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THE BIG PICTURE OF CLIMATE CHANGE RESEARCH IN THE ARAB WORLD: INSIGHTS FROM BIBLIOMETRIC ANALYSIS*

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Abstract. Global impacts of climate change are wide-ranging and unprecedented in scope, ranging from shifting weather patterns that threaten a permanent change of the ecosystem on earth (which may severely affect human life, including water and food security), to major events directly affecting human lives, such as natural / climate-related disasters, rising sea levels, etc. With the organization of two successive conferences of the parties (COP) in the Arab region, it became evident that there is extensive attention from governments and regional bodies in the Arab region towards issues related to climate change. In this study, we aim to analyze the research performance of Arab scholars on climate change based via a bibliometric analysis of published research articles in 22 Arab countries. We have used a multivariate approach for data analysis and bibliometric indicators characterization. Many indicators are used to examine scientific performance, as well as the trends of a growing number of publications, number of citations, number of authors, etc. Using a predefined set of keywords related to climate change and UN climate change themes, we were able to assemble a dataset of 68,193 documents (published papers) that were further analyzed to set the scene and show the status of scholarly publications from authors of the Arab world. Saudi Arabia comes on top of the Arab countries in terms of the number of publications in climate change research-related publications, followed by Egypt, Morocco and the United Arab Emirates, while IEEE, Energy Procedia and Arabian journal of geosciences are the top three choices for publications related to climate change among the Arab researchers.

Keywords: climate change; research productivity; bibliometric analysis; Arab countries.

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1. Introduction

The 22 countries of the Arab region (Figure 1) are considered the most vulnerable regions of the world to negative impacts of climate change, as it faces challenges such as extreme heat, threats to coastal areas, increased drought and desertification, scarcity of water resources, seawater intrusion to groundwater, the spread of epidemics, pests, and diseases (IPCC, 2014).

Climatic changes in the Arab world affected water resources, sea level and coastal areas, human health and development, food production, biodiversity, land use and urban planning, tourism, and national security and conflict control, among other aspects of daily life (Al-Mebayedh 2013; El-Kassas et al., 2022).

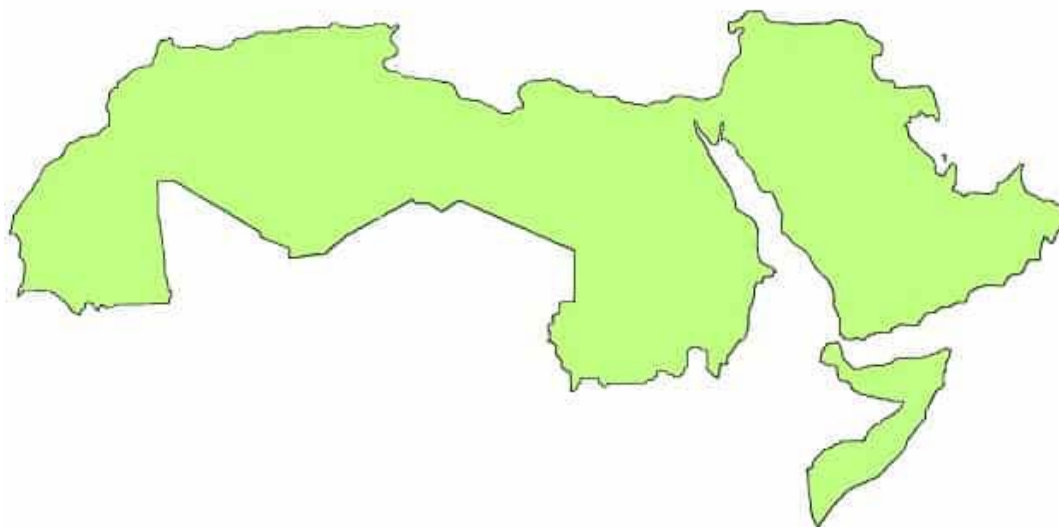


Figure 1. Map of the 22 Arab countries

The Arab region has the largest food deficit and imports the most food globally (UNDP, 2018) and is already one of the most water-scarce regions in the world; the annual per capita share of renewable water resources is less than 500 m³ in 70 per cent of the region where the average per capita share is 800 m³ (below the global water poverty line, estimated by the United Nations, 1,000 M³), where 19 of the 22 Arab countries faces from water scarcity, and desertification and land degradation affect 17 countries (AOAD, 2017). This would indirectly affect the region's education, income, health and brain circulation (Radwan and Sakr, 2018; Rezk et al., 2020).

Over the past 10 years, many Arab countries have implemented several adaptation and mitigation strategies to reduce the negative effects of climate change, such as Initiatives to convert old cars and renovation of roads, installation of electric trains, agricultural water pumping using PVs and Natural gas utilization (Karim, 2018; Djoundourian, 2021).

There is also a political commitment of Arab countries towards climate change, which is demonstrated by the participation of 16 Arab countries in the United Nations Sustainable Development Summit in New York in 2015, the Climate Summit in Paris, the hosting of Egypt and the United Arab Emirates for the 27th and 28th versions of the “Conference of the Parties, COP (Ghaemi et al., 2022; Mantlana et al., 2022).

At the level of the Arab Summits, interest in climate change has emerged through Arab strategies, plans and programs for sustainable consumption and production (2009), food security (2010 and 2017), water security (2012), climate change (2012), disaster risk reduction (2012 and 2018), health and environment (2012), renewable

energy (2013), housing and sustainable urban development (2016 and 2019), and environmental dimensions of the sustainable development goals (2016 and 2019).

Hence, On November 2022, the United Nations Climate Change Conference (UNFCCC) Conference of the Parties in its 27th version (COP27) will take place at Sharm Elsheikh – Egypt, while it is expected that the United Arab Emirates will organize the COP28 in November 2023. Those trending activities, in number, prove an increasing interest of countries of the region to deal with climate change issues and tools for remediation (Rachid et al., 2020; Tomaszekiewicz, 2021; Khiyat, 2022).

Therefore, this paper aims to assess the Arab world's commitments to Research and Development on climate change and to recognize the research trends over the past ten years, to assist in directing future policies and improving research activities in climate change research. The assessment is conducted by investigating peer-reviewed literature on climate change published by Arab researchers and indexed in Scopus.

We have used bibliometric data analysis techniques, which offer valuable quantitative and qualitative indicators for a well-informed understanding of the Arab scientific outputs of climate change research. While conducting the research, we have also consulted other studies that assessed the scientific output of the Arab world and Africa in specific domains, such as the development trends of Environmental Impact Assessment (Zyoud, 2021), bibliometric assessment of drinking water research in Africa (Wambu, 2016), mapping of climate change research in the Arab world (Zyoud et al., 2020) and mapping environmental impact assessment research landscapes in the Arab world using visualization and bibliometric techniques (Zyoud and Zyoud, 2021).

2. Bibliometric data

Bibliometric analysis is a quantitative method that deals with many publications and scientific literature. For this analysis, the data of climate change publications were extracted from the Scopus database (Scopus, 2022), with a search query involving 80 Keywords derived from "Elsevier 2021 SDG mapping" and based on SDG number 13 for climate actions keywords (Rivest et al., 2021), in addition to few keywords stemming as a reflection to thematic areas of COP26 in Glasgow. Those additional keywords are: "renewable energy", "nature conservation", "biodiversity", "endangered plant", "endangered animal", "green technologies", "green cities", "recycling", "water desalination", and "environment". The search is limited to the 22 Arab countries shown in Figure 1. The data extraction from Scopus and SciVal covers the last ten years, from 2012 to 2021, based on available data.

The search in the title and abstract using the list of keywords resulted in identifying 68,128 publication entries (unique publications with no duplications) as follows:

- 43799 Journal articles,
- 17657 Conference papers,
- 3245 Reviews,
- 2986 Book and chapters,
- 441 other types of publications (e.g. reports)

Publications with at least one author affiliated with one of the Arab countries' research institution were selected. The data extracted included publication year, authorship, institutions, countries/regions of the institutions, journal title, abstract, journal category, publication types, language, publication count and citation count.

The analysis of the collected data was performed using various tools and software, including MS Excel® v16.0, SPSS® v22.0, VOS viewer® v1.6.18, Tableau® v2022.1 and R® v.4.2.1.

The VOS viewer software was used to analyze the terms used in titles and abstracts of the included publications and displays the findings as a "term map", a form of presentation where the bubble size reflects how frequently a term is mentioned in the included publications. The bubble colour, on the other hand, reflects how often a publication mentioning the term is cited on average, while the distance between two bubbles reflects how

frequently two terms are mentioned in the same publications. (Yeung et al., 2017; Yeung et al., 2019; Almulhim et al., 2021, Korshid et al., 2020)

3. Bibliometric Data Analysis

Overview of the data points

The data covered the publications of Arab countries researchers that were published in the last ten years (2012-2021). The total number of publications indexed in Scopus (TP) is 68,128. These articles are primarily published in English (67,507; 98.9%), French (652; 0.95%), and Arabic language (114; 0.16%). The total number of authors (AUS) for all the articles is 185,800, and the total citations (TC) received by all publications is (902,806), while the Field weighted citation impact (FWCI)[†] is 1.28, and the Citations per Publication (C/P) is 13.3. The percentage of international collaboration publications (IC)[‡] is 53.2%, and the collaborative publications between academia and industry are only 1.9% of all the publications.

The document types on climate change research by Arab researchers are shown in Table 1. Most of the publications are in the form of articles (TP= 43,799; TC= 648,271), followed by conference papers (TP= 17,657; TC= 648,271) and books and chapters (TP= 2,986; TC= 14,213). Notably, the field weight citation impact and citation per publication for the review types are higher than the other publications (FWCI = 1.69; C/P= 50.8).

Table 1. Types of publication on climate change published by Arab researchers (2012 to 2021)

Document Type	TP ¹ *	TC ² *	FWCI ³ *	C/p ⁴ *	IC ⁵ *
All Scholarly Output	68,128	902,806	1.28	13.3	53.2
Articles	43,799	648,271	1.28	14.8	143,454
Conference	17,657	69,486	1.14	3.9	40,993
Book and Chapters	2,986	14,213	1.4	4.8	45.2
Review	3,245	164,827	1.69	50.8	67.8

¹*TP: Total number of publications, ²*TC: Total citations, ³*FWCI: Field weight citation impact, ⁴*C/P: Citation per publication, ⁵*IC: Percentage of International Collaboration publications

Publications and citation Trends

While the total number of publications of Arab countries' scholars in the climate change domain is 68,128 publications during the last ten years, the number of publications followed an ascending trend from 3,012 publications in 2012 to 13,339 publications in 2021 (Table 2 & Figure 2). The average annual growth rate of publication represents 18.4%, while the highest growth rate was in 2019, representing 28.7% followed by 23.3% in 2021. Comparing the ascending trend in number of publications in the Arab world to the same trend observed in the whole world revealed that while both trends are following the same pattern of yearly relative increase and decrease, but on average, the growth rate of publications in the Arab world is 2-3 folds that of the world average (Table 2).

[†] FWCI: A statistic defined as the ratio of the citations received by an entity's outputs and the average number of citations received by all other similar outputs

[‡] IC: A statistic defined as co-authored publications with institutions in other countries/regions

Table 2. Publications and citation trends of climate change by researchers 2012-2021

Year	TP	TC	FWCI	C/P	IC	AUS	Growth Rate	TP (World)	Growth Rate (World)
2012	3,012	62,425	1.05	20.7	46.8	9,623		151700	
2013	3,603	77,765	1.05	21.6	50.9	15,455	19.6%	162081	6.8%
2014	3,935	85,327	1.11	21.7	53.5	17,291	9.2%	167075	3.1%
2015	4,685	96,017	1.14	20.5	52.5	17,595	19.1%	172491	3.2%
2016	5,487	100,649	1.14	18.3	52.5	20,332	17.1%	184120	6.7%
2017	6,339	113,179	1.23	17.9	54.2	27,000	15.5%	198393	7.8%
2018	7,403	109,279	1.2	14.8	51.3	27,104	16.8%	218128	9.9%
2019	9,531	106,679	1.32	11.2	50.3	36,525	28.7%	244534	12.1%
2020	10,807	94,538	1.37	8.7	52.8	42,701	13.4%	260575	6.6%
2021	13,326	56,948	1.54	4.3	58.5	52,928	23.3%	293710	12.7%
Total	68,128	902,806					Average: 18.1%		Average: 7.7%

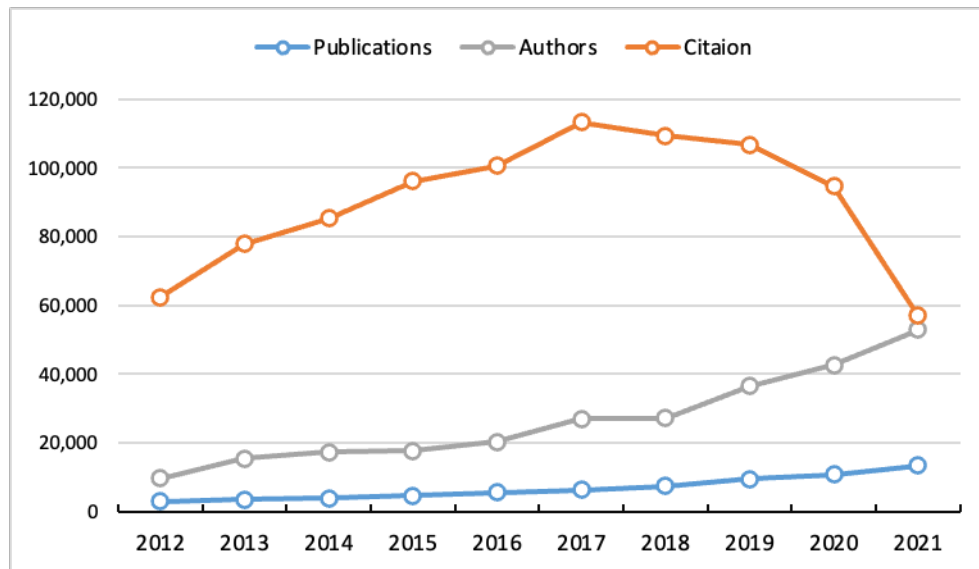


Figure 2. Publications, Citations and Authors trends (2012-2021)

Top leading Arab Countries in Climate Change Research

Table 3 shows the ranking of Arab countries' publications in climate change research from 2012 to 2021 in descending order. The top five countries are Saudi Arabia (TP=16,851, AUS=54,898), Egypt (TP=12,607, AUS=39,147), Morocco (TP=6,664, AUS=26,363), United Arab Emirates (TP=6,634, AUS=21,945), and Algeria (TP=6,301, AUS=16,293). Those five countries alone represent a cumulative 65% of the number of publications and 64% of the authors (cf. Table 3).

In terms of citations, the publications from Saudi Arabia have received the highest number of citations (TC=333,032), followed by Egypt (TC= 174,114), United Arab Emirates (TC=87,248), Tunisia (55,121), Morocco (TC=61,918), and Qatar (TC=55,700). Qatar comes at the top of Arab countries in Field Weight Citation Index (FWCI=1.76), followed by Saudi Arabia (FWCI=1.65) and United Arab Emirates (FWCI=1.45). Saudi Arabia comes as the top Arab countries in terms of total publication per million people (5750.2), followed by Qatar (560.9) and United Arab Emirates (555.8).

Table 3. Rank of Arab countries on Climate change research, 2012-2021

Rank	Country	TP	Cumulative TP	TC	FWCI	C/P	IC	AUS	Cumulative AUS	TP/million People
1	Saudi Arabia	16,851	22.3%	333,032	1.65	19.8	71.3	54,898	22.1%	5750.2
2	Egypt	12,607	39.0%	174,114	1.36	13.8	54.7	39,147	37.8%	282.6
3	Morocco	6,664	47.9%	61,918	1.14	9.3	41.3	26,363	48.4%	178.4
4	United Arab Emirates	6,634	56.7%	87,248	1.45	13.2	63.2	21,945	57.2%	555.8
5	Algeria	6,301	65.0%	53,673	0.87	8.5	43.5	16,293	63.8%	14.2
6	Tunisia	5,684	72.5%	66,121	1.03	11.6	55.2	17,739	70.9%	311.0
7	Iraq	5,315	79.6%	40,438	1.16	7.6	42.7	13,503	76.3%	51.0
8	Jordan	3,121	83.7%	32,881	1.16	10.5	50.3	8,611	79.8%	75.8
9	Qatar	2,930	87.6%	55,700	1.76	19	71.1	12,829	84.9%	560.9
10	Lebanon	2,234	90.6%	35,375	1.41	15.8	62.3	7,838	88.1%	516.1
11	Oman	1,913	93.1%	24,759	1.42	12.9	64.1	5,905	90.4%	400.6
12	Kuwait	1,690	95.3%	17,909	1.1	10.6	53.4	5,056	92.5%	164.6
13	Bahrain	663	96.2%	4,549	0.95	6.9	52.3	1,684	93.2%	379.2
14	Palestine	661	97.1%	8,004	1.25	12.1	65.1	8,004	96.4%	129.6
15	Sudan	619	97.9%	8,531	1.36	13.8	76.7	2,502	97.4%	13.8
16	Libya	555	98.6%	5,242	0.98	9.4	72.8	2,117	98.2%	107.1
17	Yemen	452	99.2%	5,895	1.38	13	88.7	1,552	98.8%	14.8
18	Syria	427	99.8%	5,449	1.05	12.8	12.4	1,691	99.5%	26.1
19	Mauritania	85	99.9%	1,213	0.92	14.3	96.5	702	99.8%	12.2
20	Djibouti	30	100.0%	573	1.26	19.1	96.7	175	99.9%	29.9
21	Somalia	28	100.0%	234	0.89	8.4	85.7	169	99.9%	0.8
22	Comoros	2	100.0%	22	0.81	11.0	100.0	128	100.0%	2.3

Figure 3 and Figure 4 below show combined illustrations of the number of publications, number of citations and number of authors. Figure 3 describes the relationship between the number of publications and number of citations with the best fit of polynomial 4th order ($R^2=0.99$, and P-Value <0.0001), while Figure 4 shows a discretization of the same graph on a lg-log scale (to identify all the 22 countries).

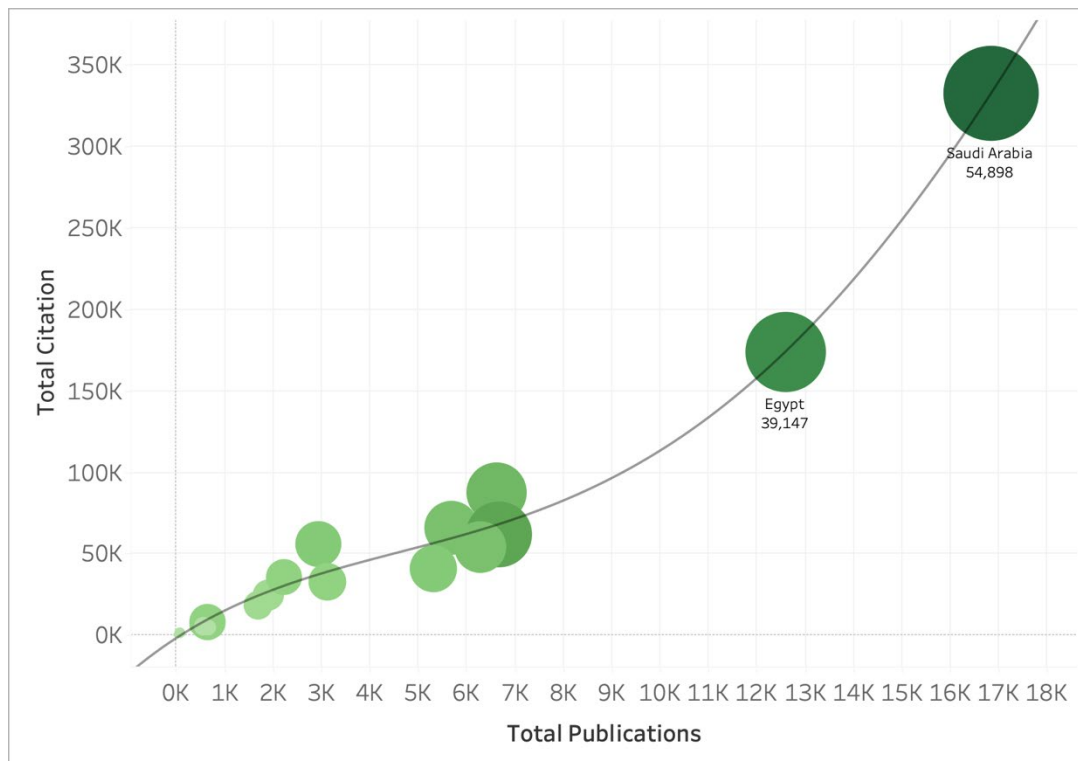


Figure 3. Trend curve for the number of publications vs. number of citations (Polynomial 4th order, $R^2=0.99$, P-Value <0.0001)

Deviating from the general trend of Figure 3 are the United Arab Emirates, Tunisia and Qatar, where the data points are "above" the curve (the number of citations is higher than the general trend). On the other hand, Iraq shows a number of citations that is "below" the curve. Those observations should be explained using extra data points and characteristics in further studies, as the pattern of citation in those four countries is different than in other countries in the region.

Focusing on environmental science, renewable energy and recycling research (as shown partially in Figure 5), the bibliometric analysis shows that the total number of publications in environmental science, including pollution, water science and technology, environmental chemistry, waste management and disposal, nature, and the landscape was 13,443 for Arab countries during 2012-2021, the total number of authors (AUS) was 46,031, and the total citations received by all publications in environmental science was 227,658. While for renewable energy research, the total amount of publications was 17,951, the total number of authors (AUS) was 17,951, and the total citations received by all publications was 130,255 and for recycling research, the total amount of publications was 4,176 during 2012-2016, the total number of authors (AUS) was 13,386, and the total citations was 77,572.

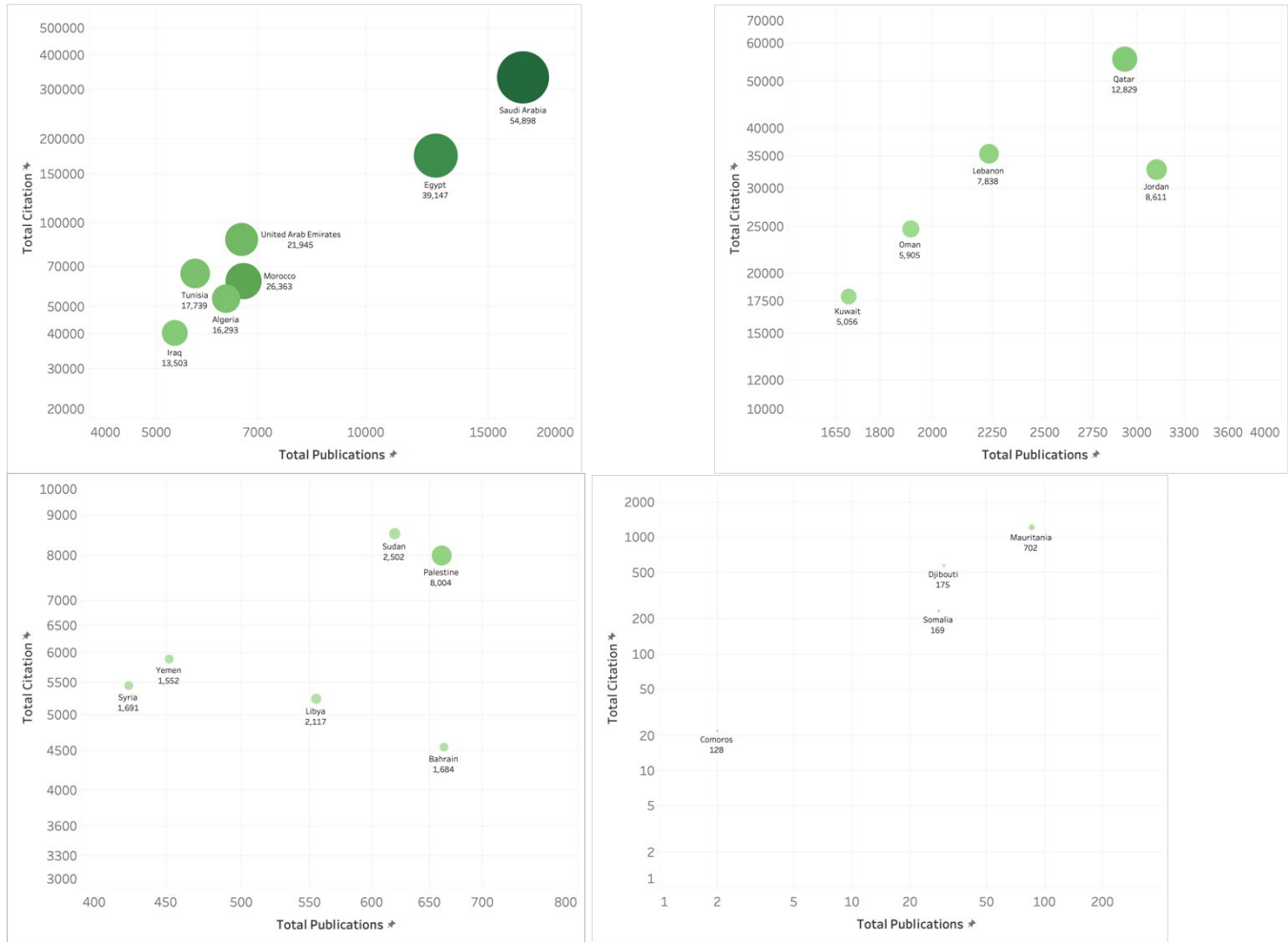


Figure 4. Arab countries scholar outputs in Climate change research, 2012-2021 (log-log scale was used for illustration purposes. The graph is divided into four graphs of different log-log scales)

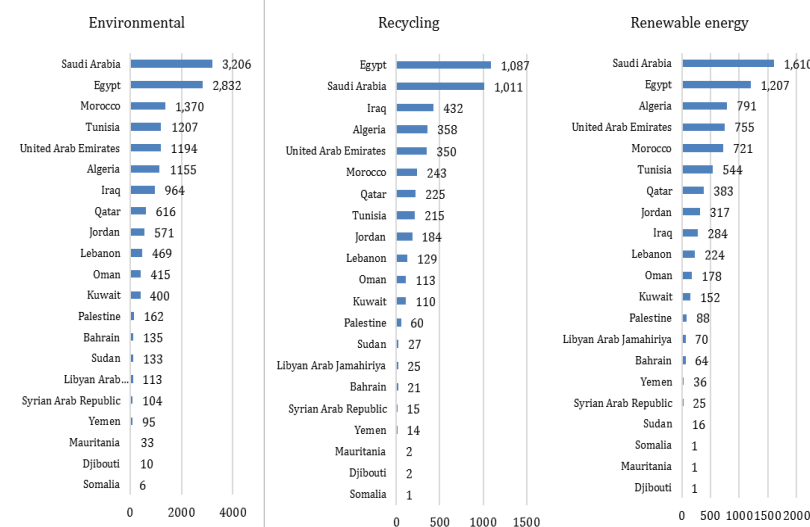


Figure 5. The publication of Arab countries in environmental, renewable energy and recycling research

Top Arab Institutions in Climate change research

In an attempt to deepen the analysis of bibliometric data for the Arab countries, the data revealed that more than 50% of the scientific output is attributed to only 30 institutions (universities, research centres, etc.) in the Arab world (cf. Table 4). Those 30 institutions are in only ten countries of the Arab world. Table 5 shows a pivot table for the countries and their institutions in terms of the total number of publications. We may conclude here that with respect to the total number of institutions from which the 68,128 publications in the past ten years are attributed, those 30 top institutions are positive outliers; from the tables below, it is evident that the five most active institutions are: King Saud University (Saudi Arabia), King Abdulaziz University (Saudi Arabia), King Abdullah University of Science and Technology (Saudi Arabia), Qatar University (Qatar), and Mohammed V University (Morocco). Citations and the number of authors follow the same pattern, while the FWCI and the C/P follow a different pattern that needs more in-depth analysis to understand the underlying meaning better.

Table 4. Top 30 Arab Institutions in Climate change research, 2012-2021

Rank	Institution	Country	TP	TC	FWCI	C/P	AUS	% of total	Cumulative Percentage
1	King Saud University	Saudi Arabia	3398	72517	1.71	21.3	2593	3.96%	3.96%
2	King Abdulaziz University	Saudi Arabia	3029	95817	1.93	31.6	1951	3.68%	7.64%
3	King Abdullah University of Science and Technology	Saudi Arabia	1804	58640	2.29	32.5	1567	2.27%	9.92%
4	Qatar University	Qatar	1654	29998	1.74	18.1	1136	2.13%	12.05%
5	Mohammed V University in Rabat	Morocco	1637	13450	1.08	8.2	1723	2.16%	14.21%
6	Cairo University	Egypt	1611	19451	1.18	12.1	1680	2.17%	16.38%
7	King Fahd University of Petroleum and Minerals	Saudi Arabia	1597	36391	1.6	22.8	1181	2.20%	18.58%
8	University of Sfax	Tunisia	1455	15599	1.01	10.7	1624	2.05%	20.63%
9	Université de Tunis El Manar	Tunisia	1373	14478	0.9	10.5	1737	1.97%	22.60%
10	University of Carthage	Tunisia	1370	17453	1.12	12.7	1421	2.01%	24.61%
11	Khalifa University of Science and Technology	United Arab Emirates	1315	25778	1.5	19.6	1041	1.97%	26.58%
12	Ain Shams University	Egypt	1059	12114	1.11	11.4	1115	1.62%	28.20%
13	University of Hassan II Casablanca	Morocco	1003	6927	0.98	6.9	1250	1.56%	29.75%
14	Alexandria University	Egypt	977	14100	1.43	14.4	997	1.54%	31.29%
15	Sultan Qaboos University	Oman	954	14043	1.36	14.7	747	1.53%	32.82%
16	United Arab Emirates University	United Arab Emirates	939	10785	1.22	11.5	841	1.53%	34.35%

Rank	Institution	Country	TP	TC	FWCI	C/P	AUS	% of total	Cumulative Percentage
17	National Research Center	Egypt	927	13732	1.06	14.8	1097	1.53%	35.88%
18	University of Baghdad	Iraq	807	4481	0.8	5.6	945	1.35%	37.23%
19	Cadi Ayyad University	Morocco	785	10749	1.42	13.7	914	1.33%	38.57%
20	American University of Beirut	Lebanon	779	16812	1.54	21.6	856	1.34%	39.91%
21	Mansoura University	Egypt	773	12833	1.85	16.6	607	1.35%	41.26%
22	University of Sharjah	United Arab Emirates	745	12135	2.44	16.3	526	1.32%	42.58%
23	Zagazig University	Egypt	725	11352	1.88	15.7	582	1.30%	43.88%
24	University of Jordan	Jordan	673	8235	1.21	12.2	685	1.22%	45.10%
25	University of Science and Technology Houari Boumediene	Algeria	640	4563	0.75	7.1	804	1.18%	46.28%
26	Sidi Mohamed Ben Abdellah University	Morocco	632	6722	1.24	10.6	820	1.18%	47.45%
27	King Khalid University	Saudi Arabia	624	5269	1.34	8.4	479	1.18%	48.63%
28	Taif University	Saudi Arabia	621	5030	1.44	8.1	413	1.18%	49.81%
29	Assiut University	Egypt	608	10183	1.41	16.7	483	1.17%	50.99%
30	Tanta University	Egypt	585	10207	1.65	17.4	423	1.14%	52.13%

Table 5. Total publications per country and institutions (only top 30 institutions)

Institutions	Algeria	Egypt	Iraq	Jordan	Lebanon	Morocco	Oman	Qatar	Saudi Arabia	Tunisia	United Arab Emirates	Total
Ain Shams University		1059										1059
Alexandria University		977										977
American University of Beirut					779							779
Assiut University		608										608
Cadi Ayyad University						785						785
Cairo University		1611										1611
Khalifa University of Science and Technology											1315	1315
King Abdulaziz University									3029			3029

Institutions	Algeria	Egypt	Iraq	Jordan	Lebanon	Morocco	Oman	Qatar	Saudi Arabia	Tunisia	United Arab Emirates	Total
King Abdullah University of Science and Technology									1804			1804
King Fahd University of Petroleum and Minerals									1597			1597
King Khalid University									624			624
King Saud University									3398			3398
Mansoura University		773										773
Mohammed V University in Rabat						1637						1637
National Research Center		927										927
Qatar University								1654				1654
Sidi Mohamed Ben Abdellah University						632						632
Sultan Qaboos University							954					954
Taif University									621			621
Tanta University		585										585
United Arab Emirates University											939	939
Université de Tunis El Manar										1373		1373
University of Baghdad			807									807
University of Carthage										1370		1370
University of Hassan II Casablanca						1003						1003
University of Jordan				673								673
University of Science and Technology Houari Boumediene	640											640
University of Sfax										1455		1455
University of Sharjah											745	745
Zagazig University		725										725
Total	640	7265	807	673	779	4057	954	1654	11073	4198	2999	35099

Keyword's Evolution

The keyword co-occurrence network analysis of the most used authors' keywords in climate change research by Arab researchers in the last five years (2017-2021) by using VOS viewer is shown in Figure 6. The keywords up to a minimum occurrence of keywords was 50 out of 156,633 keywords, 1,776 keywords meet the threshold, where the distance and size of the bubble indicate the occurrence of the keywords and links of co-occurrence

[illegible]

Vos Viewer identifies five clusters of 1,776 keywords: blue, red, green, yellow and purple; the blue cluster has keywords such as temperature, biomass, recycling, pollutant removal, water filtration, etc., the green clusters have keywords as a controlled study, marine environment, water pollutant, salinity, etc., the red clusters has keyword as renewable energy, solar energy, energy utilization, decision making, etc., the yellow clusters have keywords as air quality, air pollution, carbon monoxide, education, etc., and the purple clusters have keywords as climate change, climate effect, climate modelling, land use, regional climate, etc.

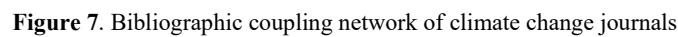
The top 15 productive journals on climate change research by Arab researchers during 2012-2022 are shown in Table 6. The top 15 journals publish 9.2% of all papers on climate change in Arab countries. The top leading journals were IEEE Access (TP=684, TC=11,945) followed by sustainability (TP=598, TC=5,973), energy procedia (TP=569, TC=6,700) and Arabian journal of geosciences (TP=545, TC=3,787). In terms of citation count, the renewable and sustainable energy reviews are a highly cited source of publications that received citations (TC=28,991), followed by journals of cleaner production (TC=14,479) and desalination (TC=12,122).

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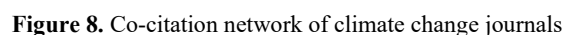
Table 6. The top 15 journals on climate change for Arab researchers

Rank	Journal name	TP	TC	FWCI	C/P	CiteScore 2021
1	IEEE Access	684	11,945	17.5	2483	6.7
2	Sustainability	598	5,973	10	2616	5
3	Energy Procedia	569	6,700	11.8	1459	-
4	Arabian Journal of Geosciences	545	3,787	6.9	1599	2.3
5	IOP Conference Series: Materials Science and Engineering	397	823	2.1	1041	1.1
6	Advances in Intelligent Systems and Computing	392	921	2.3	1107	-
7	ACM International Conference Proceeding Series	388	843	2.2	1063	1
8	Environmental Science and Pollution Research	377	7,702	20.4	1612	6.6
9	Energies	376	5,299	14.1	1526	5
10	Desalination and Water Treatment	375	2,594	6.9	1224	1.7
11	Journal of Cleaner Production	372	14,479	38.9	1421	15.8
12	Lecture Notes in Computer Science	354	1121	3.2	1058	2.1
13	Renewable and Sustainable Energy Reviews	343	28,991	84.5	1102	28.5
14	PLoS ONE	302	7046	23.3	2268	5.6
15	Scientific Reports	262	5635	21.5	1742	6.9

Bibliographic coupling is a similarity measure of scientific literature. It is primarily based on the idea that the two articles that cite similar references are expected to address the related or the same research issues (Almulhim, 2021). Bibliographic coupling links between publications indicate the number of cited references they have in common (van Eck and Waltman, 2020). The bibliographic coupling of journals during the last five years having at least ten publications and five citations are illustrated in Figure 7, where 662 of 8591 journals meet the criteria. IEEE access shows the highest occurrence of 538 documents, 8073 citations and a link strength of 27,703 followed by sustainability through the occurrence of 517 documents, 4650 citations and a link strength of 37,650 and energies with 304 documents, 3724 citations, and total link strength of 21,280.



Co-citation analysis involves tracking pairs of papers cited together in the source articles; a journal co-citation network provides an understanding of the collective intellectual base of a knowledge field (Liu et al., 2015). The Co-citation of journals during the last five years contains 3797 of 438060 journals with equal or more than 50 citations, as shown in Figure 8. Journal of desalination shows the highest citation TC=9034 and a link strength of 338,606 followed by energy (TC=9034) with a link strength of 297,109 and Science (TC= 6,634) with a link strength of 250,724.



Arab countries Collaboration

The percentage of international collaboration in climate change research between Arab countries and other countries was 53.2% of the total research from 2012 to 2021, while the percentage of collaboration between researchers within the country (national collaboration) was 13.9%. The percentage of single authorship (no collaboration) publications represented 8.6%; the percentage of publications according to the type of collaboration for each Arab country is shown in Figure 9. The international publications of Arab countries were 36,234 documents that received 661,264 citations, and Arab authors were 140,127 from 2012 to 2021. The top leading countries with higher research collaboration with other countries in climate change research were Saudi Arabia (TP=12,011) followed by Egypt (TP=6,899), United Arab Emirates (TP=4,192) and Tunisia (TP=3,136), the most collaborated non-Arab countries as shown in Figure 9 were United States (TP= 6,260), followed by France (TP= 5,420), United Kingdom (TP=4,211) and China (TP=4,192).

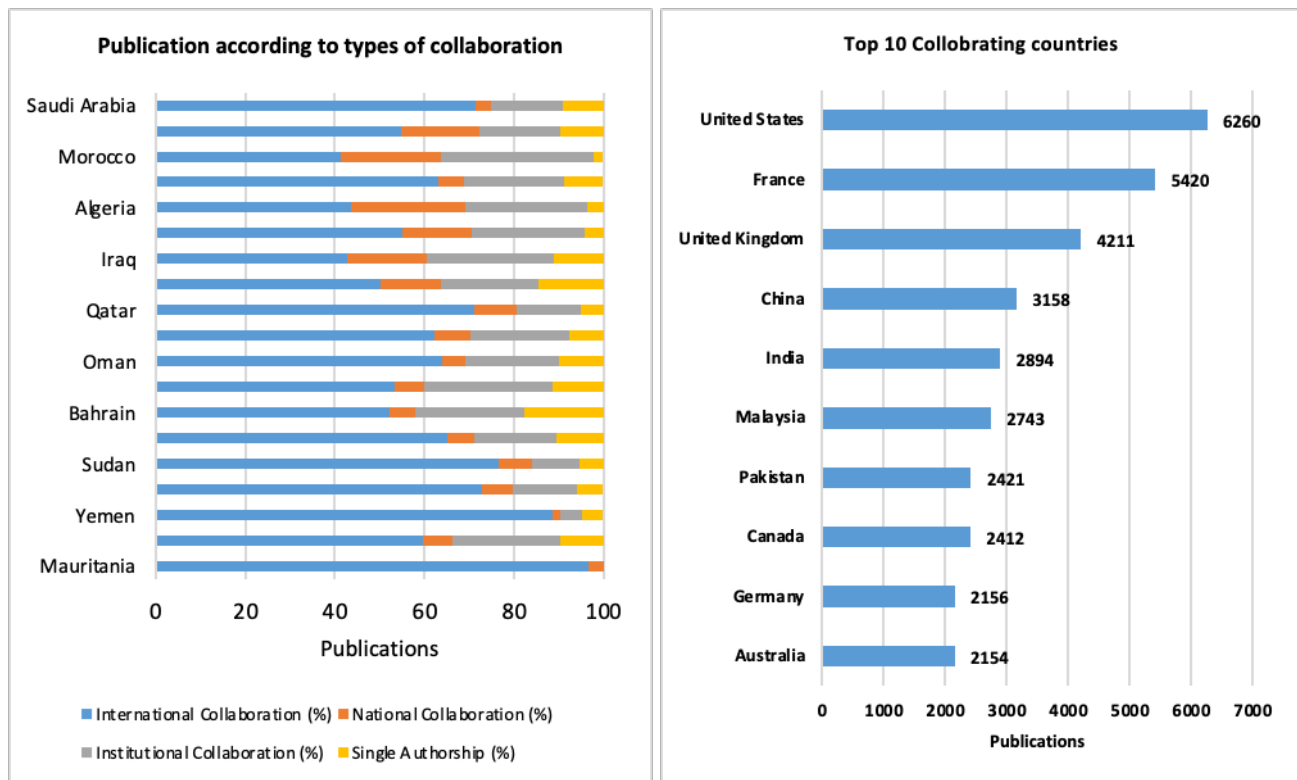
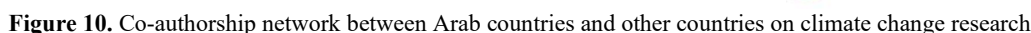


Figure 9. Publication according to types of collaboration in Arab countries and top 10 International collaboration Countries

Finally, Figure 10 illustrates the analysis of the collaborating countries with Arab countries through co-authored publications on climate change research with a minimum of 10 documents of a country during the last five years; 116 countries meet the threshold. The bubble size reflects the number of co-authored publications per collaborating country in climate change research with Arab countries. In contrast, the distance between the two bubbles reflects how frequently countries were mentioned in the same publications. There is noticeably strong cooperation between researchers in Egypt, Saudi Arabia, UAE, and Jordan. On the other hand, there is also strong cooperation between Northwest African countries, Morocco, Algeria, and Tunisia, whilst these countries showed similarities in science and research policies (Radwan, 2018).



The main objective of this paper is to review the publishing trends of climate change research by Arab researchers, including the most productive countries, institutions, journals, authorship, and international collaboration countries. A total of 68,128 documents were examined from the Scopus database. The bibliometric analysis covers the period from 2012 to 2021. Saudi Arabia institutions produced the highest number of documents and received the highest number of citations. The result of the analysis indicates that the performance of Saudi institutes is also superior in terms of the quality of research publications (FWCI) which is higher than the global average. Egypt's research performance is also considered very high compared to many other Arab countries. The percentage of international cooperation in climate change research between Arab countries and other countries reached 53.2% of the total research from 2012 to 2021, a relatively high percentage. The most collaborating countries were the United States, France, United Kingdom, and China; it is noticed that the rise in international cooperation research in Saudi Arabia is remarkable, as it represents about 71%. On a different front, the rate of increase and growth of the number of publications on Climate change within the Arab world is another excellent information, as the rate of growth is about two to three folds that of the rate of growth of the world's publication for the exact keywords and the same period (2012-2021).

At a country level, Saudi Arabia and Egypt alone were the most productive countries representing 43.2% of all research, which shows tremendous efforts exerted during the past 10 years by authorities in the two countries

towards financing climate research; for instance, several funding initiatives at the Egyptian Academy of Scientific Research and Technology are targeting research for confronting climate change.

Nevertheless, countries on the lower side in number of publications (Mauritania, Djibouti, Somalia, Comoros) should realize the challenges ahead in terms of research and research funding. They should adopt similar strategies as other countries in the Arab world to boost their research contribution.

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