Bibliometric Analysis of Knowledge and Awareness about Climate Change from in a decade (2010 to 2019)

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Abstract

Climate change is the biggest issue and challenge in this era. Climate change is a complex issue that spans many disciplines. This study aims to present a bibliometric overview of the leading trends of knowledge and awareness of climate change from 2010 to 2019. The database from the Web of Science (WOS) was used to collect the data. This study uses VOSviewer to create a visualization image to show the result. The results showed that the USA has most research on the topic, but if ranking by the organizations, the institute from Australia produces most research. Of the 34 countries, 22 are from developed countries, whereas the rest are from developing countries. Keyword contribution also indicates that awareness research needs to be improved. The results of this study will enable the researchers to focus more on knowledge and awareness of climate change in the future.

Keywords: *knowledge, awareness, climate change, bibliometric analysis, VOSviewer..*

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1. Introduction

Climate change has become a topic of worldwide concern. Climate change may be due to natural internal processes, external pressures, or continuous anthropogenic changes in the atmosphere of composition or land use factors (World Meteorological Organization 2018). Various disciplines of science have explained the causes and effects of either in natural science, social, economic, and political aspects (Haunschild, Bornmann, and Marx, 2016). Scientific studies on climate change have been carried out in a variety of ways by maximizing existing technologies such as weather forecasting stations and others to predict future weather conditions. However, studies on the impact of climate change are increasingly needed due to the various disasters that result from climate change. The reason is that climate change is one of the greatest challenges now until the 21st century (Hassan, Ghias, and Fatima, 2018; Kuthe et al. 2019).

A healthy natural environment requires awareness of environmental issues (Masud et al. 2016). Therefore, knowledge from various fields such as physics, chemistry, meteorology, and geosciences are interrelated to improve awareness and reduce the impact of climate change. These are important because humans, as an agent of the cause of climate change risk, should be aware of the causes and effects of everyday life. Therefore, this study is to identify the development of knowledge and awareness of climate change-related research. Thus, the bibliometric analysis was used to show past and present research data that was extracted from the Web of Science (WOS).

2. Objectives

This article mainly identifies the contribution from the WOS based on all of the articles related to knowledge and awareness towards climate change, which were published during 2010-2019. Thus, the contribution of this topic will be identified based on the authorship pattern, organization contribution, country-wise distribution, visible publication, and visualization of keyword contribution.

3. Methods and Limitations

This study employed a bibliometric analysis method that uses secondary data to generate useful information for research. This analysis used the results of the data analyzed using VOSviewer as a tool to show the pattern of authorship and organizational contributions. Additionally, the article also developed a graphical visualization of the bibliographic material by using the VOSviewer to visualize contributions of

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countries' wise distribution of the contribution, visible publications, and keywords with bibliographic coupling and co-citation analysis. Visualization techniques using VOSviewer will be presented as a network of visualizations that show colored, circle size, and connecting lines to show data results parameters. This paper focuses on examining 827 papers (all types of paper) published in the Web of Science (WOS) from 2010 to 2019 (10 years) in the topic (knowledge AND awareness AND climate change). The data was extracted and refined by only English languages and index SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, and ESCI. The extracted data also included only articles that were published up to 28 November 2019 (included) and in the English Language.

4. Literature Review

4.1 Bibliometric Analysis

Bibliometric analysis is a method for studying bibliographic material from an objective and quantitative perspective to develop and determine the impact of knowledge in all fields (Castillo-Vergara, Alvarez-Marin, and Placencio-Hidalgo, 2018; Alfonzo, Sakraida, and Hastings-Tolsma, 2014). Many tools can be used to visualize image from bibliometric analysis, namely, VOSviewer, Pajek, SPSS IBM Corporation, Google Scholar, Cytoscape, CiteSpace, Network Workbench, Science of Science Tool, Tableau, NVivo, Bibexcel, Gephi, Tools from Loet Leydesdorff Science and Technology Dynamics, and others (Alfonzo, Sakraida, and Hastings-Tolsma, 2014). Many studies use bibliometric analysis as an approach to explain findings based on past and previous studies. Based on several articles, it is shown that bibliometric analysis has two categories of article analysis. The first category is based on the topic of discussion as can be found in many articles such as those of Jan and Ludo (2010); Nguyen and Chowdhury (2012); Xu and Marinova (2013); Alfonzo, Sakraida, and Hastings-Tolsma, (2014); Cobo et al. (2015) Haunschild, Bornmann, and Marx (2016); Li et al. (2015); Sweileh (2016); Wang et al. (2016); Rey-Martí, Ribeiro-Soriano, and & Palacios-Marqués (2016); Mongeon and Paul-Hus (2016); Sweileh (2016); Sweileh et al. (2016); Wai (2017); Sweileh et al. (2017); Castillo-Vergara, Alvarez-Marin, and Placencio-Hidalgo (2018); Nunen et al. (2018 Liao et al. (2018); Niñerola, Sánchez-Rebull, and Hernández-Lara (2019); Gaviria-Marin, Merigó, and Baier-Fuentes (2019); and Muhuri, Shukla, and Abraham (2019).

Mostly, this category discussed on research trends, countries and institutes, authors, categories of publications, sources of publication, terms and citations, and maps of this knowledge in terms of main topics. This analysis offers to guard about the field of study, such as authors or experts in the field or journals that publish most articles related to the field of study and analyze the trends related to the fields studied every year. For example, in the study of Rey-Martí, Ribeiro-Soriano, and Palacios-Marqués (2016), it is clear that bibliometric analysis guided the researchers in the field under the study. Unfortunately, the disadvantages of this bibliometric analysis study are its limited use on the web, such as WOS, SCOPUS, and others.

The second category is articles that use bibliometric analysis methods based on articles from an organization. For example, an article from Martínez-López et al. (2018) developed and viewed the bibliometric analysis on the European Journal of Marketing from 1967 to 2017 while Wang et al. (2018) researched on the First Twenty-Five Years of the International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems from 1994 to 2015. Also, Swain and Rautaray (2014) studied the contribution article from the Journal of Educational Media and Library Science from 2008 to 2012 using bibliometric analysis. These researchers followed the first method based on the topic of knowledge and awareness towards climate change article in WOS. However, this method also analyzes similarly to the first one, but its limit is that it can focus only on articles published in the studied journal organization. In contrast, its strength is that it can focus on the trends of the journal over a past half-century. Readers can get a sense whether the journal, particularly the topics discussed in the journal, is preferably in a focused area or not.

In conclusion, the first category of bibliometric analysis is beyond its scope, covering the entire article and journal organization involved in a topic in any research web. The second category of bibliometric analysis is focused more on one or more journal organizations. However, both have their advantages and disadvantages. Since the study of climate change is extensively covered by pure science and

social science, of which the focus of the journal organization is extensive, therefore, the first method is suitable for this study.

4.2 Knowledge and Awareness towards Climate Change

Literally, "Climate change" is a long-term change in the distribution of statistics which shows that weather patterns such as temperatures, rain, and others have lasted for decades, even millions of years (Rahman 2013, Haunschild, R., Bornmann, L., & Marx, W. 2016; Ismail A. 2018). The anthropogenic activity factor has been the dominant factor in climate change since the mid-20th century (IPCC 2013). Anthropogenic activities are human activities such as deforestation, farming, factories, and others with uncontrollability. These factors have caused climate change to become more severe and cause various disasters such as floods, drought, ice melt, sea-level rise, and many more. On a global scale, the highest annual daily rainfall has increased by an average of 5.73 mm over the last 110 years, or 8.5% relative (Asadieh, Behzad and Krakauer, Nir Y. (2015)). According to the IPCC, the average global temperature rise (soil and surface mixing) between 1850-1900 and 2003-2012 was 0.78 ∘C (0.72 to 0.85) (Leena, Kaewunruen, & Jaroszweski (2016).

According to the IPPC (2013) report, children born around the year 2000 are likely to face the experience of carbon dioxide (CO_2) concentrations in the atmospheric space of between 463 and 623 parts per million by volume (ppmv), compared to about 400 ppmv in 2016. They seem to live with 8.4-11.3 billion people in planets from 0.8 ∘C to 2.6 ∘C warmer, with sea levels higher between 5-32 cm as compared to 1990 (IPPC 2013). Therefore, raising public awareness and educating the public on climate change is necessary for returns in health, wealth, and well-being of all concerned (Daud, Z. M., Mohamed, N., & Abas, N. 2015; Körfgen, A., et al. 2019). One of the processes to give people an understanding of climate change is to explore their knowledge and the impact of climate change in their area (Barimah, P. T., Kwadwo, S. O., & David O. 2015; Akrofi, M. M., Antwi, S. H., & Gumbo, J. R. 2019). Akrofi, M. M., Antwi, S. H., & Gumbo, J. R. (2019) explained that raising awareness of global climate change is crucial to responding to global climate change. Unconscious disasters resulting from climate change will be an obligation to the public to be knowledgeable and self-aware in addressing the risks of climate change. There are many studies conducted to identify the level of knowledge and awareness of climate change at various levels of society (Daud, Z.M., Mohamed, N., & Abas, N. 2015).

For example, Barimah, P. T., et al. (2015) showed that the level of knowledge concerning the climate change of farmers is still low. However, for civil servants, the results are somewhat higher than the others. Other studies by Kabir, I., et al. (2016) also showed that more educated respondents have a higher level of knowledge of climate change. The findings of Akrofi, M. M., Antwi, S. H., & Gumbo, J. R. (2019) found that students were aware of the causes of climate change such as deforestation, global warming, waste burning, and others. Nevertheless, they are unaware of factors such as improper disposal of garbage and the use of carts that indirectly contributes to climate change. Kuthe, A. et al. (2019) have found that there is a difference in the level of awareness as to their cognitive, affective, and conative aspects towards climate change. Therefore, consideration in determining the best way to raise awareness is needed on these aspects. In conclusion, the importance of knowledge and awareness of climate change is necessary for the society around the world. As such, this article aims to look at research trends that demonstrate knowledge and awareness of climate change from a popular website with high impact articles, Web of Sciences (WOS).

5. Results and Discussion

The discussion in this study involved five sub-themes using bibliometric analysis with the use of VOSviewer to determine authorship pattern, organization contribution, country-wise distribution of the contribution, visible publication, and visualization of knowledge and awareness of climate change based on keyword contributions.

5.1 Authorship Patterns

For each author, the total strength of the citation links with other authors was calculated using VOSviewer. The author with the highest total link strength will be selected. This analysis intended to select 6 authors from 827 journals. Table 1 shows the final six authors, each with four articles. The first rank is Dows Anne-Maree, with 84 citations on the topic of climate change. The author Dows AM is from CSIRO, Australia. Studies conducted by Dows AM that were traced from WOS are related to knowledge, perception, behavior, subjective norm, awareness, and adaptation related to climate change such as renewable energy technologies, in the agriculture sector, low and clean energy future, and geothermal technology. The second rank is Bi Peng, with 64 citations, followed by Grose Jane and Richardson Janet with the same results of 40 citations. Lastly, the last two were Liu Qiyong with 33 citations and Masud Muhammad Mehedi with 22 citations.

Table 1 The most productive authors in WOS about knowledge and awareness toward climate change from 2010-2019

Rank	Author	No of Article	Citations	Total Link Strength
1	Dowd, Anne-Maree	4	84	0
2	Bi, Peng	4	64	5
3	Grose, Jane	4	40	10
4	Richardson, Janet	4	40	10
5	Liu, Qiyong	4	33	5
6	Masud, Muhammad Mehedi	4	22	0

5.2 Organization contribution

Organizations define the institution such as university or college and others. Table 2 presented the organizations involved in knowledge and awareness of climate change publications and had a minimum of 5 publications in the field. There are 44 organizations involved. Most active organizations in the field were in Australia, with a total of 11 institutions. James Cook University and Griffith University Center in Australia were the most productive organizations in publishing articles related to knowledge and awareness of climate change and ranked first and second, respectively. They both have a total of 11 documents, followed by the Chinese Academy of Sciences in China with ten articles. There are 9 articles produced by four organizations which are from Wageningen University and Research in the Netherlands, The University of Adelaide in Australia, Utrecht University in the Netherlands, and the University of Malaya in Malaysia.

Table 2 Ranking of organization contribution

Rank	Organization	Countries	No of Article	Citations	Total Link Strength
1	James Cook University	Australia	11	166	1127
2	Griffith University	Australia	11	107	1460
3	Chinese Academy of Sciences	China	10	110	256
4	Wageningen University & Research	Netherlands	9	437	675
5	The University of Adelaide	Australia	9	154	680
6	Utrecht University	Netherlands	9	109	240
7	University of Malaya	Malaysia	9	108	552
8	Helmholtz-Centre for Environmental Research	German	8	364	1457
9	The University of Western Australia	Australia	8	234	2132

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Rank	Organization	Countries	No of Article	Citations	Total Link Strength
10	The University of Queensland	Australia	8	182	270
11	University of Melbourne	Australia	8	122	772
12	University of Tasmania	Australia	8	106	796
13	University of Oxford	England	8	102	1592
14	Swedish University of Agricultural Sciences	Sweden	7	256	1162
15	Deltares	Netherlands	7	242	1547
16	Macquarie University	Australia	7	133	1062
17	College of Natural Resources (CNR)	California	7	132	448
18	CSIRO Publishing	Australia	7	106	825
19	University of Helsinki	Finland	7	87	355
20	University of Leeds	England	7	58	1129
21	University of Cambridge	United Kingdom	7	44	930
22	Purdue University	United State	7	30	435
23	University of Groningen	Netherlands	7	17	311
24	University of Amsterdam	Netherlands	6	380	1155
25	The University of Manchester	England	6	368	690
26	University of Oslo	Norway	6	292	1114
27	University of Washington	Washington	6	259	1048
28	McGill University	Canada	6	192	347
29	James Hutton Institute	Scotland	6	147	749
30	The Australian National University	Australia	6	119	1242
31	Linköping University	Sweden	6	105	239
32	Universiti Putra Malaysia	Malaysia	6	33	87
33	University of Florida	United State	6	22	119
34	University of Michigan	United State	6	21	414
35	Lancaster University	England	5	367	1203
36	Lund University	Sweden	5	209	241
37	University of Alaska Fairbanks	Alaska	5	113	208
38	The University of Sydney	Australia	5	106	402
39	Shandong University	China	5	105	230
40	University of Exeter	United Kingdom	5	74	719
41	Charles Sturt University	Australia	5	61	772
42	Stockholm University	Sweden	5	47	181
43	University of Reading	England	5	32	268
44	Beijing Normal University	China	5	9	57

5.2 Country-wise Distribution of the Contributions

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A total of 34 countries contributed to the advancement of knowledge and awareness of climate change research. With the minimum number of articles by countries of 10, 34 of 111 countries meet the thresholds. Table 3 shows the rank of all countries that contributed to publications. The USA had the highest share of publications, followed by Australia, England, and Germany. Of the total States, 22 were from developed countries while 12 were from developing countries. The list below of developed and developing countries is adhered by the International Statistical Institute (ISI), effective from 1 January until 31 December 2019. China has the most publications from developing countries, followed by South Africa, Malaysia, and Brazil. Figure 1 shows the citation link with the country based on the size of the circle and the color of the circle and link.
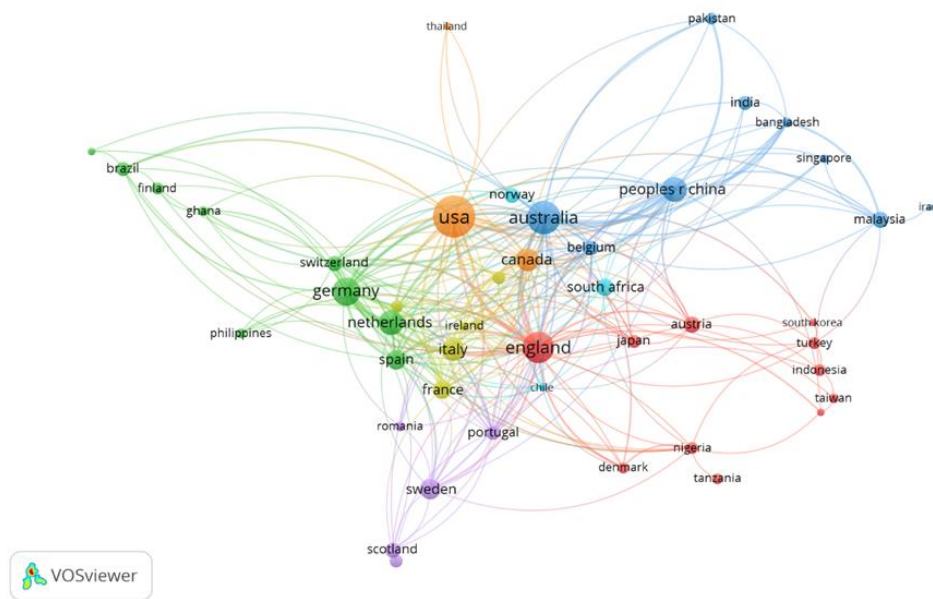

Figure 1 Citation link with country

Table 3 List of journals that published at least 10 articles (2010 – 2019)

Rank	Country	Type of Country	Documents	Citations	Total Link Strength
1	United State	Developed	164	2176	26741
2	Australia	Developed	108	1712	21040
3	England	Developed	95	1380	20116
4	Germany	Developed	74	1371	19596
5	Netherlands	Developed	61	1304	15058
6	China	Developing	57	397	11392
7	Canada	Developed	49	834	14684
8	Italy	Developed	47	912	14071
9	Sweden	Developed	41	866	9973
10	Spain	Developed	38	779	8253
11	France	Developed	34	436	13639

Rank	Country	Type of Country	Documents	Citations	Total Link Strength
12	South Africa	Developing	28	133	5091
13	Austria	Developed	24	439	7794
14	Malaysia	Developing	24	189	4608
15	Norway	Developed	23	644	7839
16	Scotland	Developed	23	701	5836
17	Switzerland	Developed	23	489	12185
18	Belgium	Developed	20	398	6890
19	Brazil	Developing	19	353	5318
20	India	Developing	18	26	2972
21	Portugal	Developed	18	112	7552
22	Japan	Developed	17	218	3645
23	New Zealand	Developed	17	317	8669
24	Greece	Developed	16	94	4340
25	Kenya	Developing	15	82	3197
26	Pakistan	Developing	15	99	1809
27	Finland	Developed	14	148	2275
28	Nigeria	Developing	14	37	1585
29	Turkey	Developing	14	121	1418
30	Indonesia	Developing	13	99	2694
31	Denmark	Developed	11	325	6270
32	Tanzania	Developing	11	196	5403
33	Bangladesh	Developing	10	93	2860
34	Taiwan	Developed	10	49	1099

5.3 Visible Publications

The visible publication was ranked by looking at their citations in WOS data. Table 3 presents the 30 most cited documents in WOS about knowledge and awareness of climate change between 2010 to 2019. During the past ten years, the most cited document is the research by Keesstra et al. (2016), with 298 citations. This article is about the significance of soils and soil science towards the realization of the United Nations Sustainable Development Goals (SDG), published in 2016 in the Soil Journal. Climate change is one of the challenges of major issues in achieving SDG objectives.

Table 3 The most cited documents in WOS publications about knowledge and awareness toward climate change: 2010- 2019

Rank	Cited reference (only the first author is indicated)	Year	Citations
1	Keesstra	2016	298
2	Frederiks	2015	186
3	Mccormick	2013	166

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4	Mooij		2010	138
5	Reynolds		2010	134
6	Ford		2010	127
7	Junk		2014	115
8	Dotterweich		2013	103
9	Stromso		2010	97
10	Kabisch		2016	92
11	Butzer		2012	91
12	Stokes		2014	82
13	Wallquist		2010	80
14	Wennersten		2015	72
15	Ens		2015	70
16	Loreto		2014	70
17	Mertens		2013	68
18	Huntjens		2010	68
19	Sakr		2011	67
20	Gelcich		2014	64
21	Williams		2013	63
22	Drescher		2013	62
23	Marshall		2011	62
24	Beniston		2018	60
25	Maxim		2011	55
26	Taylor		2012	54
27	Hughes		2015	53
28	Cochran		2013	52
29	Ford		2012	52
30	Hjort		2010	51

Figure 2 shows the citation document by using the minimum number of 30, of the 827 documents, only 65 meet the threshold. For each of the 65 documents, the number of citation links will be calculated, and the documents with the most significant number of links will be selected. As shown in Figure 2, the brighter and larger the color, the size of the circle, and the font means the higher the value of the citation link.
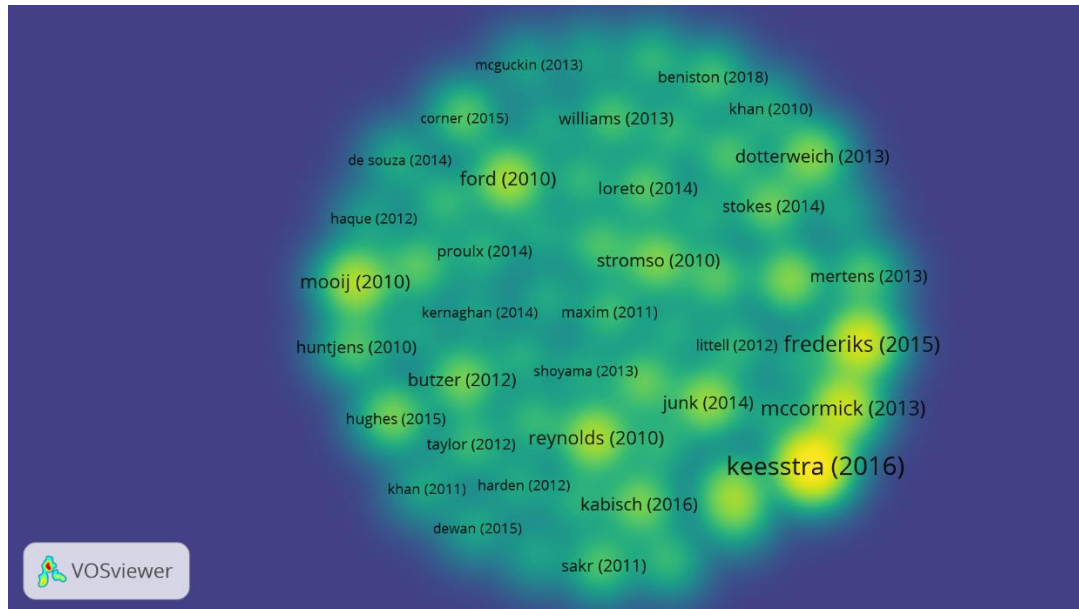
Figure 2 Citation-Publication Years (2010-2019)

5.4 Visualization of the knowledge and awareness toward climate change evolution

Climate change is such a complex phenomenon that its causes, different physical properties, and the consequences can lead to various risks. Therefore, managing climate change disasters may involve various alternatives in various aspects, such as adaptation and mitigation (Anderson, A. 2012). The keyword contributions can be found in Table 4 and Figure 3. Table 4 shows that the first rank is related to the topic of "climate change," with 208 occurrences, and has the highest total link strength. Besides, the keyword "knowledge" contribution to the topic of climate change is ranked second with 129 occurrences. Whereas the contributions keyword for "awareness" which ranked 15th from a total of 20 keywords indicates that awareness studies need to be enhanced.

Table 4 The most occurrences keyword in WOS publications about knowledge and awareness toward climate change: 2010- 2019

Rank	Keyword	Occurrences	Total Link Strength
1	Climate-Change	208	478
2	Knowledge	129	394
3	Management	90	269
4	Perceptions	67	231
5	Adaptation	65	219
6	Risk	54	175
7	Vulnerability	53	166
8	Impacts	51	145
9	Policy	50	161
10	Science	50	157
11	Attitudes	48	170

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12	Governance	32	106
13	Conservation	31	94
14	Resilience	31	104
15	Awareness	29	86
16	Challenges	29	101
17	Information	28	93
18	Behavior	27	80
19	Framework	26	94
20	Health	26	51

Figure 3 shows 64 keywords from 2023, which meet the minimum number of keyword occurrences of at least 10. The diagram shows that the link between knowledge and awareness shows a strong link towards climate change. According to Barimah et al. (2015), learning about understanding the perspective of the population to prepare for climate change is to explore their knowledge and the impact of climate change in their area. Therefore, exploring knowledge and awareness of climate change is essential to discuss, especially in the social aspect because people need to be exposed to knowledge and given awareness so that they can deal with all the risks of climate change.
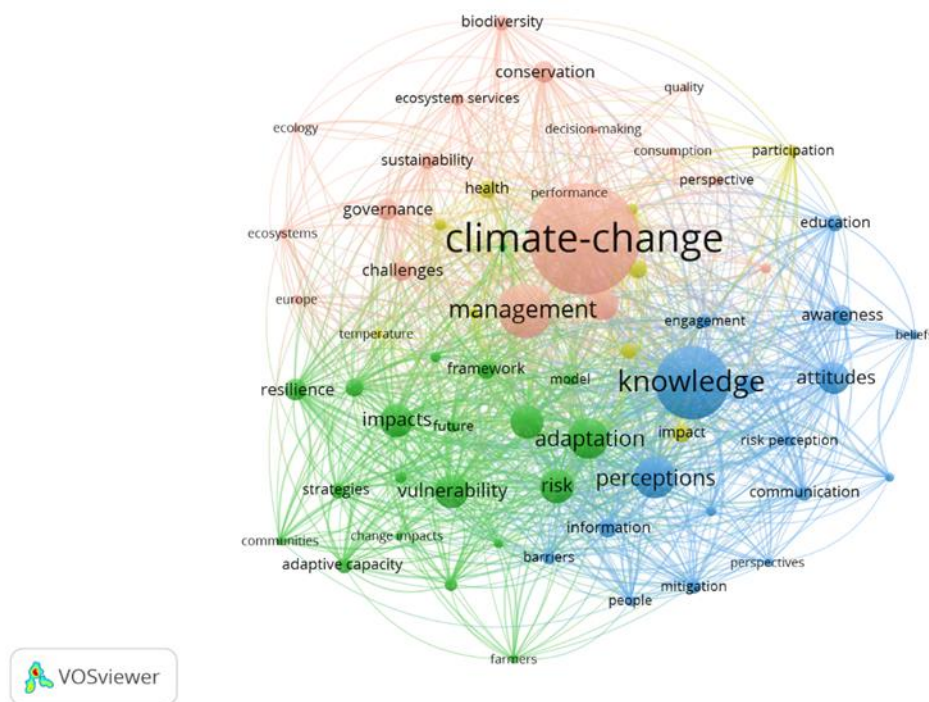

Figure 3 Keyword expanding from bibliographic coupling of knowledge and awareness toward climate change papers published within the average publication years from 2010-2019.

6. Conclusion

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In conclusion, the overall results reflect trends related to knowledge and awareness of climate change in all fields. From 827 articles, the results reveal that the most popular author came from Australia. Besides, the highest percentage of organization contribution is also from Australia, though the USA is the most contribution country. Furthermore, the findings also indicated that developed countries contribute knowledge and awareness on climate change research and discussion more than the developing countries. Contribution keywords show growth of knowledge of climate change while awareness is on the low end. Efforts on sustaining livable earth for the current and future generations must be a priority in any community. Some efforts have been undertaken in several developed countries on public awareness of climate change effect, and the results do vary with regions and communities. Ignorance of climate change will be a hindrance to efforts made by policymakers, scientists, environmentalists, and others. Hence continuous efforts must be carried out as a mitigation measure.

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