mathematics

Review

A Bibliometric Review of the Ordered Weighted Averaging Operator

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Abstract: The ordered weighted averaging (OWA) operator was proposed by Yager back in 1988 and constitutes a parameterized family of aggregation functions between the minimum and the maximum. The purpose of this paper is to perform a bibliometric review of this aggregation operator during the last 35 years through the Web of Science (WoS) Core Collection database and the Visualization of Similarities (VOS) viewer software. The results show that the OWA operator is an increasingly popular aggregation operator, especially in Computer Science. The results also allow the assertion that Yager, as expected, is still the most influential and productive author. Moreover, the study reveals that institutions from over 80 countries have contributed to OWA research, highlighting the high presence of Chinese universities and the emergence of Pakistani ones. Other interesting findings are presented to provide a comprehensive and up-to-date analysis of the OWA operator literature.

Keywords: aggregation operator; bibliometric analysis; OWA operator; VOS viewer; Web of Science

MSC: 68-02

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1. Introduction

Aggregation can be described as the process of combining multiple values into a single representative one, and an aggregation operator or function conducts this operation [1,2]. The ordered weighted averaging (OWA) operator was presented by Yager [3] and provides a parameterized class of aggregation operators, ranging from the minimum to the maximum. Moreover, the OWA operator is equivalent to a Choquet integral with respect to a symmetric fuzzy measure [4]. Since its appearance, this operator has been applied to various problems [5,6], especially in decision-making. See, for instance, the works of Cheng et al. [7] and Xie et al. [8].

Likewise, the OWA operator has also been widely extended. Some well-known extensions are the induced OWA (IOWA) operator [9], the heavy OWA (HOWA) operator [10], the generalized OWA (GOWA) operator [11], the quasi OWA (QOWA) operator [12], the uncertain OWA (UOWA) operator [13], the linguistic OWA (LOWA) operator [14,15], and the OWA distance (OWAD) operator [16]. Scholars have also studied the OWA operator on partially ordered sets (posets) or lattices [17,18].

Research on OWA operators is abundant, as well as on other disciplines. Hence, bibliometric analysis is becoming more commonplace as it allows to quantitatively analyze large amounts of bibliographic information [19]. Accordingly, bibliometric studies have been carried out in a wide variety of fields, including economy [20], blockchain [21], healthcare [22], and scientific journals [23].

Furthermore, in [24], the authors conducted an interesting bibliometric analysis of the OWA operator for the period of 1988–2015, and in [25] during the years 1988–2014. Recently, Yu et al. [26] carried out a main path analysis to explore the development trajectories of the

OWA operator. Also, in [27], the researchers prepared a survey of aggregation operators as a whole.

The main objective of this paper is to provide a comprehensive and up-to-date state-of-the-art of the OWA operator knowledge domain. It aims to explore the most active and influential research constituents, identify research trends, and detect potential collaborations, among others. In order to achieve this, a bibliometric analysis of the OWA operator between the years 1988 and 2022 is developed using the Web of Science (WoS) Core Collection database in conjunction with the Visualization of Similarities (VOS) viewer software (version 1.6.18) [28].

With regard to [24–26], this article discusses additional items, among others, the citation composition, the percentage of OWA-related publications within a journal, and the temporal evolution of the leading countries. Also, a different retrieval strategy has been followed.

This paper is structured as follows. Section 2 reviews the methodology followed and data collection. Section 3 presents the obtained results. Primarily, the publication and citation structure, the major authors/institutions/countries/journals/research areas (from both static and dynamic perspectives), and the co-citation, co-occurrence, and bibliographic coupling networks. Section 4 provides a detailed discussion of the findings and limitations. Finally, Section 5 summarizes the main conclusions.

2. Methodology and Data

When conducting a bibliometric analysis, it is critical to choose the right bibliometric indicators [29,30]. This study considers different types of indicators, which are the number of documents published, the number of citations, and the h index, among others. The number of publications and citations are used to evaluate the productivity and influence, respectively, while the h index unifies these two. The h index was proposed by Hirsch [31] and can be interpreted as the number of documents that have h or more citations.

Currently, there are several databases for conducting a bibliometric analysis, such as Scopus, PubMed, WoS, Google Scholar, and dblp. This study uses the WoS Core Collection to collect all the scientific data. As of the date of this review, the WoS is owned by the company Clarivate Analytics.

The retrieval strategy was carried out as follows. The search topics were “ordered weighted averag*”, “OWA operator*”, “OWA function*”, and “OWA aggregat*”. The selection of these terms widens the search scope while ensuring the exclusion of inaccurate outcomes; for instance, the acronym OWA is also used to denote “ocean warming and acidification”. The asterisk (*) is employed in order to represent any group of characters, including no character. For example, searching for “ordered weighted averag*” will find “ordered weighted averaging”, “ordered weighted average”, and more. The time range applied was 1988–2022. This search was conducted in November 2023 and a total of 2808 publications were found. However, this number was reduced to 2191 publications, as only articles (2175), review articles (13), notes (2), and letters (1) were considered.

Additionally, the software VOS viewer was employed to provide a more comprehensive view of the bibliometric networks. Specifically, maps were drawn up in terms of co-citation, keyword co-occurrence, and bibliographic coupling. Co-citation can be described as the frequency with which two documents are cited in conjunction [32]. With regard to co-occurrence, the number of co-occurrences of two keywords is the number of documents in which both keywords appear jointly [33]. Bibliographic coupling refers to the relationship between two documents when they both reference the same third document [34]. Lastly, indicate that in some cases, the VOS viewer thesaurus file was operated to perform data cleaning.

3. Results

3.1. Publication and Citation Structure

The annual evolution of the number of documents published in OWA is exhibited in Figure 1. The graph line shows a clear growing trend. Additionally, it can be seen that most of the documents have been published during the last decade. Also, a total of 197 documents published in OWA were reached during the peak year of 2019. While in the last year analyzed, that is, 2022, 182 documents were recorded.

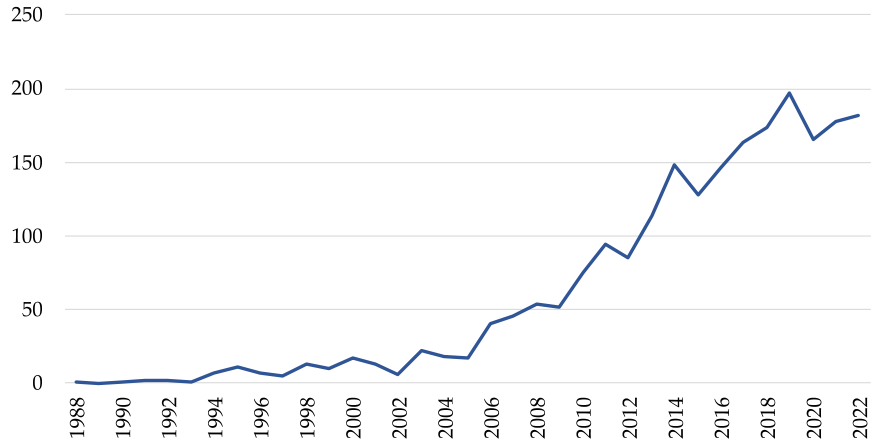

Figure 1. Evolution of the annual number of documents published in OWA.

Another interesting issue is the citation structure in OWA within the WoS Core Collection, which is shown in Table 1. There is only one document that exceeds the 5000 citations. Specifically, it is the letter "*On ordered weighted averaging aggregation operators in multicriteria decisionmaking*", written by Yager in 1988 [3]. Likewise, there are three documents with between 1000 and 5000 citations. Although, most of the documents have between 0 and 25 citations, equivalent to approximately 64% of the total.

Table 1. Citation structure in OWA.

TC	TP	% TP	TC	TP	% TP
[5000, +∞)	1	0.05%	≥5000	1	0.05%
[1000, 5000)	3	0.14%	≥1000	4	0.18%
[500, 1000)	11	0.50%	≥500	15	0.68%
[400, 500)	11	0.50%	≥400	26	1.19%
[300, 400)	9	0.41%	≥300	35	1.60%
[200, 300)	41	1.87%	≥200	76	3.47%
[100, 200)	125	5.71%	≥100	201	9.17%
[50, 100)	239	10.91%	≥50	440	20.08%
[25, 50)	339	15.47%	≥25	779	35.55%
[0, 25)	1412	64.45%	≥0	2191	100%

Source: own elaboration through WoS. Abbreviations: TC = total citations in OWA; TP = total publications in OWA; % TP = percentage of publications in OWA.

The thirty-five most cited documents ranged from 303 to 5126 citations, which can be seen in Table 2. This equates to an average of 714 citations per document and a median of 476. The most cited document is the already mentioned "*On ordered weighted averaging aggregation operators in multicriteria decisionmaking*" from Yager [3], published in the *IEEE Transactions on Systems, Man, and Cybernetics* journal in 1988. Concretely, it has been cited 5126 times until November 2023, which is 3206 citations more than the second most cited document. Considering that this publication introduces the OWA operator, it is not surprising that it is the most cited document.

Table 2. Top 35 most cited documents in OWA.

R	Article	Author	Journal	TC	PY
1	On ordered weighted averaging aggregation operators in multicriteria decision making	Yager, RR [3]	IEEE T Syst Man Cyb	5126	1988
2	Intuitionistic fuzzy aggregation operators	Xu, ZS [35]	IEEE T Fuzzy Syst	1920	2007
3	Linguistic decision analysis: Steps for solving decision problems under linguistic information	Herrera, F; Herrera-Viedma, E [36]	Fuzzy Set Syst	1221	2000
4	Hesitant fuzzy information aggregation in decision making	Xia, MM; Xu, ZS [37]	Int J Approx Reason	1216	2011
5	Families of OWA operators	Yager, RR [38]	Fuzzy Set Syst	926	1993
6	Quantifier guided aggregation using OWA operators	Yager, RR [39]	Int J Intell Syst	892	1996
7	Induced ordered weighted averaging operators	Yager, RR; Filev, DP [9]	IEEE T Syst Man Cy B	810	1999
8	A model based on linguistic 2-tuples for dealing with multigranular hierarchical linguistic contexts in multi-expert decision-making	Herrera, F; Martínez, L [40]	IEEE T Syst Man Cy B	716	2001
9	An overview of operators for aggregating information	Xu, ZS; Da, QL [41]	Int J Intell Syst	663	2003
10	Uncertain linguistic aggregation operators based approach to multiple attribute group decision making under uncertain linguistic environment	Xu, ZS [42]	Inform Sciences	657	2004
11	A fusion approach for managing multi-granularity linguistic term sets in decision making	Herrera, F; Herrera-Viedma, E; Martínez, L [43]	Fuzzy Set Syst	631	2000
12	Integrating three representation models in fuzzy multipurpose decision making based on fuzzy preference relations	Chiclana, F; Herrera, F; Herrera-Viedma, E [44]	Fuzzy Set Syst	620	1998
13	An overview of methods for determining OWA weights	Xu, ZS [45]	Int J Intell Syst	589	2005
14	A consensus model for group decision making with incomplete fuzzy preference relations	Herrera-Viedma, E; Alonso, S; Chiclana, F; Herrera, F [46]	IEEE T Fuzzy Syst	522	2007
15	Some induced geometric aggregation operators with intuitionistic fuzzy information and their application to group decision making	Wei, GW [47]	Appl Soft Comput	515	2010
16	A sequential selection process in group decision making with a linguistic assessment approach	Herrera, F; Herrera-Viedma, E; Verdegay, JL [14]	Inform Sciences	491	1995
17	Group decision-making model with incomplete fuzzy preference relations based on additive consistency	Herrera-Viedma, E; Chiclana, F; Herrera, F; Alonso, S [48]	IEEE T Syst Man Cy B	482	2007
18	A new generalized Pythagorean fuzzy information aggregation using Einstein operations and its application to decision making	Garg, H [49]	Int J Intell Syst	476	2016
18	Dynamic intuitionistic fuzzy multi-attribute decision making	Xu, ZS; Yager, RR [50]	Int J Approx Reason	476	2008
18	The weighted OWA operator	Torra, V [51]	Int J Intell Syst	476	1997
21	Application of fuzzy measures in multi-criteria evaluation in GIS	Jiang, H; Eastman, JR [52]	Int J Geogr Inf Sci	449	2000

Table 2. *Cont.*

R	Article	Author	Journal	TC	PY
22	The uncertain OWA operator	Xu, ZS; Da, QL [13]	Int J Intell Syst	441	2002
23	Generalized aggregation operators for intuitionistic fuzzy sets	Zhao, H; Xu, ZS; Ni, MF; Liu, SS [53]	Int J Intell Syst	417	2010
23	On the issue of obtaining OWA operator weights	Filev, DP; Yager, RR [54]	Fuzzy Set Syst	417	1998
25	A linguistic modeling of consensus in group decision making based on OWA operators	Bordogna, G; Fedrizzi, M; Pasi, G [55]	IEEE T Syst Man Cy A	415	1997
26	Consistency and consensus measures for linguistic preference relations based on distribution assessments	Zhang, GQ; Dong, YC; Xu, YF [56]	Inform Fusion	400	2014
27	Induced uncertain linguistic OWA operators applied to group decision making	Xu, ZS [57]	Inform Fusion	376	2006
28	The induced generalized OWA operator	Merigó, JM; Gil-Lafuente, AM [58]	Inform Sciences	375	2009
29	An approach for combining linguistic and numerical information based on the 2-tuple fuzzy linguistic representation model in decision-making	Herrera, F; Martínez, L [59]	Int J Uncertain Fuzz	371	2000
30	Induced aggregation operators	Yager, RR [60]	Fuzzy Set Syst	323	2003
30	Ordered weighted averaging with fuzzy quantifiers: GIS-based multicriteria evaluation for land-use suitability analysis	Malczewski, J [61]	Int J Appl Earth Obs	323	2006
32	Intuitionistic fuzzy Choquet integral operator for multi-criteria decision making	Tan, CQ; Chen, XH [62]	Expert Syst Appl	320	2010
33	OWA aggregation over a continuous interval argument with applications to decision making	Yager, RR [63]	IEEE T Syst Man Cy B	317	2004
34	Some Hamacher aggregation operators based on the interval-valued intuitionistic fuzzy numbers and their application to group decision making	Liu, PD [64]	IEEE T Fuzzy Syst	305	2014
35	Direct approach processes in group decision making using linguistic OWA operators	Herrera, F; Herrera-Viedma, E; Verdegay, JL [65]	Fuzzy Set Syst	303	1996

Source: own elaboration through WoS. Abbreviations are available in Table 1 except for the following: R = ranking; PY = publication year.

The second most influential publication comprising the OWA topic was written by Xu [35] and is entitled "*Intuitionistic fuzzy aggregation operators*". In this document, the author developed different types of aggregation operators for aggregating intuitionistic fuzzy information. One of them is the intuitionistic fuzzy OWA (IFOWA) operator, which extends the OWA operator by using intuitionistic fuzzy values.

In the third position appears the document "*Linguistic decision analysis: Steps for solving decision problems under linguistic information*", prepared by the authors Herrera and Herrera-Viedma [36]. This document describes the steps for addressing a multi-criteria decision-making (MCDM) problem with linguistic information, including an analysis of the LOWA operator.

3.2. Leading Authors in OWA

Since Yager introduced the OWA operator, many authors and himself have made several contributions. Table 3 lists the top 50 authors with the most publications in OWA for the last 35 years. We can see that Yager, followed by Merigó, are by large the authors with the highest numbers of published documents. Specifically, they contributed with

130 and 128 publications, respectively. They have the highest h indices in the ranking too. The study further shows that the researcher Mesiar ranks third with 62 publications. The average number of citations per publication achieved by Herrera is also noteworthy, with a value of 264.70.

Table 3. Top 50 most productive authors in OWA.

R	Author	TP	TC	Avg	h	≥500	≥100	≥50
1	Yager, RR	130	14,333	110.25	46	4	21	40
2	Merigó, JM	128	5255	41.05	39	0	14	32
3	Mesiar, R	62	1301	20.98	20	0	3	6
4	Xu, ZS	59	10,559	178.97	37	5	24	30
5	Zeng, SZ	47	1582	33.66	21	0	2	8
6	Jin, LS	45	560	12.44	14	0	0	0
7	Chen, HY	42	1472	35.05	24	0	3	8
8	Liu, XW	41	1597	38.95	21	0	4	11
8	Zhou, LG	41	1442	35.17	23	0	3	8
10	Wei, GW	40	3990	99.75	29	1	20	27
11	Herrera-Viedma, E	38	7709	202.87	30	4	21	28
12	Abdullah, S	37	790	21.35	14	0	1	4
13	Liu, PD	36	1705	47.36	19	0	4	9
14	Bustince, H	34	851	25.03	13	0	2	7
15	Gil-Lafuente, AM	31	1565	50.48	18	0	4	8
16	León-Castro, E	30	336	11.20	9	0	0	1
17	Mahmood, T	29	619	21.34	15	0	1	2
18	Chiclana, F	28	3810	136.07	22	2	13	20
19	Herrera, F	27	7147	264.70	21	5	16	19
20	Casanovas, M	23	1520	66.09	16	0	7	11
20	Garg, H	23	2213	96.22	19	0	6	15
22	Dong, YC	21	2425	115.48	16	0	11	12
23	Akram, M	20	729	36.45	15	0	1	5
23	Blanco-Mesa, F	20	262	13.10	8	0	0	2
23	Chen, XH	20	1376	68.80	14	0	4	9
23	Martínez, L	20	3239	161.95	15	2	8	12
27	Ahn, BS	19	467	24.58	13	0	0	3
27	Wang, JQ	19	984	51.79	15	0	2	7
27	Xu, YJ	19	814	42.84	13	0	4	4
30	Ali, Z	17	182	10.71	8	0	0	0
30	Liu, JP	17	476	28.00	13	0	1	2
30	Llamazares, B	17	269	15.82	9	0	0	1
30	Paternain, D	17	210	12.35	6	0	0	2
34	Beliakov, G	16	451	28.19	10	0	0	6
34	Torra, V	16	880	55.00	11	0	2	3
34	Xian, SD	16	303	18.94	11	0	0	0
37	Calvo, T	15	456	30.40	9	0	1	4
37	Rahman, K	15	225	15.00	9	0	0	0
39	Chen, ZS	14	445	31.79	8	0	1	3
39	Zarghami, M	14	314	22.43	10	0	0	2
41	Amin, F	13	350	26.92	9	0	0	3
41	Amin, GR	13	345	26.54	10	0	0	3
41	Cheng, CH	13	390	30.00	9	0	1	3
41	Su, WH	13	492	37.85	10	0	1	2
41	Wan, SP	13	642	49.38	12	0	2	5
46	Alajlan, N	12	197	16.42	9	0	0	0
46	Bordogna, G	12	597	49.75	6	0	1	2
46	Fahmi, A	12	337	28.08	8	0	0	3

Table 3. *Cont.*

R	Author	TP	TC	Avg	*h*	≥500	≥100	≥50
46	Kacprzyk, J	12	432	36.00	9	0	1	3
46	Wu, J	12	757	63.08	11	0	5	6
46	Yi, PT	12	67	5.58	4	0	0	0
46	Zhang, HY	12	846	70.50	11	0	2	7

Source: own elaboration through WoS. Abbreviations are available in Tables 1 and 2 except for the following: Avg = average citations per publication in OWA; *h* = *h* index only for works related to OWA; ≥500, ≥100, ≥50 = number of publications in OWA with equal or more than 500, 100, and 50 citations.

3.3. Leading Institutions in OWA

Next, Table 4 lists the most productive institutions in OWA. Note that institutions represent the author's affiliation at the time of publication. The study reveals that among the top 50 most productive institutions, 20 of them are from China, 6 from Spain, and 4 from Pakistan. Despite this, Iona College from the United States of America (USA) occupies the first position in the ranking with 134 publications. This is explained by the fact that Yager was, and still is, a professor at Iona College.

Table 4. Top 50 most productive institutions in OWA.

R	Institution	TP	TC	Avg	*h*	≥500	≥100	≥50
1	Iona College	134	14,374	107.27	46	4	21	40
2	U Barcelona	79	4266	54.00	34	0	14	28
3	Southeast U China	73	7732	105.92	36	4	17	30
4	Slovak U Technology Bratislava	70	1385	19.79	21	0	3	6
5	U Granada	62	9854	158.94	37	5	27	36
6	U Chile	61	1191	19.52	20	0	0	6
7	Nanjing Normal U	47	610	12.98	14	0	0	0
8	Abdul Wali Khan U	46	880	19.13	15	0	1	4
8	U Tehran	46	1080	23.48	20	0	0	6
10	Anhui U	43	1488	34.60	24	0	3	8
11	Public U Navarre	41	920	22.44	14	0	2	7
11	Sichuan U	41	2294	55.95	19	0	8	12
13	Central South U	38	1859	48.92	21	0	4	11
14	Shandong U Finance Economics	37	1747	47.22	19	0	4	9
15	U Technology Sydney	36	395	10.97	11	0	0	0
16	Hazara U	33	632	19.15	15	0	0	3
17	International Islamic U Pakistan	31	612	19.74	15	0	1	2
17	Zhejiang Wanli U	31	825	26.61	16	0	1	3
19	King Abdulaziz U	30	1668	55.60	16	0	9	11
20	U Manchester	29	1149	39.62	18	0	2	7
21	De Montfort U	28	3126	111.64	21	1	12	18
21	Palacky U Olomouc	28	230	8.21	7	0	0	0
21	U Jaen	28	3816	136.29	20	2	9	16
21	U Punjab	28	889	31.75	16	0	1	6
25	Zhejiang U Finance Economics	27	696	25.78	17	0	0	4
26	Sichuan Normal U	26	2022	77.77	19	0	11	13
27	Hohai U	25	997	39.88	14	0	5	5
27	Northeastern U China	25	429	17.16	10	0	0	3
27	U Valladolid	25	426	17.04	12	0	0	1
30	Ghent U	24	733	30.54	12	0	1	5
30	Ningbo U	24	860	35.83	14	0	1	5
30	Polish Academy Sciences	24	643	26.79	12	0	1	4
30	Thapar Institute Engineering Technology	24	2221	92.54	19	0	6	15
30	U Tabriz	24	981	40.88	15	0	3	6
35	Chinese Academy Sciences	23	440	19.13	11	0	0	2

Table 4. *Cont.*

R	Institution	TP	TC	Avg	*h*	≥500	≥100	≥50
35	Deakin U	23	760	33.04	11	0	2	8
35	Islamic Azad U	23	518	22.52	13	0	0	4
38	Catholic U Most Holy Conception	22	135	6.14	7	0	0	1
38	Chongqing U Arts Sciences	22	2142	97.36	19	1	9	15
38	King Saud U	22	292	13.27	13	0	0	0
38	U Ostrava	22	518	23.55	14	0	1	2
42	Army Engineering U Pla	20	1286	64.30	13	0	4	4
42	Beijing Institute Technology	20	372	18.60	12	0	0	1
42	U Trento	20	787	39.35	12	0	1	3
45	North China Electric Power U	19	316	16.63	10	0	0	2
45	Pedagogical Technological U Colombia	19	212	11.16	8	0	0	1
45	Wuhan U	19	501	26.37	10	0	1	3
45	Zhejiang Gongshang U	19	569	29.95	12	0	1	2
49	Polytechnic U Valencia	18	419	23.28	12	0	0	3
49	Southwest U China	18	492	27.33	11	0	0	4

Source: own elaboration through WoS. Abbreviations are available in Tables 1–3.

3.4. Leading Countries in OWA

More than 80 countries have published at least one document related to OWA operators. In Table 5, the most productive countries in OWA are highlighted. Nowadays, China is the leading contributor to the development of OWA research. In concrete terms, China has the largest number of publications, citations, and *h* indexes. Yet, the average number of citations per publication is lower compared to other countries, occupying the seventh place. The second country with the greatest number of publications as well as citations is Spain, with a record of 344 and 18,792, respectively. The USA, which has a total of 233 publications, ranks third.

Table 5. Top 40 most productive countries in OWA.

R	Country	TP	TC	Avg	*h*	≥500	≥100	≥50
1	China	972	42,136	43.35	102	6	107	215
2	Spain	344	18,792	54.63	68	5	48	86
3	USA	233	18,088	77.63	54	4	29	61
4	Iran	144	3401	23.62	33	0	3	20
5	Pakistan	143	3239	22.65	33	0	7	16
6	India	103	3288	31.92	28	0	6	18
7	United Kingdom	96	5837	60.80	40	1	18	37
8	Saudi Arabia	80	2294	28.68	23	0	9	12
9	Chile	77	1284	16.68	21	0	0	6
9	Italy	77	2472	32.10	23	0	5	13
11	Slovakia	76	1439	18.93	22	0	3	6
12	Australia	74	1826	24.68	21	0	4	12
13	Canada	66	2122	32.15	23	0	3	12
14	Czech Republic	59	1284	21.76	20	0	3	7
14	Poland	59	1648	27.93	22	0	3	12
16	Turkey	44	1327	30.16	16	0	5	8
17	South Korea	42	871	20.74	16	0	0	6
18	Mexico	36	347	9.64	10	0	0	0
19	France	34	936	27.53	16	0	1	5
20	Belgium	33	1068	32.36	15	0	2	6
21	Japan	28	1192	42.57	18	0	2	9
22	Malaysia	26	337	12.96	9	0	0	1
23	Colombia	25	290	11.60	9	0	0	2
24	Brazil	22	589	26.77	10	0	1	5

Table 5. *Cont.*

R	Country	TP	TC	Avg	*h*	≥500	≥100	≥50
25	Finland	17	551	32.41	10	0	1	3
25	Germany	17	742	43.65	11	0	3	5
25	Hungary	17	907	53.35	9	0	3	4
28	Oman	16	377	23.56	10	0	1	2
29	Greece	14	298	21.29	8	0	1	2
29	Thailand	14	205	14.64	8	0	0	0
31	Austria	13	870	66.92	11	0	4	5
31	Serbia	13	105	8.08	6	0	0	0
33	Netherlands	12	457	38.08	9	0	2	3
34	Algeria	10	77	7.70	5	0	0	0
34	Egypt	10	74	7.40	6	0	0	0
34	Lithuania	10	301	30.10	9	0	0	2
37	Argentina	8	76	9.50	7	0	0	0
37	Cuba	8	102	12.75	5	0	0	1
39	Denmark	7	116	16.57	6	0	0	0
39	Ireland	7	59	8.43	6	0	0	0
39	Israel	7	224	32.00	6	0	0	1

Source: own elaboration through WoS. Abbreviations are available in Tables 1–3.

3.5. Leading Journals in OWA

Journals play a particularly important role in the dissemination and advance of science. Table 6 presents the top 50 journals with the most publications in OWA. The *International Journal of Intelligent Systems* is the one with the most publications, with a record of 195 publications, which equals 8.90% of the total. Also, a large portion of the documents published by this journal are related to OWA (7.20%). Currently, this journal is part of a partnership between two publishers, which are Wiley and Hindawi. The second most productive is the *Journal of Intelligent & Fuzzy Systems*, with a total of 134 publications and a 6.12% share. The publisher of this journal is IOS Press. Nevertheless, the number of citations that this journal has received is well below that of the third most productive, which is *Fuzzy Sets and Systems*. Elsevier is the publisher of this journal.

Table 6. Top 50 most productive journals in OWA.

R	Journal	TP	% TP	% OWA	TC	Avg	*h*	IF 2022	IF 5Y	Q
1	Int J Intell Syst	195	8.90%	7.20%	9370	48.05	43	7	7.2	Q1
2	J Intell Fuzzy Syst	134	6.12%	1.47%	3219	24.02	29	2	1.9	Q4
3	Fuzzy Set Syst	90	4.11%	1.13%	7771	86.34	33	3.9	3.6	Q1
4	Inform Sciences	79	3.61%	0.60%	6151	77.86	36	8.1	7.5	Q1
5	IEEE T Fuzzy Syst	74	3.38%	2.00%	6602	89.22	37	11.9	11.3	Q1
6	Int J Uncertain Fuzz	65	2.97%	4.50%	2192	33.72	22	1.5	1.4	Q4
7	Expert Syst Appl	61	2.78%	0.35%	3887	63.72	33	8.5	8.3	Q1
8	Soft Comput	56	2.56%	0.74%	1628	29.07	19	4.1	3.7	Q2
9	Knowl-Based Syst	47	2.15%	0.69%	2369	50.40	26	8.8	8.6	Q1
10	Comput Ind Eng	39	1.78%	0.42%	2124	54.46	24	7.9	7.3	Q1
11	Appl Soft Comput	37	1.69%	0.44%	2466	66.65	26	8.7	7.9	Q1
12	Int J Fuzzy Syst	33	1.51%	1.98%	1167	35.36	18	4.3	3.9	Q2
13	Int J Approx Reason	31	1.41%	1.33%	3275	105.65	19	3.9	3.5	Q2
14	Eur J Oper Res	30	1.37%	0.17%	2157	71.90	19	6.4	6.4	Q1
15	Mathematics	26	1.19%	0.21%	274	10.54	8	2.4	2.3	Q1
16	Group Decis Negot	25	1.14%	2.42%	1222	48.88	17	3	2.5	Q2
16	Symmetry	25	1.14%	0.24%	241	9.64	9	2.7	2.7	Q2
18	Int J Gen Syst	23	1.05%	1.86%	882	38.35	13	2	1.9	Q3
18	Math Probl Eng	23	1.05%	0.11%	281	12.22	9	-	-	-

Table 6. *Cont.*

R	Journal	TP	% TP	% OWA	TC	Avg	*h*	IF 2022	IF 5Y	Q
20	Int J Comput Int Sys	21	0.96%	1.36%	895	42.62	13	2.9	2.6	Q3
21	Granular Comput	19	0.87%	5.64%	357	18.79	11	5.5	4.7	-
22	IEEE Access	17	0.78%	0.03%	274	16.12	9	3.9	4.1	Q2
22	Inform Fusion	17	0.78%	1.24%	1971	115.94	16	18.6	17.4	Q1
22	Technol Econ Dev Eco	17	0.78%	1.92%	451	26.53	12	5.9	4.2	Q1
25	Int J Inf Tech Decis	16	0.73%	1.55%	504	31.50	9	4.9	3.5	Q1
25	Sustainability	16	0.73%	0.03%	225	14.06	9	3.9	4	Q2
27	Appl Math Model	15	0.68%	0.16%	882	58.80	14	5	4.5	Q1
27	Cybernet Syst	15	0.68%	1.01%	304	20.27	9	1.7	1.8	Q4
27	Econ Comput Econ Cyb	15	0.68%	1.41%	179	11.93	8	0.9	0.8	Q4
27	IEEE T Syst Man Cy B	15	0.68%	0.73%	2877	191.80	14	-	-	-
31	Iran J Fuzzy Syst	13	0.59%	1.51%	331	25.46	6	1.8	1.6	Q1
32	Fuzzy Optim Decis Ma	12	0.55%	3.03%	409	34.08	9	4.7	4.4	Q2
33	Ecol Indic	11	0.50%	0.12%	310	28.18	9	6.9	6.6	Q1
33	Int J Knowl-Based In	11	0.50%	5.09%	252	22.91	6	0.7	1	-
33	Int J Mach Learn Cyb	11	0.50%	0.65%	156	14.18	8	5.6	4.5	Q2
36	Ann Oper Res	10	0.46%	0.16%	142	14.20	7	4.8	4.6	Q1
36	Appl Intell	10	0.46%	0.21%	175	17.50	7	5.3	5.2	Q2
36	Comput Appl Math	10	0.46%	0.42%	223	22.30	6	2.6	2.2	Q1
36	Eng Appl Artif Intel	10	0.46%	0.22%	153	15.30	6	8	7.4	Q1
36	J Clean Prod	10	0.46%	0.03%	292	29.20	7	11.1	11	Q1
36	J Syst Eng Electron	10	0.46%	0.44%	202	20.20	7	2.1	1.9	Q3
36	Kybernetes	10	0.46%	0.29%	152	15.20	7	2.5	2.4	Q3
43	J Appl Math	9	0.41%	0.30%	86	9.56	4	-	-	-
44	Axioms	8	0.37%	0.52%	46	5.75	4	2	1.9	Q2
44	Informatica	8	0.37%	1.01%	72	9.00	5	2.9	3	Q1
44	Water Resour Manag	8	0.37%	0.17%	100	12.50	5	4.3	4.2	Q1
47	Int J Adv Manuf Tech	7	0.32%	0.03%	80	11.43	6	3.4	3.4	Q2
47	Land Use Policy	7	0.32%	0.12%	333	47.57	7	7.1	6.9	Q1
47	Sci Iran	7	0.32%	0.22%	174	24.86	6	1.4	1.4	Q3
50	Arab J Sci Eng	6	0.27%	0.07%	404	67.33	5	2.9	2.7	Q2
50	Energy	6	0.27%	0.02%	147	24.50	6	8.9	8.2	Q1
50	ISPRS Int J Geo-Inf	6	0.27%	0.14%	53	8.83	4	3.4	3.5	Q2
50	J Amb Intel Hum Comp	6	0.27%	0.18%	246	41.00	6	-	-	-
50	J Environ Manage	6	0.27%	0.04%	308	51.33	5	8.7	8.4	Q1
50	J Intell Syst	6	0.27%	1.17%	70	11.67	4	3	2.5	-
50	Neural Comput Appl	6	0.27%	0.07%	72	12.00	6	6	5.6	Q2

Source: own elaboration through WoS. Abbreviations are available in Tables 1–3 except for the following: % OWA = percentage of OWA publications within the journal; IF 2022 = 2022 impact factor; IF 5Y = 5-year impact factor; Q = best quartile in 2022.

Moreover, it should be emphasized that the *Information Fusion* journal from Elsevier is the one with the highest impact factor (IF), also referred to as the journal impact factor (JIF). Recall that the IF is a scientometric index calculated by Clarivate Analytics in the Journal Citation Reports (JCR), and it reflects the number of times an average paper in a journal has been cited during a specific year or period. Also, based on the IF, this journal appears in the first quartile (Q1) for the categories "Computer Science, Artificial Intelligence" and "Computer Science, Theory & Methods".

3.6. Leading Research Areas in OWA

In order to get an enhanced understanding of the OWA research areas, Table 7 lists the top 35. The OWA operator has evolved in many directions. It can clearly be seen that Computer Science is leading the ranking of the most productive research areas. Similarly, the OWA operator plays a key role in other fields, such as Engineering and Mathematics.

Table 7. Top 35 most productive research areas in OWA.

R	Research Area	TP	TC	Avg	*h*
1	Computer Science	1425	74,065	51.98	124
2	Engineering	454	24,428	53.81	72
3	Mathematics	315	12,094	38.39	53
4	Operations Research Management Science	194	8915	45.95	53
5	Business Economics	140	5109	36.49	38
6	Environmental Sciences Ecology	130	3635	27.96	34
7	Automation Control Systems	98	5552	56.65	32
8	Science Technology Other Topics	96	2073	21.59	25
9	Water Resources	41	1174	28.63	19
10	Geology	34	1494	43.94	18
11	Energy Fuels	32	1258	39.31	19
12	Social Sciences Other Topics	30	1325	44.17	18
12	Telecommunications	30	664	22.13	13
14	Remote Sensing	22	780	35.45	12
15	Physics	19	166	8.74	7
16	Geography	18	1029	57.17	11
17	Mechanics	17	1086	63.88	15
17	Physical Geography	17	829	48.76	10
19	Materials Science	15	100	6.67	5
20	Biodiversity Conservation	13	326	25.08	10
21	Agriculture	12	314	26.17	8
21	Instruments Instrumentation	12	159	13.25	7
21	Mathematical Computational Biology	12	111	9.25	6
24	Forestry	11	283	25.73	7
24	Imaging Science Photographic Technology	11	177	16.09	7
24	Information Science Library Science	11	890	80.91	7
27	Chemistry	10	68	6.80	6
28	Thermodynamics	9	356	39.56	7
29	Construction Building Technology	8	54	6.75	3
29	Meteorology Atmospheric Sciences	8	572	71.50	7
29	Public Environmental Occupational Health	8	188	23.50	6
32	Mathematical Methods in Social Sciences	7	178	25.43	4
33	Robotics	6	10	1.67	2
33	Transportation	6	237	39.50	3
35	Neurosciences Neurology	5	133	26.60	3

Source: own elaboration through WoS. Abbreviations are available in Tables 1–3.

3.7. Temporal Evolution of the Most Productive Authors, Institutions, Countries, Journals, and Research Areas in OWA

Next, Tables 8–12 display the evolution of the most productive authors, institutions, countries, journals, and research areas in OWA over the last three decades. Starting with the author's results, from 1993 to 2002, Yager was the most prolific, with 26 publications. Nevertheless, during the periods of 2003–2012 and 2013–2022, it was Merigó with 41 and 87 publications, respectively.

If we analyze the most productive institutions through time, Iona College, represented primarily by Yager, was the leading institution during the periods of 1993–2002 and 2013–2022. But throughout the decade from 2003 to 2012, it was the University of Barcelona, mainly due to the works of Merigó. Additionally, during the period of 1993–2002, the University of Granada was the second institution, basically explained by the professors Herrera and Herrera-Viedma. Nonetheless, between 2003 and 2012, Southeast University (China) managed to establish itself as the second most productive institution, largely driven by the researchers X.W. Liu and Z.S. Xu. However, from 2013 to 2022, the University of Chile secured second place, which came mostly from the contributions made by Merigó.

Table 8. Productivity evolution of the authors over the last three decades.

1993–2002			
R	**Author**	**TP**	**TC**
1	Yager, RR	26	4449
2	Herrera, F	10	4841
3	Herrera-Viedma, E	9	3840
4	Filev, DP	7	1692
5	Mitchell, HB	6	202
5	Torra, V	6	642

2003–2012			
R	**Author**	**TP**	**TC**
1	Merigó, JM	41	3332
2	Yager, RR	37	3537
3	Xu, ZS	33	9279
4	Liu, XW	24	1181
5	Herrera-Viedma, E	19	2849

2013–2022			
R	**Author**	**TP**	**TC**
1	Merigó, JM	87	1923
2	Yager, RR	63	1023
3	Mesiar, R	49	851
4	Jin, LS	45	560
5	Zeng, SZ	43	1304

Source: own elaboration through WoS. Abbreviations are available in Tables 1 and 2.

Table 9. Productivity evolution of the institutions over the last three decades.

1993–2002			
R	**Institution**	**TP**	**TC**
1	Iona College	26	4449
2	U Granada	12	5057
3	ELTA Electronics Industries	6	202
4	Rovira Virgili U	5	555
4	U Balearic Islands	5	100

2003–2012			
R	**Institution**	**TP**	**TC**
1	U Barcelona	41	3332
2	Southeast U China	40	6147
3	Iona College	38	3554
4	U Granada	24	3126
5	Slovak U Technology Bratislava	13	441

2013–2022			
R	**Institution**	**TP**	**TC**
1	Iona College	66	1046
2	U Chile	60	1191
3	Slovak U Technology Bratislava	56	929
4	Abdul Wali Khan U	46	880
4	Nanjing Normal U	46	603

Source: own elaboration through WoS. Abbreviations are available in Tables 1 and 2.

Table 10. Productivity evolution of the countries over the last three decades.

1993–2002			
R	**Country**	**TP**	**TC**
1	USA	33	5041
2	Spain	32	6024
3	Belgium	7	367
4	Israel	6	202
5	China	4	781
5	Italy	4	490

2003–2012			
R	**Country**	**TP**	**TC**
1	China	182	18,330
2	Spain	101	7578
3	USA	70	5282
4	Iran	33	852
5	United Kingdom	27	2783

2013–2022			
R	**Country**	**TP**	**TC**
1	China	786	23,025
2	Spain	211	5190
3	Pakistan	143	3239
4	USA	124	2431
5	Iran	111	2549

Source: own elaboration through WoS. Abbreviations are available in Tables 1 and 2.

Table 11. Productivity evolution of the journals over the last three decades.

1993–2002				2003–2012			
R	**Journal**	**TP**	**TC**	**R**	**Journal**	**TP**	**TC**
1	Fuzzy Set Syst	19	4968	1	Int J Intell Syst	47	3235
2	Int J Intell Syst	16	2358	2	Expert Syst Appl	38	2952
3	Int J Uncertain Fuzz	15	686	3	Fuzzy Set Syst	35	2249
4	Int J Approx Reason	8	582	4	Inform Sciences	25	2946
5	Eur J Oper Res	4	379	5	IEEE T Fuzzy Syst	21	4198
5	IEEE T Fuzzy Syst	4	422				
5	IEEE T Syst Man Cy B	4	1635				
5	Inform Sciences	4	854				
5	Int J Gen Syst	4	244				
2013–2022							
R	**Journal**	**TP**	**TC**				
1	Int J Intell Syst	132	3777				
1	J Intell Fuzzy Syst	132	3156				
3	Inform Sciences	50	2351				
4	IEEE T Fuzzy Syst	49	1982				
5	Soft Comput	43	1002				

Source: own elaboration through WoS. Abbreviations are available in Tables 1 and 2.

Table 12. Productivity evolution of the research areas over the last three decades.

1993–2002				2003–2012			
R	**Research Area**	**TP**	**TC**	**R**	**Research Area**	**TP**	**TC**
1	Computer Science	83	12,847	1	Computer Science	379	29,021
2	Mathematics	21	5025	2	Engineering	130	10,771
3	Engineering	9	705	3	Operations Research Management Science	86	5597
4	Business Economics	6	520	4	Mathematics	71	3277
5	Automation Control Systems	5	1655	5	Automation Control Systems	32	2045
				5	Business Economics	32	2471
2013–2022							
R	**Research Area**	**TP**	**TC**				
1	Computer Science	958	26,894				
2	Engineering	312	7651				
3	Mathematics	223	3792				
4	Environmental Sciences Ecology	118	2792				
5	Operations Research Management Science	104	2939				

Source: own elaboration through WoS. Abbreviations are available in Tables 1 and 2.

Likewise, during the past decades, China has experienced significant growth in academic research productivity in OWA. On the other hand, the USA began as the most productive country but ended up being the fourth. By comparison, Spain has remained constant over the past 30 years.

Looking at the development of the journals, *Fuzzy Sets and Systems* has been a mainstay of OWA research. Moreover, the *International Journal of Intelligent Systems* has managed to consolidate its position. Also outstanding is the number of documents successfully published by the *Journal of Intelligent & Fuzzy Systems* during the period of 2013–2022.

Concerning the research fields, Computer Science, Engineering, and Mathematics have always been the most popular. Despite this, the research area of Environmental Sciences Ecology has become more relevant in the last decade of the study. This is also reflected in Figure 2.

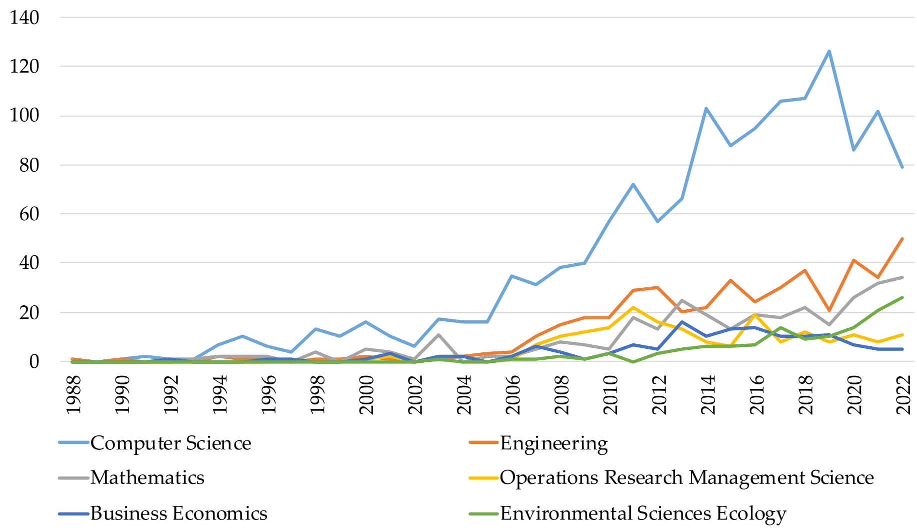

Figure 2. Annual evolution of the six most productive research areas.

3.8. Analysis with VOS Viewer

VOS viewer is a software tool developed by van Eck and Waltman at Leiden University's Centre for Science and Technology Studies. With VOS viewer, it is possible to obtain the citation and co-citation of cited references, authors, and journals; the occurrence and co-occurrence of keywords; and the bibliographic coupling of countries. In the current study, fractional counting is used instead of full counting [66]. Table 13 presents the most cited references among OWA publications along with their corresponding co-citation strengths. Note that a minimum of 20 citations of a cited reference was applied as a constraining factor. First, we have the document "*On ordered weighted averaging aggregation operators in multicriteria decisionmaking*", written by Yager [3]. Second, we find the seminal paper "*Fuzzy sets*", authored by Zadeh [67], which proposed a new way of representing uncertainty. Third, we get the document "*Families of OWA operators*", from Yager [38].

Table 13. Documents most cited by OWA publications between 1988 and 2022.

R	Cited Reference (Only First Author)	Citations	TLS	PY
1	Yager RR, IEEE T Syst Man Cyb, V18, P183	1598	1544	1988
2	Zadeh LA, Inform Control, V8, P338	592	589	1965
3	Yager RR, Fuzzy Set Syst, V59, P125	466	462	1993
4	Yager RR, Int J Intell Syst, V11, P49	426	423	1996
5	Yager RR, IEEE T Syst Man Cy B, V29, P141	412	408	1999
6	Atanassov KT, Fuzzy Set Syst, V20, P87	409	409	1986
7	Xu ZS, Int J Intell Syst, V20, P843	290	288	2005
8	Yager RR, The Ordered Weighted Averaging Operators	283	282	1997
9	Xu ZS, IEEE T Fuzzy Syst, V15, P1179	264	264	2007
10	Xu ZS, Int J Intell Syst, V18, P953	261	261	2003
11	Zadeh LA, Inform Sciences, V8, P199	254	253	1975
12	Xu ZS, Int J Gen Syst, V35, P417	234	234	2006
13	Torra V, Int J Intell Syst, V12, P153	229	229	1997
14	Beliakov G, Aggregation Functions	227	227	2007
15	Yager RR, Fuzzy Optim Decis Ma, V3, P93	226	226	2004
16	Merigó JM, Inform Sciences, V179, P729	220	220	2009
17	Filev DP, Fuzzy Set Syst, V94, P157	218	217	1998
18	Zadeh LA, Comput Math Appl, V9, P149	199	199	1983
19	Herrera F, IEEE T Fuzzy Syst, V8, P746	190	189	2000
20	Fullér R, Fuzzy Set Syst, V124, P53	178	178	2001

Source: own elaboration through VOS viewer. Abbreviations are available in Table 2 except for: TLS = total link strength.

The originality of the OWA operator has drawn the attention of many researchers from all over the world. Figure 3 displays the co-citation network of cited authors among OWA publications. To do so, a minimum of 70 citations of an author are contemplated. Note that only the first author of a cited document is considered in the co-citation analysis of cited authors. Each node or circle constitutes an author, and the size of the node is proportional to the number of citations. Likewise, the lines represent the strongest co-citation relations between authors. Also, clusters are differentiated by colors. As can be seen, the biggest nodes correspond to the researchers Yager, Z.S. Xu, Merigó, Wei, Herrera, and Zadeh, respectively.

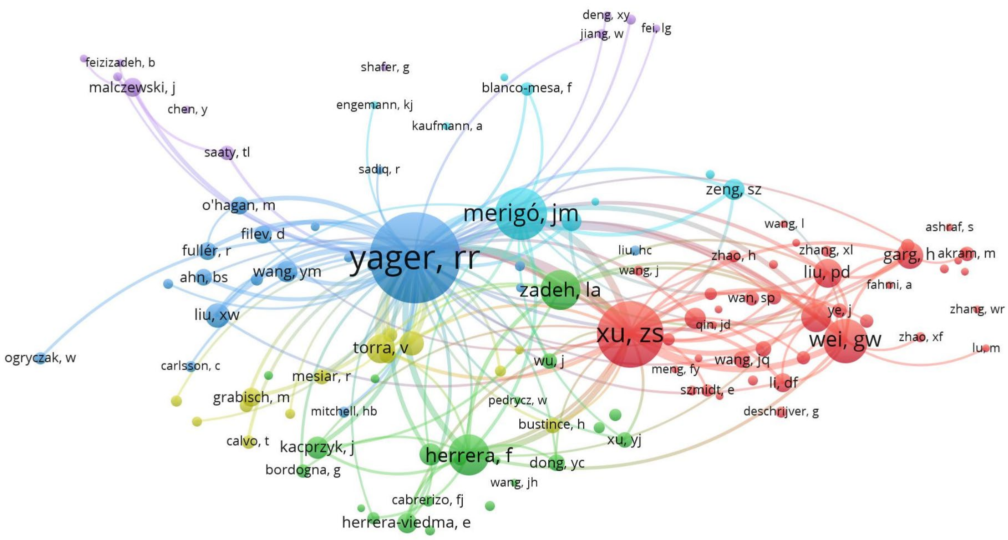

Figure 3. Co-citation network of cited authors between 1988 and 2022 using VOS viewer.

Similarly, Figure 4 visualizes the co-citation network of cited journals among OWA publications, taking into account a minimum of 130 citations of a journal. In this case, each node represents a journal. The bigger the node, the higher the number of citations received by the journal. The major co-citation links between journals are illustrated with lines. The color of the node indicates the cluster. It can be seen that the largest nodes are those from *Fuzzy Sets and Systems*, *International Journal of Intelligent Systems*, and *Information Sciences*. Further, these journals are likely to be related, as they are placed close to each other.

Next, Figure 5 presents the co-occurrence network of keywords, while considering a threshold of 20 occurrences of a keyword. Each node represents a keyword. The node size reflects the number of publications that have the keyword in their title, abstract, or keyword list. That is, the higher the frequency, the larger the node. The node color illustrates the cluster to which keywords belong. The lines denote the strongest co-occurrence links. We can observe five different clusters and that the most frequent keywords are "OWA operator", "aggregation operators", "model", "decision-making", and "group decision-making".

In order to detect current research trends in OWA, an additional keyword co-occurrence analysis has been conducted, but in this case, considering only publications from the last two years (2021–2022). As can be seen in Figure 6, there are several emerging keywords related to environmental sciences, including "ecosystem services", "climate-change", and "conservation".

Lastly, Figure 7 depicts the bibliographic coupling of countries. Publications from two countries are said to be bibliographically coupled if they both cite the same third publication. Only countries with at least 10 documents are included in the overlay visualization. A total of 36 countries meet this threshold. Each node constitutes a country, and the gradient color from blue to yellow denotes the average publication year. The most important country in terms of publications, citations, and total link strength is China. Furthermore, according to the thickness of the lines, the map shows a strong connection between this country and

Spain. It should be also stressed the large number of documents published by Pakistan in recent years, being 2020.49 its average publication year.

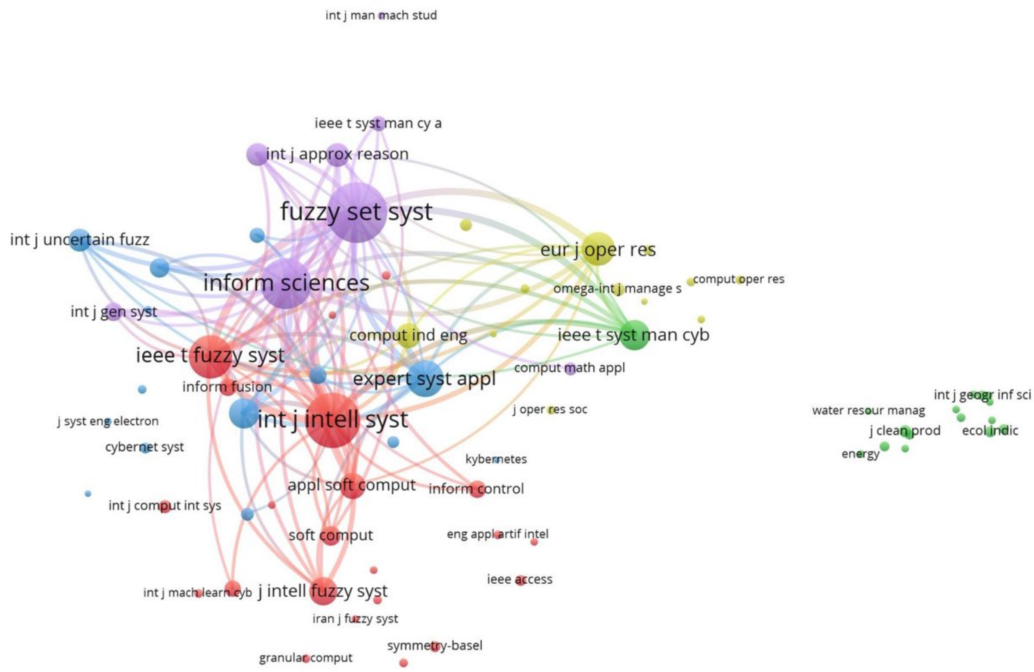

Figure 4. Co-citation network of cited journals between 1988 and 2022 using VOS viewer.

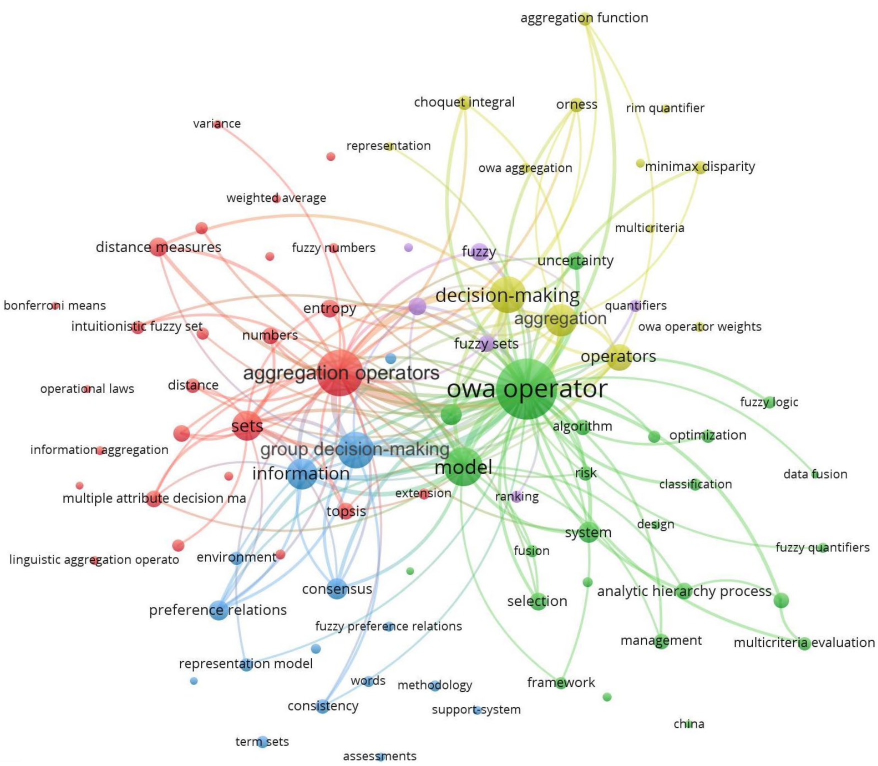

Figure 5. Co-occurrence network of keywords between 1988 and 2022 using VOS viewer.

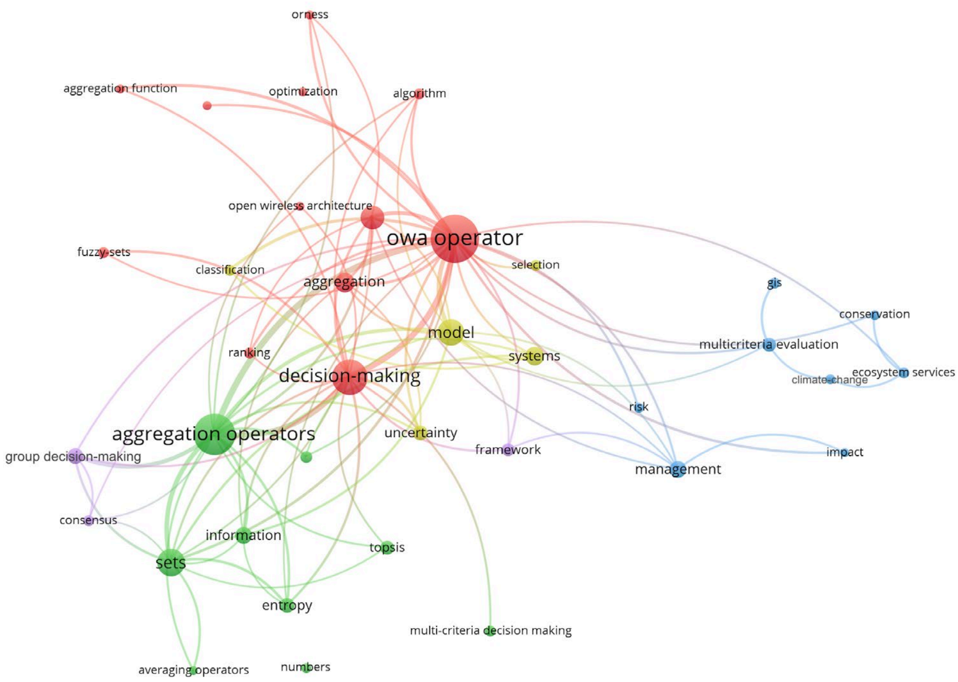

Figure 6. Co-occurrence network of keywords between 2021 and 2022 using VOS viewer.

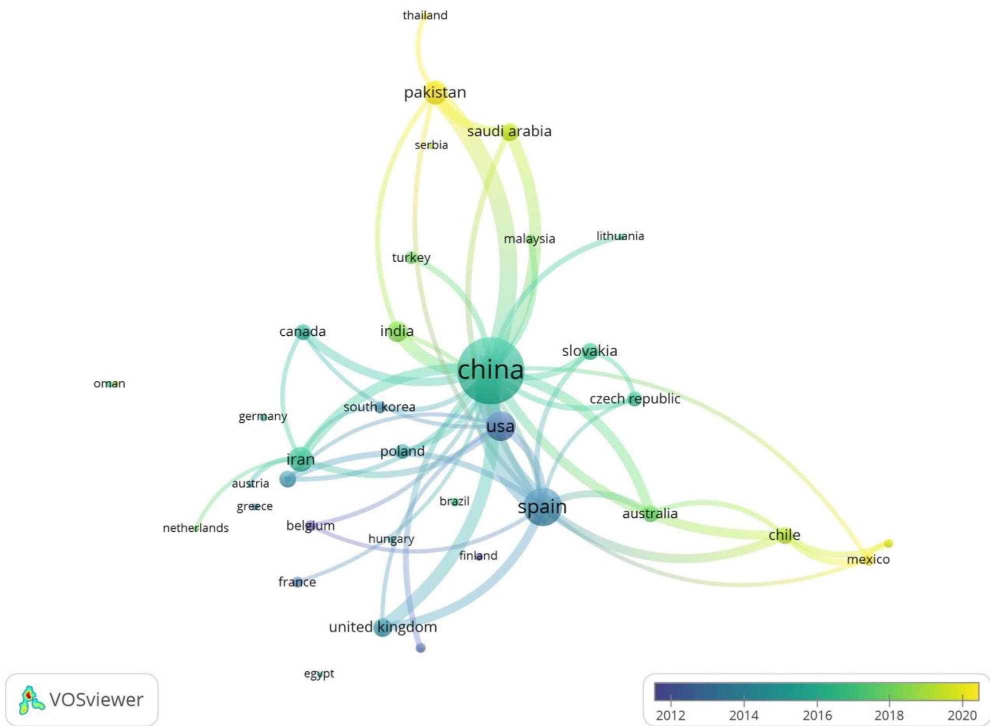

Figure 7. Bibliographic coupling overlay of countries between 1988 and 2022 using VOS viewer.

4. Discussions

There is a growing interest in the OWA operator. This is reflected in the fact that the number of publications has increased significantly since 1988, especially during the last two decades. The success of the OWA operator lies in its generality and flexibility.

Another finding is that Yager is the most prolific and influential researcher regarding the OWA operator. He also has written the most cited document, which is "*On ordered weighted averaging aggregation operators in multicriteria decisionmaking*", where the OWA operator is introduced for the very first time. Additionally, he represents the Iona College, which is the leading institution in OWA.

Moreover, based on the obtained results, we can confirm that China has the largest number of publications and citations. A key factor of China's dominance is explained by its high population. However, in the early years, the USA and Spain were the most contributing countries to OWA research. It is also worth emphasizing Pakistan's rapid productivity rise over the past 8 years. One reason underlying this trend relates to the fact that higher education has expanded considerably in this country during the last two decades.

According to the analysis of the journals with the most publications as well as citations, the *International Journal of Intelligent Systems* heads the ranking, suggesting that there is a good balance between quantity and quality of OWA-related research. In terms of productivity, it is followed by the *Journal of Intelligent & Fuzzy Systems* and *Fuzzy Sets and Systems*. As for the number of citations, it is followed by *Fuzzy Sets and Systems* and *IEEE Transactions on Fuzzy Systems*. With regard to the IF metric, *Information Fusion* ranks first, indicating that the research published in this journal is usually widely recognized and utilized by other scholars.

Furthermore, the bibliometric review points out that Computer Science is by far the preferred research area, with a total of 1425 publications until December 2022. Additionally, in the last decade, there has been an increasing number of studies that apply the OWA operator to Environmental Sciences Ecology.

Some inferences can be drawn from the citation and co-citation analysis of cited references, authors, and journals, as well as the occurrence and co-occurrence of keywords. For example, among OWA publications, the most cited reference is "*On ordered weighted averaging aggregation operators in multicriteria decisionmaking*", the most cited author is Yager, the most cited journal is *Fuzzy Sets and Systems*, the most frequent keyword is "OWA operator", and "ecosystem services" is one of the emerging topics. Also, the bibliographic coupling analysis of countries offers valuable insights. For instance, China is the most influential contributor to OWA, coupling frequently with Spain. The presence of bibliographic coupling suggests potential collaboration opportunities.

This research has some limitations. One of these limitations is using only the WoS Core Collection database. Thus, future research should include additional databases like Elsevier's Scopus. Additionally, conduct a comparative exercise between them. Another limitation is the selection of solely articles, review articles, notes, and letters, disregarding other types of documents, such as proceeding papers. A limitation is also the fact that through time some authors may change the institution to which they belong.

5. Conclusions

This paper conducted a comprehensive bibliometric analysis of the OWA operator from 1988 to 2022 based on the WoS Core Collection database and the VOS viewer software. Since the OWA operator was presented for the first time in 1988, many theoretical and practical studies have been provided on this topic.

The results show that Yager continues to be the most productive and influential author, as it is the institution that he represents (Iona College). China is by far the leading country in scholarly output and has the highest number of citations. The *International Journal of Intelligent Systems* has an outstanding OWA research productivity and citation frequency. As per the research areas, Computer Science is identified as the most relevant.

To enhance the understanding of the OWA literature, this study provided visualizations of different types of bibliometric networks, including co-citation, keyword co-occurrence, and bibliographic coupling.

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