) ≈ I_g (*Scopus*), and is located at the midpoint of the value.

There is not great equality in the distribution of articles among the journals, i.e., there is a large number of journals that, in total, do not publish a high percentage of papers. This fact corroborates the previous result of the Bradford Core, where it was mentioned that a small number of journals published most of the articles.

WoS and Scopus have, so far, been compared through their different fields. In the specific case of the thematic areas, it is complex, since the classification of journals differs (Table 11). Despite this fact, there are certain similarities: in both WoS and Scopus, most of the papers fall into the categories related to the environment, and more specifically, to water resources (as was to be expected), with economics and business and everything related to agriculture, which is greatly affected by fluctuations in *Water Markets*, also occupying a prominent place.

Table 11. Main subject areas in which articles on the Water Market are classified.

WoS						Scopus					
Area	**fi**	**hi%**	**C**	**C/fi**	**h**	**Area**	**fi**	**hi%**	**C**	**C/fi**	**h**
Water Resources	129	0.49	2331	18.07	27	Environmental Science	213	0.70	3986	18.71	37
Environmental Sciences Ecology	110	0.42	2584	23.49	32	Social Science	107	0.35	1655	15.47	23
Business Economics	74	0.28	2062	27.86	30	Economics; Econometrics and Finance	83	0.27	2365	28.49	31
Engineering	45	0.17	660	14.67	15	Agricultural and Biological Sciences	64	0.21	1540	24.06	23
Agriculture	44	0.17	1191	27.07	22	Earth and Planetary Sciences	28	0.09	646	23.07	15
Marine Freshwater Biology	25	0.10	841	33.64	14	Engineering	21	0.07	239	11.38	8
Geology	16	0.06	344	21.50	10	Business; Management and Accounting	18	0.06	255	14.17	8
Government Law	15	0.06	165	11.00	8	Biochemistry; Genetics and Molecular Biology	10	0.03	92	9.20	5

Note: fi, frequency (number of articles published); hi%, relative frequency; C, the total number of citations received by the published articles; C/fi, average citations received by the published articles; h, Hirsch's index. Source: own elaboration.

5. Conclusions

The main conclusions reached in the bibliometric study on research concerning the *Water Market* are summarised below. As a consequence of the disparate indexing policy carried out by both bases, the data from the comparative study of overlap and singularity carried out with the aim of determining which of them is more convenient to use in the field of the Water Market is also included. The results obtained in the analysis show a strong correlation in articles and citations between both databases. However, as in other areas [80], it is Scopus that provides greater coverage (22% of unique documents and 91% of overlap with the WoS database).

The first conclusion drawn from the bibliometric indicators used is that research on the *Water Market* has been developing homogeneously since the early 1990s, becoming a topical issue in the last 5 years, during which about 25% of the total number of articles were published (329 in the last 50 years). The subject is in the exponential growth phase within the research life cycle, so it is likely that interest in the area will continue in the coming years.

Bjornlund (14 publications) and Wheeler (12 publications) are the authors considered to be large producers, as they have published more than 10 articles. Only 17.19% (99) of them are intermediate producers with 2–9 authorships, while practically all authors, 475 (82.42%), are transient, with only one authorship. This low production by authors results in a Productivity Index close to 1.

A Collaboration Index of 2.38, together with a degree of collaboration of 67.48%, gives an approximate idea of the high level of collaboration between researchers. Although two thirds of the documents are of multiple authorship, half of the total are written by two or three authors. It is worth noting the very high transience authorship index, revealing that 9 out of 10 authors have only contributed one paper.

On the other hand, the ranking of the countries with affiliated authors who have contributed the highest number of articles is led in both cases by the United States, followed by Australia. At some distance behind are China and Spain. If this ranking of countries is made according to the number of citations, the top two positions are still held by the

United States and Australia, producing a change in the third position, since it would be occupied by the United Kingdom.

A small number of journals group most of the articles published on the *Water Market*, with Water Resources Research and Water Policy standing out—a fact that, together with the value of the Gini Index, confirms the unequal distribution of articles among the journals.

Although it is possible to make a clear comparison between WoS and Scopus in aspects such as production or citation, it is more difficult to compare the thematic areas in which the journals are classified, as there is no clear correspondence in the name and content between the databases. Despite this fact, there are certain similarities from which some conclusions can be drawn. In both WoS and Scopus, most of the papers fall into categories related to the environment, and more specifically, to water resources (as was to be expected), with economy and business also occupying a prominent place, as well as everything related to agriculture, which is affected by fluctuations in *Water Markets*.

In summary, this research topic is incipient and there is still a long way to go in its investigation from multiple scientific areas such as social sciences (economics and business, law, political science, social and economic geography), agricultural sciences, and environmental sciences. There are many research approaches, among which are the study of the particularities of water markets in different countries and comparative experiences, their study as a tool for water resource management and their role in the management of scarce resources, the economics and finance of water markets, the role in integrated water management, institutional frameworks, models for the efficient economic allocation of water markets, water markets versus informal markets, water markets and public management, and water markets and their economic, social, and environmental impact.

Although bibliometric studies are used as tools capable of analysing the main trends in a field of study, the interpretation of their results is not exempt from certain limitations. On the one hand is the choice of databases together with the bias implied by the use of a particular search equation and, on the other hand, is that the intention was not to evaluate the quality of the content of the selected documents, but to carry out a descriptive comparative analysis of them with the help of their number of citations.

Author Contributions: Conceptualization, data gathering, simulations, numerical tests, methodology, formal analysis, investigation, writing—original draft preparation, and writing—review and editing, A.D.-S.; M.d.l.C.d.R.-R., J.Á.-G. and M.T.C.-H. All authors have read and agreed to the published version of the manuscript.

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