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ENERGY PERSPECTIVE ON CLIMATE CHANGE RESEARCH: A VISUAL SCIENTOMETRIC ANALYSIS

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ABSTRACT

Climate change involves research in a number of fields and disciplines such as environmental science, energy, social science et al. in general. As research in these areas advances rapidly, it is critical to keep abreast of emerging trends and critical turns of the development of the collective knowledge. This article provides a review of recent research on climate change with a particular focus on drives of energy sector. Visual analytics of the literature provides a valuable, timely, repeatable and flexible approach in addition to traditional systematic reviews so as to track the development of new emerging trends and identify critical evidence. It concludes with a summary of key lessons offered by the energy sector as well as suggestions for future research.

Keywords: climate change, energy sector, visual scientometric analysis

1. INTRODUCTION

Climate change is a rapidly growing and fast-moving interdisciplinary field of study, involving environmental science [1], energy [2], social science [3], ecology [4], et al. Each of these disciplines has unique perspectives and makes noteworthy contributions to our shared understanding of climate change, but they also contribute to integrated, multidisciplinary frameworks. This article reviews recent progress on research of climate change in the energy area. Attention is also given to some of the ways in which these energy relevant disciplines contribute to research on drives of and responses to climate change.

The body of the relevant literature grows rapidly. In this article, unless stated otherwise, the literature is reviewed from January 2009. The Web of Science Core Collection has 161,835 records between 2009 and 2018 based on a topic search of the term “climate change”. Researchers also have suggested that topics of journal articles are indicators of research directions [5-6]. As a relatively young discipline of study, efforts made in reviewing and analyzing articles in energy perspective on climate change research are even more important in tracking the evolution process within the field.

Scientometrics is a branch of informatics that quantitatively analyzes patterns in scientific literature in order to understand emerging trends and the knowledge structure of a research field [7]. Many science mapping techniques are originated from the idea of co-citation analyses, which characterize the structure of intellectual knowledge in terms of networks of co-cited references [8].

Using scientometrics to analyze existing energy literature focusing on climate change problems would help provide a clear picture on how knowledge and theories advanced and how research topics evolved, therefore, this analysis is highly desirable.

2. DATA COLLECTION AND RESEARCH METHODS

Literature data is used to generate and analyze networks of co-cited references based on bibliographic records retrieved from the Web of Science Core Collection. An initial topic search for “climate change” resulted in 161,835 records published between 2009 and

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2018. After filtering out by discipline “energy”, the dataset was reduced to 6,083 original research articles, review articles, book reviews and proceedings papers and notes. The 6,083 records do not include relevant publications if the term “climate change” does not explicitly appear in the titles, abstracts or index terms. And, incorrect citation variants were corrected prior to the analysis. Thus, the analysis focuses on the development of energy respective on climate change research over the last decade.

Major paths of climate change evolution from the energy perspective were mapped first. The analytical process consists of categorizing knowledge clusters in the research area, identifying major clusters in the climate change knowledge map.

Second, hot research topics and frontline research in the climate change field were identified based on frequency of popular key terms used in references. The burst of certain terms can be used to analyze the evolution of climate change research and identify the most research trends.

Third, contributing countries, authors and cited journals are mapped. This can help identify and visualize major contributing factors for the evolution of the climate change research from the perspective of energy.

3. INTELLECTUAL STRUCTURE OF CLMIATE CHANGE FROM ENERGY PERSPECTIVE

3.1 Co-citation clusters

The literature is represented in terms of a network synthesized from a series of individual networks. Each individual network is constructed from articles published in a 1-year time interval, known as a time slice. These individual networks are integrated to form an overview of how a scientific field has been evolving over time. For this review, an individual network is derived from the 100 most cited articles published in the corresponding time slice, which ranges from 2009 to 2018. Emerging trends and patterns of change are characterized in the networks in terms of a variety of visual attributes.

We obtained the map shown in Fig 1. The clustering function was performed by choosing “Title” as the labelling source and log-likelihood ratio as the method.

Clusters #0 to #10 were the major clusters by their size, that was, the number of members in each cluster. Clusters with few members tend to be less representative than larger clusters because small clusters are likely to be formed by the citing behavior of a small number of publications.

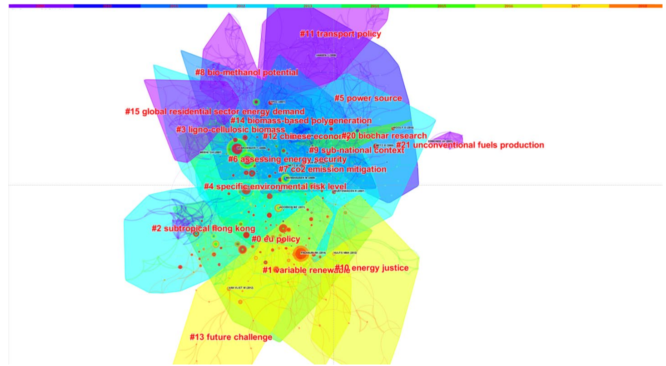

Fig 1 Co-citation clusters of cited references from 2009 to 2018

3.2 Timeline view of Co-citation clusters

To understand the origin, historical development, and current status of climate change on energy and identify key noun phrases in the knowledge evolution process, we performed a visual timeline analysis on the co-citation clusters of references. The results is showed in Fig 2.

It was evident that Cluster #1 on variable renewable energy had a high concentration of nodes with citation bursts, which echoed the fact that this was the most recently formed cluster.

4. NETWORK ANALYSIS OF COUNTRIES

4.1 Network analysis of countries

Based on the literature dataset from 2009 to 2018, 87 countries had been involved in the energy related climate change research. Among them, 1,212 articles were published by institutions in the United States, 938 articles by institutions in China, and 721 articles by institutions in United Kingdom, followed by Germany, Australia, Canada, Italy, Spain, Netherlands and Sweden, as shown in Fig 3.

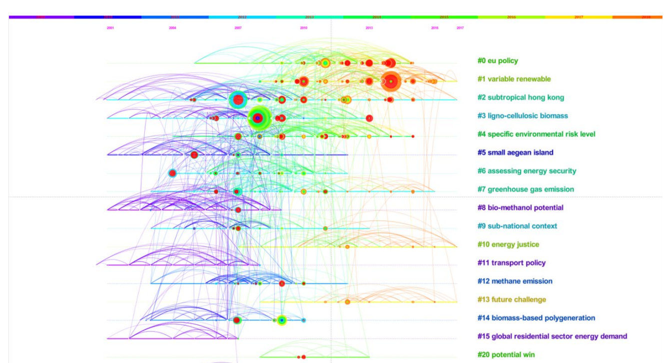

Fig 2 Timeline view of co-citation clusters from 2009 to 2018

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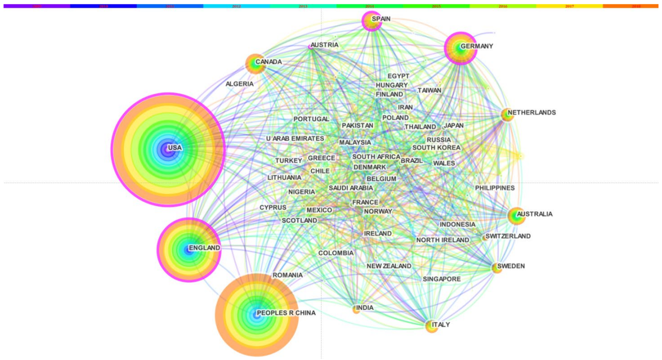

Fig 3 Network of countries for energy related climate change research

Among them, the United Kingdom ranked top in terms of number of publications and had a high centrality value of 0.17. The centrality values of articles from USA and Germany were 0.14 and 0.15, respectively, indicating high impact of these two countries in the climate change field. Although China had published a mass of articles, the impact should be further reinforced. Fig 3 also showed that the globalization requires cooperation and looking into research issues from multiple perspectives, suggesting strong potential for international cooperative network development in the climate change field.

4.2 Network analysis of contributing institutions and core scholars

In terms of contributing institutions, the Chinese Academy of Sciences ranked first with 125 articles, followed by Tsinghua University (89) and University of California, Berkeley (64). The centrality ranking slightly differed from the contribution institution ranking. The top three institutions in terms of centrality were the Chinese Academy of Sciences (0.09), Tsinghua University (0.09) and University College London (0.09), showing the importance of the three institutions in climate change research. In terms of the burst of publications, University of Cambridge ranked first with a burst value of 8.3099, followed by the Pacific Northwest National Laboratory (5.2396) and Royal Melbourne Institute of Technology (5.0028). The burst period for Harvard University was 2009–2011 and the burst period for the University College London was 2016-2018, reflective of that university's strong growth in climate change research in recent years. Details appeared in Table 1.

The Web of Science database showed that from 2009 to 2018, Dr. Benjamin K. Sovacool from Aarhus University published 25 including articles and ranked at the top of the list, followed by Dr. Jinyue Yan from the Mälardalen University (18) and Dr. Peter Smith from University of Aberdeen (17). More details were contained in Table 2.

TABLE I. CONTRIBUTING INSTITUTIONSBY FREQUENCY

Institutions	Frequency
Chinese Academy of Sciences	125
Tsinghua University	89
University of California, Berkeley	64
Utrecht University	56
University of Cambridge	54
National Institute for Environmental Studies	51
University College London	49
University of Edinburgh	48
National University of Singapore	46
University of Manchester	46

TABLE II. CONTRIBUTING AUTHORS

Authors	Institutions	Publications	Year Begin
Benjamin K. Sovacool	Aarhus University	25	2011
Jinyue Yan	Mälardalen University	18	2012
Peter Smith	University of Aberdeen	17	2009
Yiming Wei	Beijing Institute of Technology	15	2012
Guohe Huang	University of Regina	15	2010
Yong Geng	Shanghai Jiao Tong University	14	2012
Hailong Li	Mälardalen University	13	2015
Seppo Kellomaki	University of Eastern Finland	12	2010
Bin Chen	Beijing Normal University	12	2012

4.3 Network analysis of cited journals

There existed 211,963 references in the collected literature dataset. The network of the cited journals was depicted in Fig 4. As we had noted, bigger circles indicated higher citation frequencies.

Articles from the Energy Policy had a total citation of 3,176. Articles from the Renewable & Sustainable Energy Reviews had a total citation of 2,268, and articles from the Energy had a total citation of 2,149. Applied Energy had a total citation of 1,907. Among them, the Energy Policy and the Climatic Change had the largest centrality 0.12. The citation frequency and centrality indicate the appropriateness of journals' inclusion in this research.

However, for the duration 2009-2018, in terms of the burst values, the Sustainable Cities and Society ranked first with a burst value as high as 28.0384 between 2016 and 2018. The Annual Review of Environment and Resources had a burst value of 26.4939 in 2009-2013. Other journals that had relatively high burst values include Current Opinion in Environmental Sustainability

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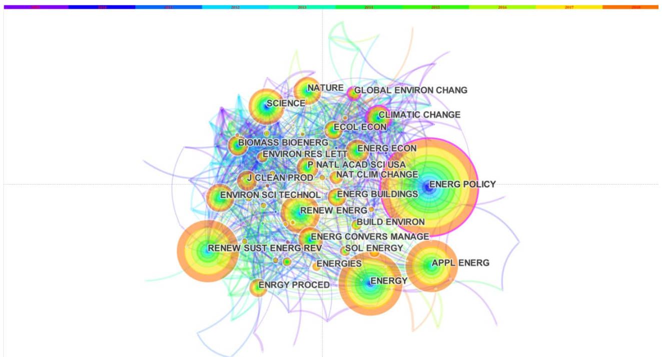

Fig 4 Network of cited journals

(22.3022), Nature Communications (16.9748), Ecological Applications (19.3868) and Energy Sources (15.5388).

5. DISCUSSIONS AND CONCLUSIONS

With the assistance of the Scientometric technology, we have found the emerging energy perspectives on climate change research.

In terms of contributing countries, institutions, authors, and journals, the major driving force of climate change on energy was from the United States, China and United Kingdom, with the Chinese Academy of Sciences, Tsinghua University and University of California, Berkeley being major contributing institutions. Dr. Benjamin K. Sovacool, Dr. Jinyue Yan and Dr. Peter Smith were top contributors with Dr. Jinyue Yan being the center of one of the most important cooperative networks. Articles from the Energy Policy had the highest number of citations, with the Renewable & Sustainable Energy Review, Energy, Applied Energy and Renewable Energy also listed in the top five.

The popularity of research topics are summarized from the scientometric analysis. Energy justice is a crucial component that should be addressed when assessing the drives of climate change, while paying explicit attention to applying justice principles to energy policy, energy production, energy consumption as well as energy security consideration. Secondly, it is critical that energy efficiency play a substantive role in the responses to climate change, which contains the increase in energy conversion efficiency and decrease in greenhouse gases emission. Lastly, renewable energy is critical to mitigating global warming, involving renewable energy technologies, renewable energy infrastructure and renewable energy adoption.

ACKNOWLEDGEMENT

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REFERENCE

[1] M.G. Grillakis. Increase in severe and extreme soil moisture droughts for Europe under climate change. Science of The Total Environment 2019; 660: 1245-1255

[2] D. Burillo, M.V. Chester, S. Pincetl, E.D. Fournier and J. Reyna. Forecasting peak electricity demand for Los Angeles considering higher air temperatures due to climate change. Applied Energy 2019; 236: 1-9.

[3] M. Berman and J.I. Schmidt. Economic Effects of Climate Change in Alaska. Weather Climate and Society 2019; 11(2): 245-258.

[4] A.K. Knapp, C.J.W. Carroll, R.J. Griffin-Nolan, I.J. Slette, F.A. Chaves, L.E. Baur, A.J. Felton, J.E. Gray, A.M. Hoffman, N.P. Lemoine, W. Mao, A.K. Post, and M.D. Smith. A reality check for climate change experiments: Do they reflect the real world. Ecology 2018; 99(10): 2145-2151.

[5] O. Tuomaala, K. Järvelin, P. Vakkari. Evolution of library and information science, 1965–2005: Content analysis of journal articles. Journal of the Association for Information Science and Technology 2014; 65(7): 1446-1462.

[6] N. Aharony. Library and Information Science research areas: A content analysis of articles from the top 10 journals 2007–8. Journal of librarianship and information science 2012; 44(1): 27-35.

[7] J. Hou, X. Yang, C. Chen. Emerging trends and new developments in information science: A document co-citation analysis (2009–2016). Scientometrics 2018. 115(2): 869-892.

[8] H. Small. Co-citation in the scientific literature: A new measure of the relationship between two documents. Journal of the American Society for information Science 1973; 24(4): 265-269.

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