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An Informetric Profile of Water Resources Management Literatures

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Abstract The main purpose of this paper is to evaluate the global performance and to assess the current trends in research of water resource management. The methods of informetric analysis were used to survey water resource management related articles in the Science Citation Index (SCI) and Social Science Citation Index (SSCI) during the past decades. The publication records, subjects, journals, countries, institutes, authors, citations and keywords were analyzed respectively for each paper. The number of papers related to water resource management in 2012 was approximately 8 times that of the year 2000 and hundreds of times more than early 1990s. Water resource management related papers were distributed unevenly by countries. The USA, P.R. China, Australia and UK were the top contributing countries, also present normalized by dividing with population that published most SCI papers as well as SSCI papers. The largest water resource management research center is located in the USA according to the number of publications and citations, with P.R. China becoming more proficient in water resource management according to the data from country and institute. In addition, the quality of papers produced by developed countries is more advanced than developing countries. All these efforts contributed to the indication in trends of water resource management research on a global scale. Earlier water resource management research appeared and was originally concentrated on engineering, irrigation and geography. Issues gradually transferred to management, economics and regime recently.

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1 Introduction

Water, especially fresh water, is one of the most important strategic resources (Vidyasagar 2007). It plays a significant role in the social development and survival of mankind (Rojas-Sola 2011). In the past, water was regarded as a natural resource that can't be used up and did not need to protect (Loukas and Vasiliades 2007). Due to the rapid economic growth and humanity's destructive activities, water safety issues have become an increasingly serious problem now (Vorosmarty et al. 2010). Water crises erupt and spread constantly around the world in our days (Qin et al. 2010). Moreover, the water quantity cannot satisfy our demand yet (Toraj Mohammadi 2003). Using China as an example, about 400 cities lack fresh water and more than 100 cities are confronted with severe water shortages in a total of 660 cities (Vorosmarty et al. 2010). The same predicament exists generally in developing countries such as Egypt (Seckler et al. 1999). Statistics provided by the United Nations Educational Scientific and Cultural Organization (UNESCO) show that more than one third of people in Africa are short of drinking water. Excepting rapid economic development and unreasonable human behaviors, poor water resource management are the main causes of water crises (Loukas et al. 2006).

Humanity has been studying and searching for effective measures to manage water resources for thousands of years, and the Du-jiang-yan Irrigation System (DIS) in China is just such a case (Cao et al. 2010). Research of water resources in modern history began in the early 20th century (Wang et al. 2011). Water conservation projects include, among others, hydraulic and hydroelectric, drinking water, drainage, water quality, flood control and irrigation projects as primary objectives, which are regarded as the core way in resolving and developing water resources in its early stages (Jiazhu 2002). Water resource monitoring, water treatment techniques are also major fields in water science research (Biswas 2004; Biswas 2008).

The past high quality engineering infrastructures indeed helped people a lot. The approach to water conservation engineering can no longer perfectly govern the water and resolve today's problems. Nowadays, water related researchers gradually realize that the management science is as important as water governing. Hence water resource management has become a major issue in recent years due to the pressures produced by the disturbed water balance and water resources degradation in the natural system as well as the increasing demand for more and better quality water in the social system (Loukas et al. 2006).

However, to define water resource management clearly is still not available and many definitions have been proposed by different fields involved in water resource management. The Global Water Partnership (GWP) gave an concept of water resource management involved in integrates politics, economics, organization, legislation and management technologies and methods (Loukas et al. 2006). The GWP regarded the water resource management as an advanced and integrated method in water science which can "promote the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (Partnership 2000).

In this context, water resource management is regarded as the work with incorporate political, economic, cultural, technical, legislative and organizational ingredients in one river basin or a total water cycle. The technical parts of water resource management are made up of decision support systems (Giupponi 2007), water allocation, water demand management, water supply management and hydraulics, engineering hydrology (Mohammad Karamouz et al. 2004).

Traditional approaches for water resource management are emphasized to provide adequate water for drinking or other application, without paying enough attention to its sustainable development. New strategies in water resource management are in the direction of considering socioeconomic, regional development and economic evaluation which underlining reducing water demand and improving water use efficiency (Loukas and Vasiliades 2007) .

Integrated Water resource management (IWRM) has been the main stream in water resource management since the early 1990's (Foster and Ait-Kadi 2012). The experience from addressing water problem indicated multi-dimensional, multi-sectorial and multi-regional, multi-interest, multi-agenda, and multi-cause mean unprecedented management complexities which promote the use of the IWRM. Mathematical modeling and/or GIS are frequently used tools in IWRM in problems such as water allocation, decision support systems and system design (Mysiak et al. 2005).

At present, some new directions and research areas have emerged in water resource management research. Water security and water strategy have attracted increasing attention by water professionals and experts, due to their significance in the long-term development in all domains (Gleick 1993). In addition, the economics of water resources, as a branch of resource economics, present the new trends in water resource management. Water rights, water demand side management, water markets, water finance, water banking and virtual water are popular fields in water resources economics. Well-defined tradable water rights can boost water efficiency, equity and sustainability by internalizing and reducing negative externalities inherent in the consumption of water (Teele 1900). Water Demand Side Management is better for utilizing limited water resources than supplying orientation water management (Renwick 1998). A reasonably designed water market could play a crucial role in ameliorating water quality and water allocation of different industries and regions (Marca Weinberg and Wilen 1993). The stellar performance of water finance in Africa, Chile and water banking in California showed that they are effective ways of optimizing water resource management (Tenge et al. 2005). Water-abundant countries can export virtual water to water-scarce ones in open international markets resulting in global virtual water flows, something good for optimization of global water resource (Hoekstra and Hung 2005).

The current and foreseeable development direction of modern society forecasts that future water problem will continue and become increasingly complex as interconnection with economic development fields such as energy, transportation and communication, industry and agriculture, and departments in social or natural systems such as environment, health, education, civilization and culture (Bank 2007). Therefore, more attentions should be paid to water resource management.

Informetrics has been applied for scientific study as the quantitative analysis method and the outcomes of statistics can measure the contribution of scientific publications within a specified theme, as well as describe current research trends that can be used to indicate future study focuses. International conference of scientometrics and informetrics were held many times already, in each one there are many research papers reporting the applications of such methods in a specific subject. In this study, the publications of water resource management research productivity were analyzed carefully.

2 Data and Method

This paper is based on the data analysis of the articles from the online Web of Science (WoS) version database by Thomson Reuters. The WoS, which is manage from the Institute for Scientific Information (ISI), is the most significant and frequently employed source database for reviewing scientific achievements and trends. Water resource management related articles from the WoS were used to investigate the present and future development trends.

The data sources are thus came from the WoS Web, and the publishing time span is up to 2012, updating in Feb 9th, 2013. Data in this paper was acquired on Feb 28th, 2013 using the topic = ("water* resourc*" and (manag* or administrit* or economic*)) selecting "all the years". Totally 10,863 articles were received from the database of WoS. The impact factor (IF) of the WoS journals with the latest data available in 2012 was determined by Journal Citation Reports (JCR) of Thomson Scientific, Philadelphia, USA.

Scientometric analysis is considered as a useful mathematical and statistical method to describe productivity of science, technology and the development trend of research, and can evaluate and predict the relative research with geographic variation in outputs and findings usually (Yao et al. 2012). The scientometrics method, which was a branch of intelligence science was firstly proposed by Alan Pritchard in 1969, is widely used to analyze scientific production and research trends in branches of learning. The statistical analysis tool is the Thomson Data Analyzer (TDA); the drawing tool is Aureka and MS Office Excel 2013. In this scientometrics study, the paper productivity, subjects, journals, countries, institutes, keywords and citations were deeply discussed in the quantitative analysis methods.

3 Results Analysis

Figures and tables are used to describe the production and the development trends of water resource management research in both the science and social science fields. Publications (as indicator for scientific performance) are commonly accepted indicators for quantitative analysis on innovation research performance.

3.1 Productivity Analysis

Figure 1 reveals the publication output of water resource management research from 1990 to 2012. During the past decades the published paper related to water resource management research rose from 1 in 1990 to more than 1,500 after 2012. It could be seen from Fig. 1 that few papers were produced before 1990 and this means few researchers paid attention to water resource management research at that time. From 1990 to 2001 the annual output of papers was no more than 200 and this was the starting stage of water resource management

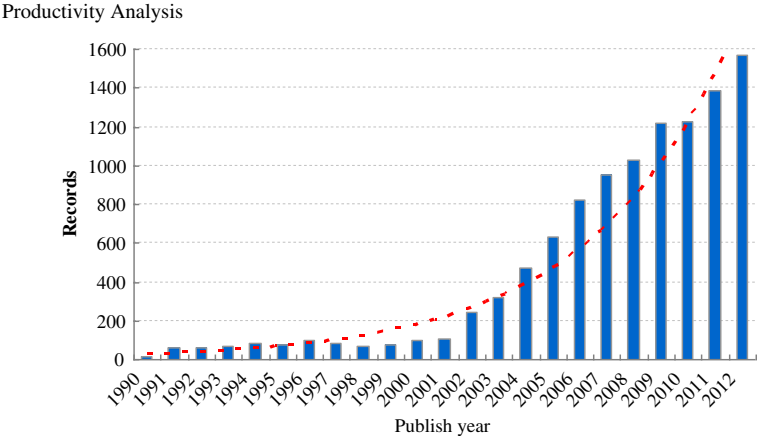

Fig. 1 Papers on water resource management published from 1990 to 2012 in WoS

research. The number of papers increased rapidly and after 2002 this growth phase is continuing. This feature signifies that water resource management is still a popular issue, with higher quality papers will be published in the future maturity period.

3.2 Subjects Analysis

According to the subject categories classification of Thomson Reuters in the Journal Citation Report (JCR), the papers produced during the past decades were distributed in more than 98 subject categories. The five most productive subjects and subject categories containing more than 1,100 papers are shown in Fig. 2. Water resources, environmental sciences & ecology and engineering occupied a dominant position on water resource management research. Agriculture and geology are in the secondary position. In addition, water resources are the most important research subject in water resource management.

Figure 3 shows that water resource management research is mainly distributed in the realms of water resources, environmental sciences & ecology, engineering, agriculture and geology. Before 1995 papers on water resource management were few and used mainly by environmental sciences & ecology, agriculture and geology. After year 2001 papers in every realm were constantly increasing with water resources, environmental sciences & ecology and engineering increased faster than agriculture and geology after 1997. The research papers of environmental sciences & ecology and engineering decreased rapidly and the agriculture and geology increased rapidly after 2011. The number of papers about engineering declined to the level of 10 years ago. Researchers giving more attention to water resource indicate that water resources are endangered and humans realized this crisis.

3.3 Journals Analysis

13, 265 journals were listed in the WoS with 2, 236 journals in the field of water resources in JCR 2012. Research in water resource management was published in 2,236 journals and the journals with more than 130 articles and their Impact Factor (IF) in 2012 are presented in Fig. 4. Approximately 2,192 of the WoS papers were found in these top 10 productive journals called core journals according to Bradford's Law in information science. From Fig. 4, it is seen

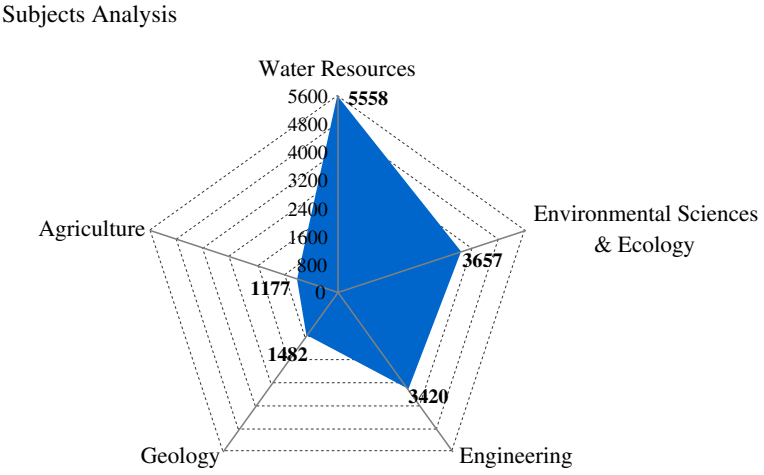

Fig. 2 Main Subject distribution of water resource management papers in WoS

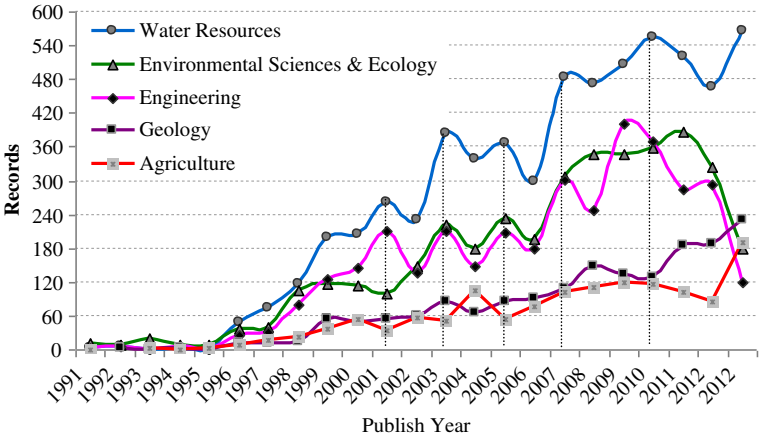

Fig. 3 Annual subjects distribution of water resource management papers in WoS

that the journal of *Water Resource Management* has the highest output with 379 papers and its IF ranked fourth, as well as the output with 135 papers and IF of *Water International* were the lowest one. In this list, there were 4 journals shown whose IF is bigger than 2.0: *Water Resources Research, Journal of Hydrology, Hydrological process* and *Water resources management*, which can be considered as the core journals in the field of water resource management. The journal of *Water Resources Management* is the most significant journal and journals with more than 200 papers are core journals on the basis of statistical data shown in Fig. 4.

The top 6 output journals are displayed in Fig. 5. Their historic performance in the past decade is also described. The journal of *Water Resources Management* published lest number of papers compared to these journals before 2006 and after that year the number increased very fast to be the top one in 2007. The gap with the journals seems to become wider. The performance now shows that this journal would be the most productive one for a long time period. A similar situation happened with the *Journal of Hydrology* whose popularity increased rapidly after 2005 in the study area and is the second in paper output.

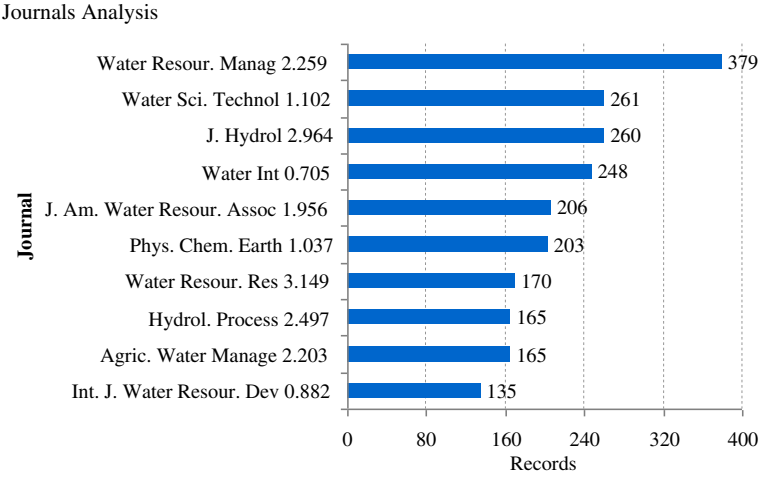

Fig. 4 Top productive journals about water resource management and its IF

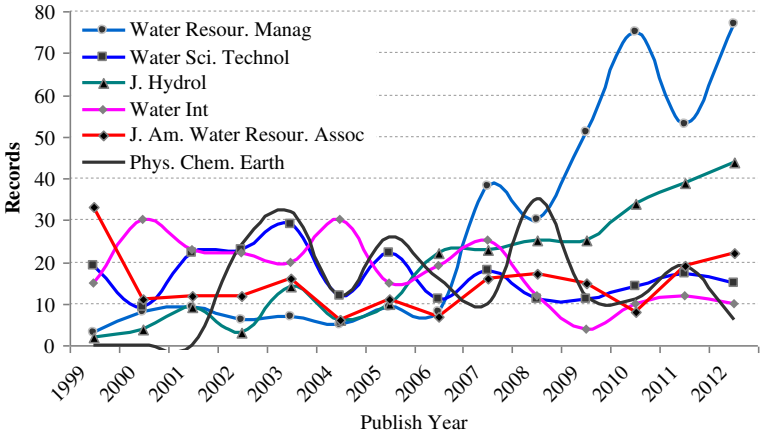

Fig. 5 Top productive journals about water resource management distribution in the research field

The journal *Water Science Technology* output has declined after 2004, which indicates that researchers pay less attention to the technology field than other fields such as institutional and economic ones. The output of the journal *Physical and Chemical of the Earth* demonstrated a fluctuating trend rising and falling, which indicates its performance in the future cannot be guaranteed. Five journals with the exception of the *Physic and Chemistry of the Earth*, show a declined popularity in 2008, probably affected by the global financial crisis.

3.4 Countries Analysis

In Fig. 6 several major countries which conduct research in water resource management and their paper output of papers are displayed. It is seen that the USA is in the lead position and P.R. China is in second, followed by Australia, UK, Germany and Canada, India and Spain.

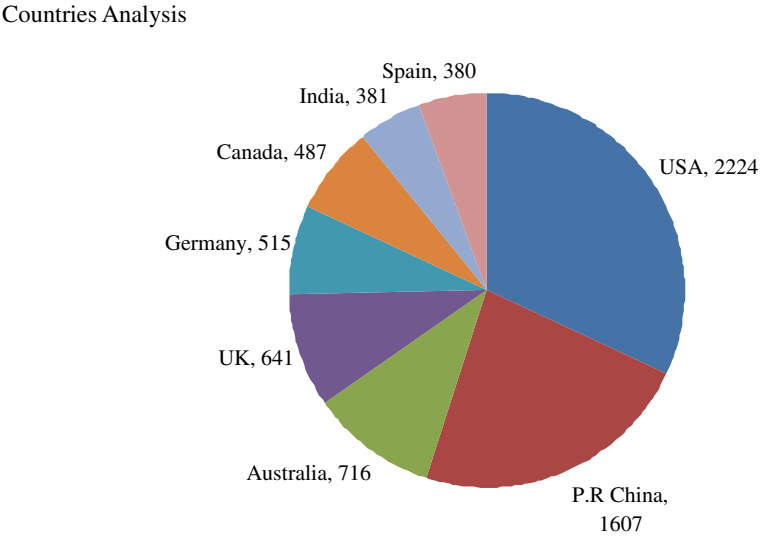

Fig. 6 Countries rank and its production of water resource management papers

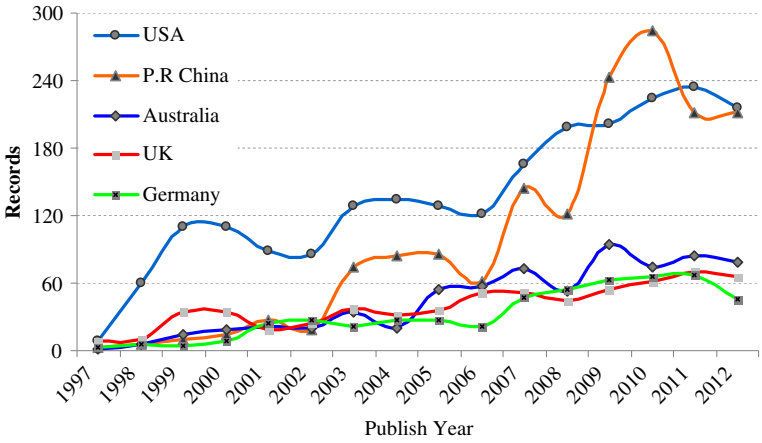

Fig. 7 Top productive countries of water resource management papers in WoS

From these 8 countries, only 2 are developing countries. This implies that developed countries have been more productive in this field and this is an indication of positive correlation of scientific research and economic development level. P.R. China, as a developing country, has a high output because of its rapidly increasing growth in the last 30 years.

Figure 7 displays the output of the top 5 countries with their development tracks from 1997 to 2012. The USA has been the leader in this period and P.R. China has narrowed the difference in 2012. After a short-term decline from 2005 to 2007, P.R. China has undergone a rapid increase from 2002 to 2011 and surpassed the USA in 2009. This track indicates that these two countries would compete fiercely in the future. The remaining countries Australia, UK and Germany have also increased paper production in the past 15 years.

Figure 8 is used to display active degrees of different countries, which means the proportion of paper quantity from countries for the issued volume of the top 5 productive countries during 2010–2012. The proportion of production in the last 3 years to publication in all years is called active degree. It is safe to conclude that the active degrees of all 5 countries were more than 39 % and the most active country was P.R. China with a ratio of

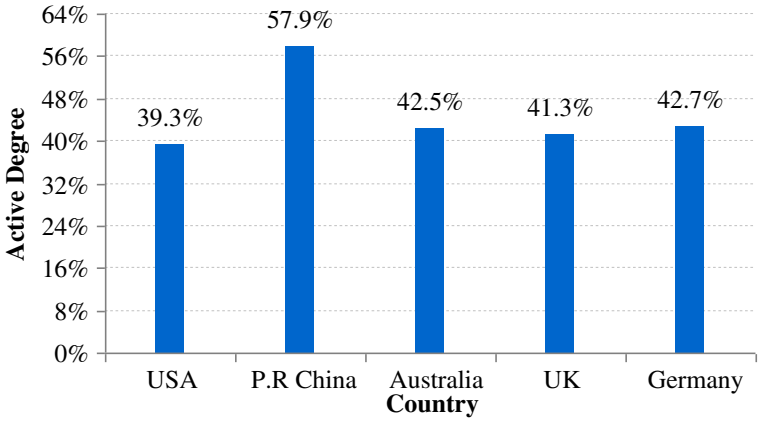

Fig. 8 Top productive countries of water resource management papers in WoS

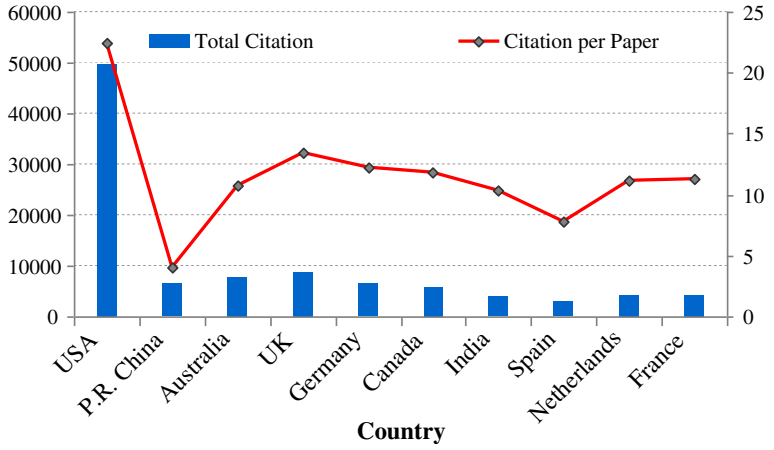

Fig. 9 Citation distribution of WoS water resource management papers

57.9 %, followed by Germany, Australia, UK and the USA. The active degrees indicate that P.R. China may become the main country for water resource management in the near future and it can also be said that developed counties are still the core countries in this field.

Total citing and average citation frequencies in the field of water resource management research from top 9 countries are shown in Fig. 9. The USA was the highest country in total citing count followed by Canada, Germany, the Netherlands and P.R. China. The citations per paper listed in descending order are UK, the USA, Canada, the Netherlands and Germany. UK, the USA and Germany are also on the front ranks in the issued number of papers demonstrating their dominance in the field of water resource management. The USA is first and UK is second in total citing. UK is the first and USA is second in average citation frequencies. This condition indicates the high quality of the papers published in the USA and UK. The P.R. China ranks first in active degrees and second in total papers published but with a low level citation both in the total citing and citation per paper.

Figure 10 is a cooperative network map and the national/regional cooperative relationship and network map of water resource management has been displayed in accordance with the

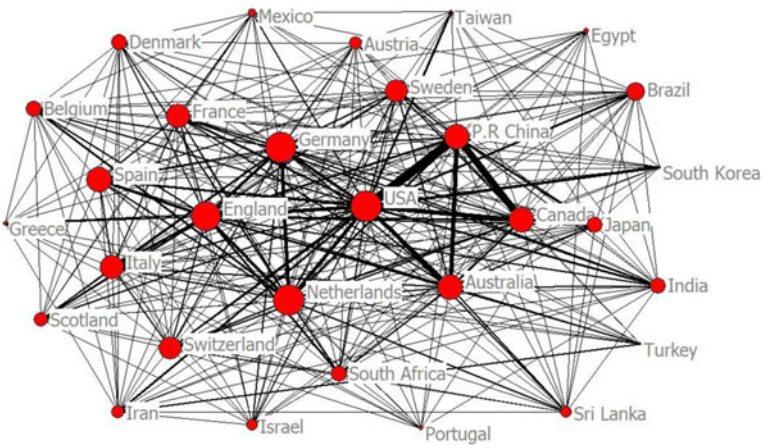

Fig. 10 The international collaboration map of countries with water resource management papers

Table 1 Paper production per population and per capita for top countries

Country	USA	P.R China	Australia	UK	Germany	Canada	India	Spain
Paper/population	77	12	36	11	6	15	4	10
Paper/GDP	139	200	716	320	170	324	272	277
Citation/Population	1717	49	385	143	77	179	38	75
Citation/GDP	3111	805	7700	4295	2104	3829	2824	2179

national/regional cooperation degree. The thickness of the lines between countries and regions can reflect their degree of cooperation. Canada, the P.R. China, Australia and the USA cooperate frequently with each other and the USA has the core position in the network. The USA benefits from the knowledge transfer among water resource management. The USA published the most papers so it is at the heart of the network and P.R. China, Australia, Canada, UK, the Netherlands and Germany are in the peripheral layer. Other countries or regions such as Denmark, Taiwan, Brazil, India, Iran and Belgium are in the outermost layer of the cooperation network and have less cooperation with each other.

For those most productive countries in water resource management, the publication per their population and capita (per million persons and per million US dollars) were listed in Table 1. USA and Australia is with the highest producing ratio and paper citation. P.R. China as well as Canada, Spain have the almost the same ratio in paper per population. Germany and Indian is with the lowest productivity per population. Australia and UK have the most paper per GDP, indicating their high out/input production in large. USA owns the highest citation per population and P.R China, Germany and Indian have the lowest ration due to the large number of population. Australia and UK have the most citation per GDP in the world. In total, Australia is a country with high productivity and output/input ratio.

3.5 Major River Analysis

Figure 11 is a map of main rivers in the world showing number of papers about them. Eleven rivers are recorded with 3 rivers in the Americas, 2 in Europe, 2 in Africa, and 4 in Asia. Three rivers are not international rivers with 1 is in the U.S.A and 2 are in P.R. China. The Yellow River in P.R. China is the most researched river with 611 written papers about it. The Yellow River basin is faced with serious water crises like water shortages and water pollution. The Nile River, the Colorado River, the Mississippi River and the Yangtze River are also studied in 289, 269, 265 and 262 papers respectively. The Yangtze River is the biggest river basin in P.R. China and is crucial to economic and social development. The Nile River, which is the longest river in the world, passing through the world's largest desert, is of great importance to agricultural production in the riparian country in Africa. The Colorado River provides the main source of water for the Western United States and parts of Mexico. The Mississippi River is the most important water way and source of irrigation water for the central part of the United States. Factors shown above are main reasons of studying these rivers more than others. Furthermore, a society's level of economic development seems to have a positively correlation with the number of paper.

3.6 Institutes Analysis

Figure 12 identifies the 11 institutes with a paper productivity of 35 or more. The Chinese Academy of Sciences performed very well and far exceeded other institutes in total number

Major River Analysis

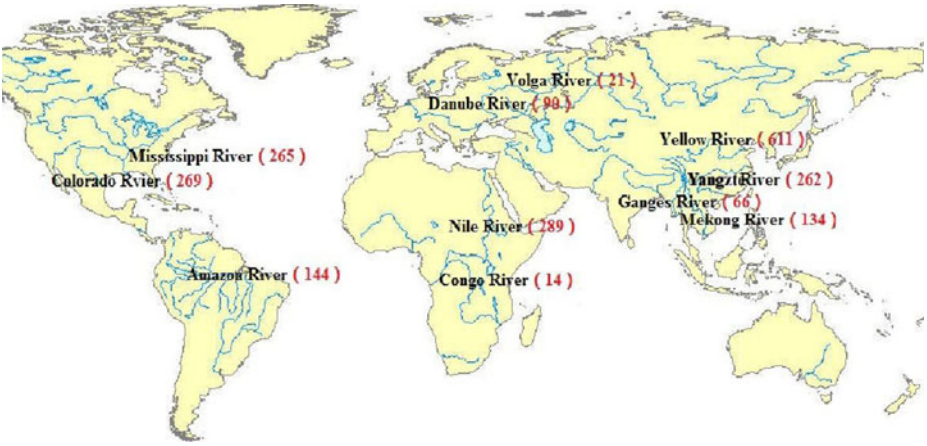

Fig. 11 Major River related water resource management papers records in WoS database

of papers with 101, followed by Texas A&M University, the USDA ARS, the University of Arizona and the International Water Management Institute. The USA has seven institutes; P.R. China, UK and India have only one each and the International Water Management Institute (IWMI) is one of 15 international research centers supported by a network of 60 governments, private foundations and international organizations collectively known as CGIAR.

Figure 13 shows the top 11 paper productive institutes in the world during the last 15 years. Research in water resource management was in its peak stage from 1999 to 2007 in all institutes, and reached its crest around 2005. It can be seen that there is a dramatic decline in paper output after 2007 which may have been affected by the global financial crisis.

Figure 14 is a cooperation of network maps of organizations in water resource management research which according to the degree of cooperation between these institutions is clearly seen that some institutions, such as the US Geological Survey, Colorado State

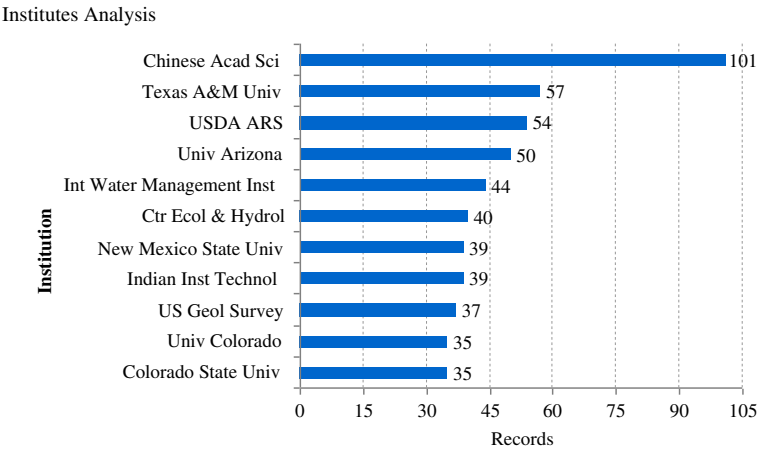

Fig. 12 Top institution distribution of water resource management papers published in WoS

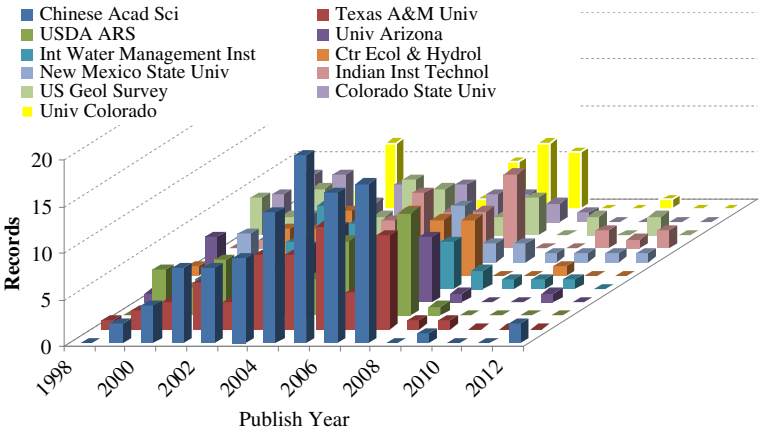

Fig. 13 Annual subjects distribution of water resource management papers in WoS

University, the University of Colorado and Texas A&M University are in the core status of the network which indicate that these institutions cooperate with other organizations more frequently. It also means these organizations play an important part in the process of knowledge transfer in water resource management on a global scale. Some institutions lower in paper production such as the University of California Davis, the Institution of Hydrology and the World Bank scatter fringe of the network because of less cooperation. In addition, there are several distinct cooperation circles. The Chinese Academy of Sciences cooperated frequently with Wuhan University and CSIRO Land & Water, and the University of Washington cooperating regularly with the University of Wisconsin, and the United Nations Educational,Scientific,and Cultural Organization (UNESCO) often cooperated with the International Water Management Institution and the University of Zimbabwe. It can be concluded that these significant institutions mostly belong to the USA and the P.R. China and parts of international organization. Therefore it can be safely concluded that the USA,

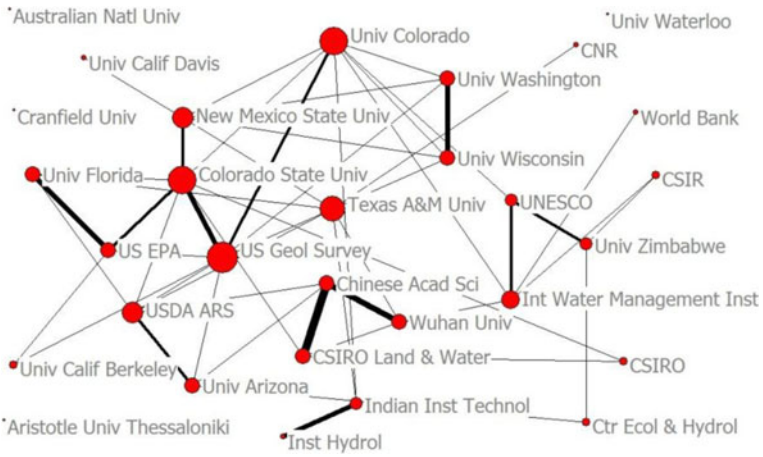

Fig. 14 Co-authorship in different institutes of water resource management publications

P.R. China and parts of international organizations have huge advantages and development strength prospects in these fields.

Total citing and average citation frequencies in the field of water resource management research of top 11 institutions are shown in Fig. 15. The United States Department of Agriculture-Agricultural Research Service (USDA ARS) had the highest in Citations per paper followed by the United States Geological Survey, the University of Colorado and Colorado State University. Total citations listed in descending order are the USDA ARS, the Chinese Academy of Sciences, the United States Geological Survey, the University of Colorado and Colorado State University. The Total citations of the USDA ARS were far more than the second one and other institutions. Moreover, the USDA ARS are first, both in citations per paper and total citations implying it has the most significant role in this field. Eleven institutions excluding the Chinese Academy of Sciences were more than the total citations indicating paper quality of these institutions are higher.

3.7 Keywords Analysis

Table 2 shows the most used popular keywords appeared in the papers in the area of water resource management, these data implied the research focused on or most related with this field. According to Table 2, words such as "management, model, and water-resources" appear more frequently than others. Followed by them were "system, water and climate-change". It is "management" and "model" the core issues of the water resource management research, more and more scholars have to put their efforts into solving this issue in the water resource management research.

Figure 16 displays the most frequently employed key words distributed from 1991 to 2012. Before 1998 key words were distributed in several fields. The key word "management" rose from less than 20 times in 1999 to more than 140 times in 2012. "Management" was the most frequently used key word used in the research of water resource management. The key word "model" was the second most frequently employed key word. The key words of water-resources, systems and climate-change increased rapidly after 2005. The research realm has been drawing more attention and may be the next popular focus.

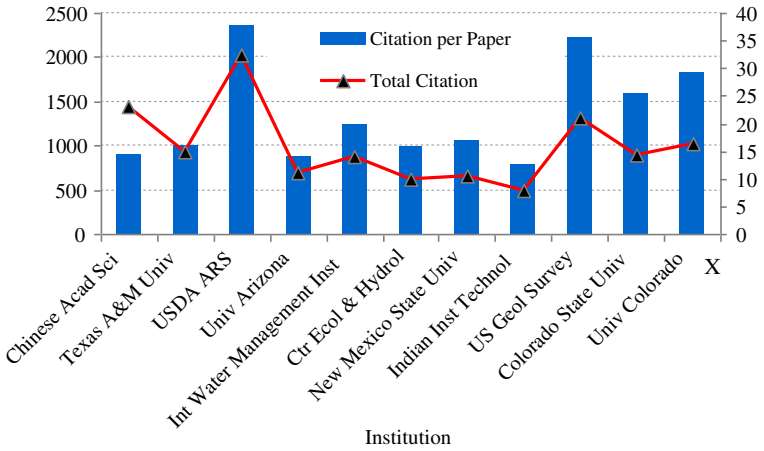

Fig. 15 Citation of top productive institutions on water resource management publications

Table 2 Key words distribution of water resource management papers in WoS

Keywords Plus	Management	Model	Water-Resources	Systems	Water
Records	1029	593	386	318	295
Keywords Plus	Precipitation	Uncertainty	Simulation	Impacts	River
Records	284	254	252	235	234
Keywords Plus	River-Basin	United-States	Quality	Optimization	Runoff
Records	226	194	193	192	190
Keywords Plus	Climate-Change	Variability	System	Basin	Resources
Records	182	181	179	168	161

Figure 17 is a map of paper topics obtained by bibliometric analysis on the papers of water resource management from the WoS database. The clusters or co-words map derived from the author key words can tell us the core competitiveness of water resource management research. A conclusion can be drawn that some topics above were popular ones in the research of water resource management, management planning practices, climate changes adaption, integrated resources management, river and river basin management and the Yellow River study. These fields are popular issues now and worth more attention and will publish more papers in the future.

3.8 Citation Analysis

The top 10 most frequently cited papers are listed in Table 3 which was based on the JCR database from 1991 to 2012. The number of total times a particular article was cited can not only imply the quality of the paper, but also reflect its influence in this field. Articles cited more than 243 times are displayed in Table 3 and it can be seen that the most frequently cited article was "Fragmentation and flow regulation of the world's large river systems" written by Nilsson. C in 2005 and it has been cited 436 times since being published in *Science*. Meanwhile, it can also be found that among these most cited papers, the USA contributed seven which exhibited its overwhelming superiority in this field. Sweden and UK held one

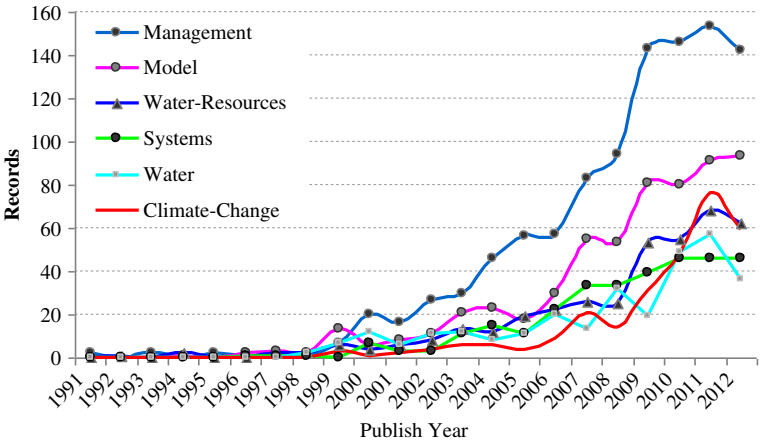

Fig. 16 Times(Annual distribution) of keywords in different period about water resource management papers, 1991–2012

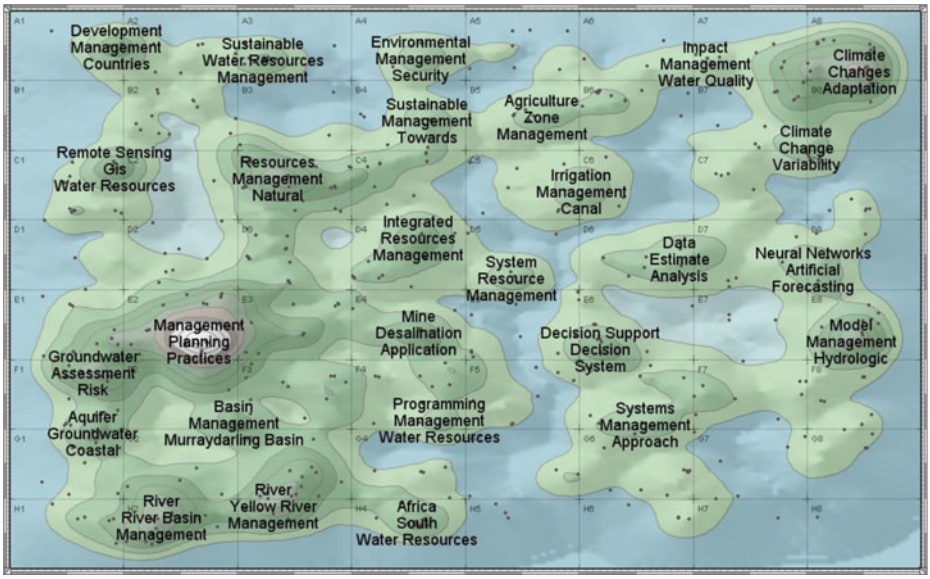

Fig. 17 Clusters and co-words map of water resource management papers in WoS

much while P.R. China published none even through its productivity was the highest in the world. In addition, the top 10 articles published from 2000 to 2007 display the research of water resource management were very active and had remarkable results.

4 Conclusion

The global water crisis is underway and is becoming more serious, and has garnered the attention of people. Water security is becoming a national strategy for some countries which are lacking of water. This study showed some remarkable viewpoints on the world-wide water resource management research trends and performance from 1990 to 2012, and some advantaged work about water resource management research was also recommended.

The water resource management research showed an upward trend as the SCI and SSCI paper production increased steadily in the last two decades and rapidly in the last 10 years. The annual paper production in 2012 was over 1,500 and was about 8 times that of the paper production in 2002. Water resource management research mainly focused on the subjects of water resource, environmental sciences, agriculture, geology and engineering and generalized to economics and regime science very quickly in recent years. Water rights and water markets have been regarded as a necessary complementary measure to traditional engineering and technical ones today, and the perspective of water resource management is no longer confined to a single river or basin for a country, but on a global scale.

In addition, the analysis of keywords explained that management models were domain focus and system, climate-change and water resource rose fast in recent years which presage these fields are becoming popular. Output concentrated in several journals such as *Water resource management*, *Water Science Technology, Journal of Hydrology* and *Water of International* as well as other several journals in SSCI and SCI database respectively. Papers quantity in developing countries such as P.R. China and India are relatively high

Table 3 Top 10 cited papers on water resource management in WoS

No	Time Cited	Authors	Title	Journal	Institute	Country	Year
1	436	Nilsson, C	Fragmentation and flow regulation of the world's large river systems	Science	Umea University	Sweden	2005
2	424	Steinmann, P	Schistosomiasis and water resources development: systematic review, meta-analysis, and estimates of people at risk	Lancet Infectious Diseases	Swiss Trop Institute,	Switzerland	2006
3	401	Lal, R	Soil carbon sequestration to mitigate climate change	Geoderma	Ohio State University	USA	2004
4	399	McClain, ME	Biogeochemical hot spots and hot moments at the interface of terrestrial and aquatic ecosystems	Ecosystems	Florida Int University	USA	2003
5	336	Moriasi, D. N	Model evaluation guidelines for systematic quantification of accuracy in watershed simulations	Transactions of The ASABE	USDA ARS Grazinglands Res Lab	USA	2007
6	301	Verschuren, D	Rainfall and drought in equatorial east Africa during the past 1,100 years	NATURE	University Minnesota,	USA	2000
7	284	Katz, RW	Statistics of extremes in hydrology	Advances in Water Resources	Natl Ctr Atmospher Res	USA	2002
8	271	Fowler, H. J	Linking climate change modelling to impacts studies: recent advances in downscaling techniques for hydrological modelling	International Journal of Climatology	University Newcastle	UK	2007
9	249	Arnold, JG	SWAT2000: current capabilities and research opportunities in applied watershed modelling	Hydrological Processes	USDA ARS	USA	2005
10	243	Dinnes, DL	Nitrogen management strategies to reduce nitrate leaching in tile-drained mid-western soils	Agronomy Journal	ARS, USDA	USA	2002

yet, their quality of papers needs to be improved. The situation above also can be found in the analysis of citations.

Figures and tables in this paper describe the entire performance, distribution and the trend of water resource management research. The explain result will be conducive to researchers who study this field. Nevertheless, papers about water resource management are so numerous scattering in a number of databases that some high quality papers may not be analyzed. Water crises are the most prominent problem in the world and water resource sustainable utilization is the key factor of the existence and sustainable human development. Population growth and economy-society development, global climate change, biofuel production and commercialization are the main driving force of the world-wide water crises. The coupling of natural and socioeconomic driving forces and the complexity of different values, religious ethics and political convictions in diverse countries and regions exacerbate water crisis restricts economic progress, damages the ecology and even triggers international conflicts. It should be mentioned at this point that the essence of the water crises is the water resource management crises. Water resource management research should be given more priority.

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