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The hot spots and frontiers of research on the Grand Canal Culture Belt in China: Literature and academic trends

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The construction of the grand canal cultural belt is the first zonal development strategy in China starting from the Spring and Autumn Periods. In recent years, it performs the link between the oceangoing Maritime Silk Road and the land-based Silk Road to promote a national policy of “One Belt and One Road”. In order to fully understand global academic hot spots and the corresponding trajectory in the research of the grand canal culture belt from 1976 to 2022, the literature review is based on 256 publications from ISI Web of Science, 4944 bibliographic records retrieved from China Academic Journals Full-Text Database, 472 articles under the theme of the cultural economy from Chinese Social Sciences Citation Index, and visualized by the scientometric software of CiteSpace. Meanwhile, comparisons of research areas with canal studies in both China and other global famous canals are implemented, including the *Grand Canal of China*, the *Venice Canal of Italy*, the *Panama Canal of Panama*, the *Colorado River of the USA*, the *Nile Delta of Egypt*, *Nicaragua Canal of USA*, *Welland Canal of Canada*, especially four canal studies cases on keywords and knowledge clusters: Grand Canal of China, Venice Canal of Italy, Nile Delta of Egypt, Rhine-Marne Canal of France. The study identifies major intellectual cooperation networks, cooccurrence keywords, research clusters, and landmark articles, including: (1) International grand canal research tendencies gradually extend the discussions from water conservancy to the cultural economy since Chinese scholars publish more articles on grand canal cultural belt, especially from the year of 2016; (2) Government-issued culture development planning and high diversity of grand canal culture belt are two crucial driven factors affecting the changes in the theme of Chinese studies. Finally, this study summarizes the future research directions that could be expanded in two ways: (1) Increase the multidisciplinary perspective of research and strengthen the cooperation of researchers and (2) Transfer the theoretical research results into canal heritage protection and development practice to fully develop the value of canal.

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Introduction

The Beijing-Hangzhou Grand Canal is the longest artificial waterway in the world with a total length of 1794 km crossing eight provinces in China. And it is also one of the oldest canals in the world more than 2500 years old. It has played an important role in promoting regional economic development and cultural exchanges in China. It performs the link between the ocean-going Maritime Silk Road and the land-based Silk Road to promote a national policy of “One Belt and One Road”. President Xi Jinping of China highlights the protection responsibility of the Grand Canal to all regions: “Grand Canal is a precious heritage left to human beings by our ancestors, and it is a flowing culture, which should be well protected, inherited and utilized” (Wang, 2018).

The influence of social events on the theme of canal research was particularly obvious in the year 2014. After 8 years of application, China’s Grand Canal was recognized by UNESCO World Heritage Committee which convened its 38th session in the Qatari capital and inscribed on the World Heritage list (Xinhua, 2014). Centering on “cultural and natural heritage”, historians, archeologists, and researchers of the cultural industry have conducted rich studies on canals. The publications in China Academic Journals Full-Text Database (CJFD) first exceeded 351 articles, with the comparison of only 4 pieces of literature that were included by CJFD in 2004, and 1 piece of literature 30 years before in 1984.

In February 2019, the issuance of the “Planning Outline for Grand Canal Cultural Protection, Inheritance and Utilization” attracted wide attention (Xinhua, 2019). In May 2019, *1st International Forum on Brand Communication of China’s Grand Canal Culture* was held in Yang Zhou. Nearly fifty scholars exchanged views in four sub-forums, including generation and evolution of the cultural brand of the Grand Canal Cultural Belt, the brand building of Grand Canal culture and national image communication, brand communication of Grand Canal Culture under the environment of multi-media convergence, brand strategy and innovation of Grand Canal Cultural business form (Jiangsu Provincial Union of Philosophy and Social Sciences, 2019). In 2020, the construction of national cultural parks such as the Great Wall, the Grand Canal, the Long March, and the Yellow River was included in the 14th Five-Year Plan. Since then, the construction of the Grand Canal National Cultural Park has been positioned as “a historical and cultural symbol for inheriting Chinese civilization, a common spiritual home for gathering Chinese strength, and a cultural experience space for improving people’s quality of life”, thus entering a new stage of the protection and inheritance of the Grand Canal.

With the continuous growth and emerging topics of grand canal culture belt literature, it is of great theoretical and practical significance to analyze the academic evolution, and predict the research prospect in the future. This paper tracks research hot spots and answer the questions listed.

- (1) Are there any significant key nodes in the evolution of grand canal culture belt research?
- (2) What are the themes and knowledge clusters in different periods?
- (3) What are the driving factors that affect the changes in the theme of Chinese studies?
- (4) What is the frontier trend of the grand canal culture belt in the future?

Methodology and data collection

This study used scientometrics as the quantitative research method to analyze the grand canal culture belt study from a much

broader and more diverse range of relevant topics than the conventional expert-compiled review approach (Chen, 2006). Firstly, previous articles from an international perspective are reviewed by tracking the evolution process of 256 publications in ISI Web of Science (WoS) within the field by 7 June 2022. Secondly, literature with “grand canal” in the title, abstract, or keyword is retrieved from China Academic Journals Full-Text Database (CJFD). The time span is from 1981 to 2022 and a total of 5453 results are obtained. The duplicates and less representative record types such as book reviews, and newspapers are removed, and a total of 4944 original research articles from 1981 to 2022 are examined in this study. Thirdly, 472 core journal literature with the themes of “cultural economy” are extracted from the Chinese Social Sciences Citation Index (CSSCI) for in-depth interpretation.

Subsequently, the scientific measurement software CiteSpace is used for literature processing. The quantification and visualization functions of CiteSpace are more concrete and efficient than traditional literature reading methods (Chen and Wu, 2017). Although the study of the grand canal had already appeared in China and worldwide a long time before, there are no publications at home and abroad using scientific measurement to analyze the knowledge map of this research field from a global perspective. Using CiteSpace to analyze existing literature would help provide a clear picture of intellectual cooperation networks, co-occurrence keywords, timeline clusters, and landmark articles in Chinese scholar studies and panoramic analysis of grand canal research. The hot research categories and keywords are identified to analyze the trends and topics of research in the grand canal field. Literature co-citation analysis can identify the literature that has had significant influence in a certain research field by analyzing the frequency of literature cited by other studies.

Knowledge mapping results of international grand canal literatures

Analysis of time and space distribution. The first literature is included by the WoS database in 1976. Before 2010, the number of published articles remains at a low level of fewer than five papers per year (see Fig. 1). It has two peaks in 2016 with 24 articles and in 2021 with 28 articles. China, USA, Canada, Italy, France, England, Egypt, and Germany, all have formed a certain scale of research institutions, since Grand Canal, Erie Canal, Rideau Canal, Venice, Canal du Midi, River Thames, Nile Delta, Kiel Canal are canals in each of these countries. Among them, China ranks first in terms of the number of published literature on the Beijing-Hangzhou Grand Canal of 106 articles. Chinese Academy of Sciences(30 articles), Zhejiang University(12 articles), University of Chinese Academy of Sciences(9 articles) occupy the top three research institutions.

Analysis of keywords and knowledge clusters. Globally, “sediment”, “water quality”, “surface water”, “soil”, “management”, “heavy metal”, and “pollution” are the seven highest frequency keywords from 1976 to 2022 (see Fig. 2). The research topics focus on ecological water conservancy and protection. For example, Boedihartono et al. (2015) adopted visualization techniques to analyze the best pygmies’ landscape in the Congo basin from the view of ecology science.

After running CiteSpace, the knowledge clusters with closer connections (Modularity Q value is 0.8557) and highly consistent (Mean Silhouette is 0.9431) are visualized (see Fig. 2). Many knowledge clusters focus on ecological attributes, like cluster (#0) of “groundwater management”, cluster (#2) of ecological risk, cluster (#6) of “fraction of heavy metals”. Typical research, for example, Eltarabily et al. (2018) utilize MODFLOW to investigate

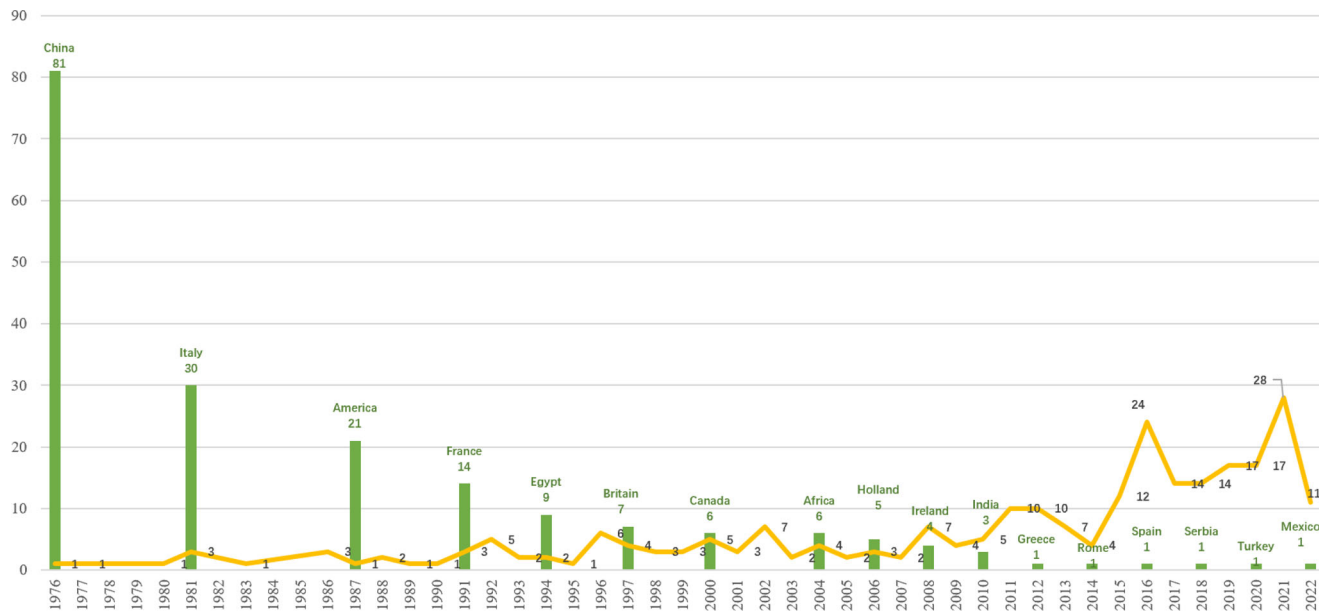


Fig. 1 Annual quantity of grand canal literatures published in WoS database (1976–2022).

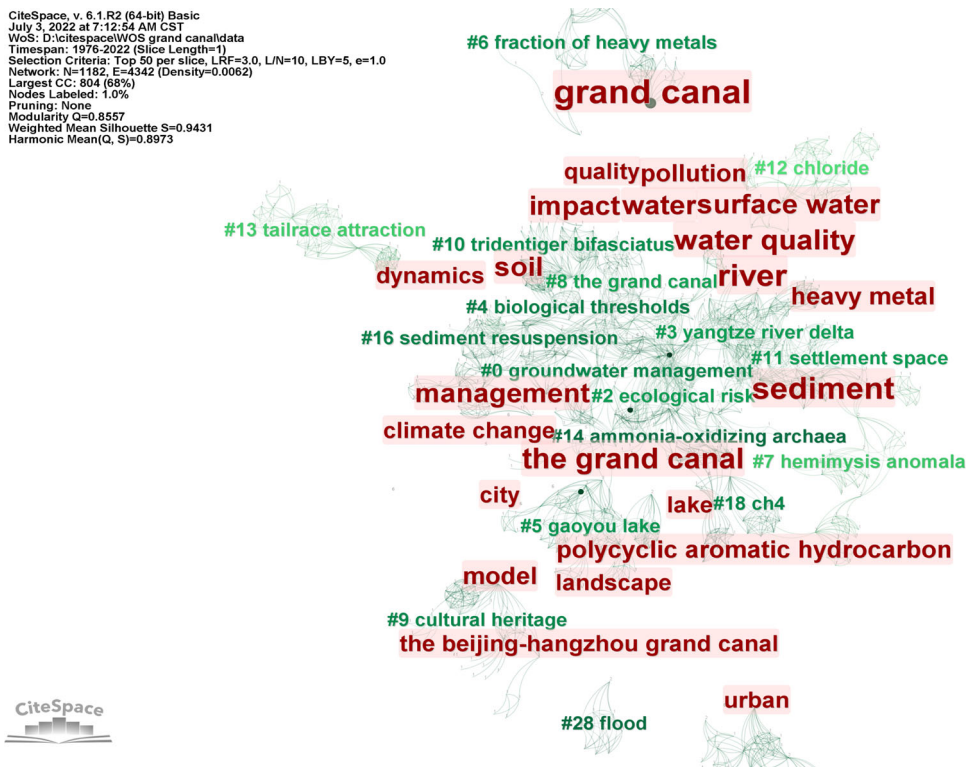


Fig. 2 Keywords and knowledge clusters of grand canal literatures in WoS database (1976–2022).

the effect of land use change and assess groundwater management strategies in Nile Delta. Grumiaux and Dhainaut-Courtois (1996) use artificial substrates to survey the benthic macroinvertebrate fauna of the Canal a Grand Gabarit in the Nord/Pas-de-Calais region in France, showing that apparent low invertebrate diversities seem to be related to the presence of heavy metals of the waterway. Some knowledge clusters pay attention to the regions through which the canal flows, like cluster (#3) of “Yangtze River delta”, cluster (#5) of “Gaoyou lake”. While others focus on biotic species, like cluster (#7) of “hemimysis anomala” and cluster (#13) of tailrace attraction. For example, Wittmann

and Ariani (2009) reveal a recent range extension of the invasive Ponto-Caspian species *Hemimysis anomala* to the Moselle, SaA’ne, and Rha’ne rivers. The articles relate to the Beijing-Hangzhou grand canal forming a cluster (#9) of “cultural heritage”. For example, Zhang et al. (2021) construct the resource–natural environment–industrial economy (RNI) evaluation system to assess linear cultural heritage.

These hot keywords and knowledge clusters reflect two major characteristics of global grand canal research: (1) International grand canal studies mainly focus on the fields of water quality management and ecological development, such as “water body”,

“Marais Vernier” and “organophosphorus pollutant”. (2) China’s grand canal has received the most extensive attention from international academic circles among thousands of canals all over the world.

Comparisons with canal studies in both China and the rest of the world

Comparisons of research area of canal literatures of Grand Canal of China, Venice Canal of Italy, Panama Canal of Panama, Colorado River of USA, Nile Delta of Egypt, Nicaragua Canal of USA, Welland Canal of Canada. Chinese scholars were first included in WoS database in 2008. The number of grand canal literature formed one peak in 2016, *International Journal of Sustainable Development* and *World Ecology* published a special issue, which included 12 articles from Chinese research institutions. Among the top five high-frequency citations, Chinese scholar Zhao Jingzhu contributes three of them, which focused on grand canal ecological construction (Zhao et al., 2010, 2013, 2016). Another Chinese high-frequency citation literature analyzes the spatial and seasonal changes of water pollution in the grand canal (Wang and Zhu, 2010).

For the research area, Grand Canal of China is analyzed mainly from environmental sciences ecology, science technology other topics, engineering, water resources (see Table 1). Compared with the studies on Venice Canal of Italy, Panama Canal of Panama, Colorado River of USA, Nile Delta of Egypt, Nicaragua Canal of USA, Welland Canal of Canada, studies on Grand Canal of China are similar to the rest of the world, that majority research focuses on environmental ecology and water conservancy. Some other disciplines are also covered, like architecture, archeology, marine freshwater biology, etc.

What is worth mentioning that, 11 articles on Grand Canal of China are illustrated from social sciences, three articles from arts humanities. And two articles on Venice Canal of Italy are also discussed from arts humanities perspective. Thus, these internationally published documents are no longer confined to the science disciplines like environmental sciences ecology, but gradually extend to social science fields like arts humanities.

Comparisons of keywords and knowledge clusters of canal literatures of Grand Canal of China, Rhine-Marne Canal of France, Venice Canal of Italy, Nile Delta of Egypt. Four canal studies in different countries are selected according to the richness of the published literatures and canal’s international popularity among the world’s top 10 canals, that is Grand Canal of China, Rhine-Marne Canal of France, Venice Canal of Italy, Nile Delta of Egypt.

The Beijing-Hangzhou Grand Canal of China was completed in AD 618. It is the oldest canal in the world. It is also the world’s largest ancient canal with the longest mileage. It is one of the symbols of Chinese cultural status. Top 10 highest frequency keywords from 2003 to 2022 include (see Fig. 3): city(9), impact(9), quality(6), model(6), landscape(6), river(6), ecological planning(6), system(6), design(5), sustainable development(5). Top knowledge clusters focus on “adverse effect index” cluster (#0), “gc ms determination” cluster (#2), “world heritage designation” cluster (#3), “perceived benefits” cluster (#4), “Zhejiang section of the grand canal” cluster (#5).

The Rhine-Marne Canal of France was built in 1841 and completed in 1852. It is the third oldest canal in the world. And it is about 312 km in length. Through the canal, industrial materials such as iron ore, are transported east to the Ruhr industrial zone and west to factories in Paris and elsewhere. Top 10 highest frequency keywords from 2003 to 2022 include (see Fig. 4): evolution(5), nitrogen mineralization(3), identification(2), management(2), soil(2), carbon(2), fossil(2), growth(2), mixture(2),

Table 1 Research areas of canal studies in seven different research objects in WoS database (1976-2022).

Research areas	Research object and volume of articles in Web of Science
Environmental Sciences Ecology	Grand Canal, China (59)
Science Technology Other Topics	Grand Canal, China (30) Grand Canal, China (20)
Engineering	Grand Canal, China (18)
Water Resources	Grand Canal, China (11)
Social Sciences Other Topics	Venice Canal, Italy (2)
Architecture	Panama Canal, Panama (2)
Marine Freshwater Biology	Venice Canal, Italy (2) Venice Canal, Italy (2) Panama Canal, Panama (2) Panama Canal, Panama (2) Panama Canal, Panama (2) Colorado River, USA (1)
Archeology	Colorado River, USA (1)
Construction Building Technology	Nile delta, Egypt (1)
Forestry	Nicaragua Canal, USA (1)
Parasitology	Nicaragua Canal, USA (1)
Microbiology	
Agriculture	
Fisheries	
Energy Fuels	
Area Studies	
Geography	

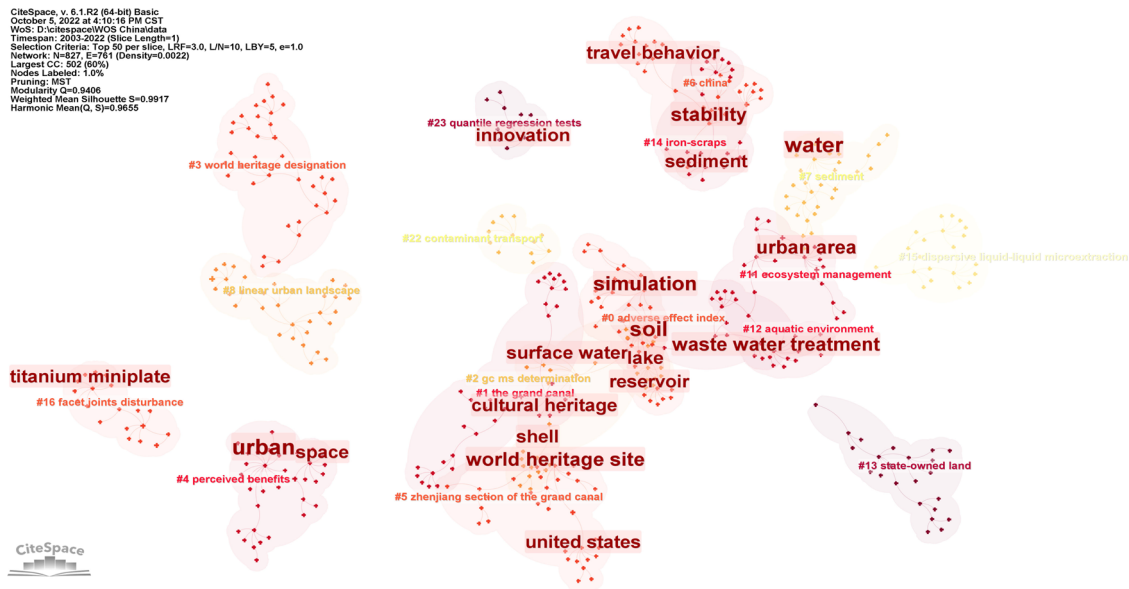


Fig. 3 Keywords and knowledge clusters of Grand Canal of China literatures in WoS database (2003-2022).

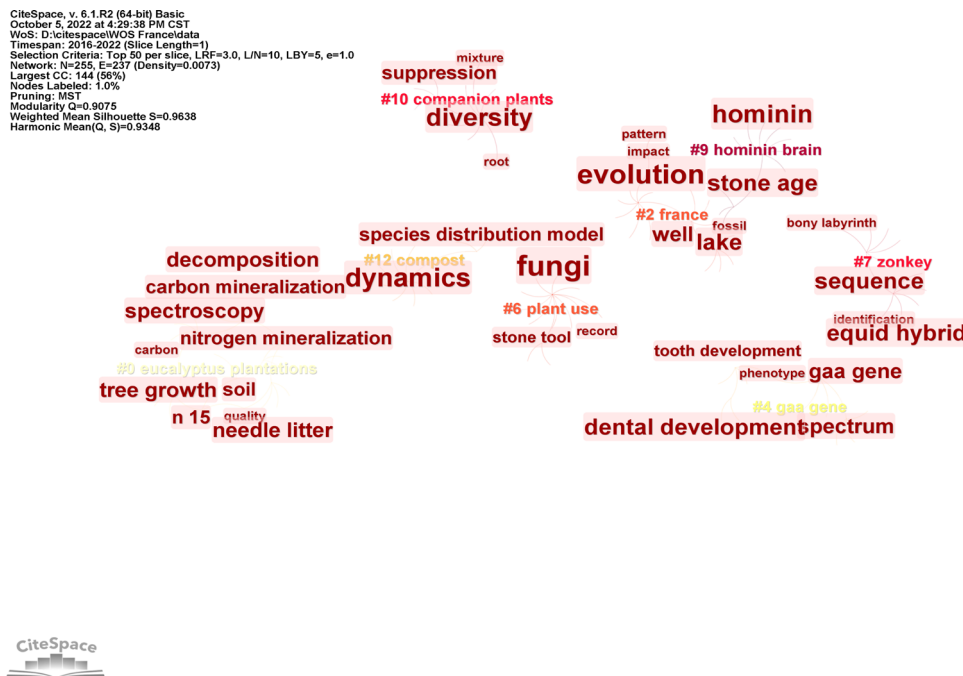


Fig. 4 Keywords and knowledge clusters of Rhine-Marne Canal of France literatures in WoS database (2003-2022).

dynamics(2). Top knowledge clusters focus on “eucalyptus plantations” cluster (#0), “gaa gene” cluster (#4), “plant use” cluster (#6), “zonkey” cluster (#7), and “companion plants” cluster (#10).

Italy is selected to do a deep analysis of research trends of the Venice canal, in order to compare with canal studies in both China and the rest of the world. Top 10 highest frequency keywords from 2003 to 2022 include (see Fig. 5): heavy metal(9), sediment(9), water(8), polychlorinated biphenyl(8), model(8), impact(8), climate change(7), dibenzo p dioxin(6), sea(6), marine(5). A large number of studies were done in 2003. Top knowledge clusters focus on “invasive species” cluster (#0), “ports” cluster (#1), “sediment management framework” cluster (#2), “risk assessment” cluster (#3), and “biological invasions” cluster (#4).

Egypt is also illustrated detailed on current research tendencies of the Nile Delta. Top ten highest frequency keywords from 2003 to 2022 include (see Fig. 6): heavy metal(10), water(9), river(9), evolution(8), water quality(7), remote sensing(7), phragmites australi(7), lake(6), area(6), climate change(6). A large number of studies were done in 2013–2016, almost ten years after Venice’s studies. Top knowledge clusters focus on the “subsidence” cluster (#0), “sebal” cluster (#1), “phenology” cluster (#2), “risk assessment” cluster (#3), and “water hyacinth” cluster (#4).

From the top 10 keywords comparison perspective, the literatures on the Grand Canal of China, Venice Canal of Italy, Nile Delta of Egypt, Rhine-Marne Canal of France, all have three to four same keywords compared to the global studies (see Table 2). However, the topics of top 10 keywords have obviously differences. For the studies of Venice Canal of Italy and Nile Delta

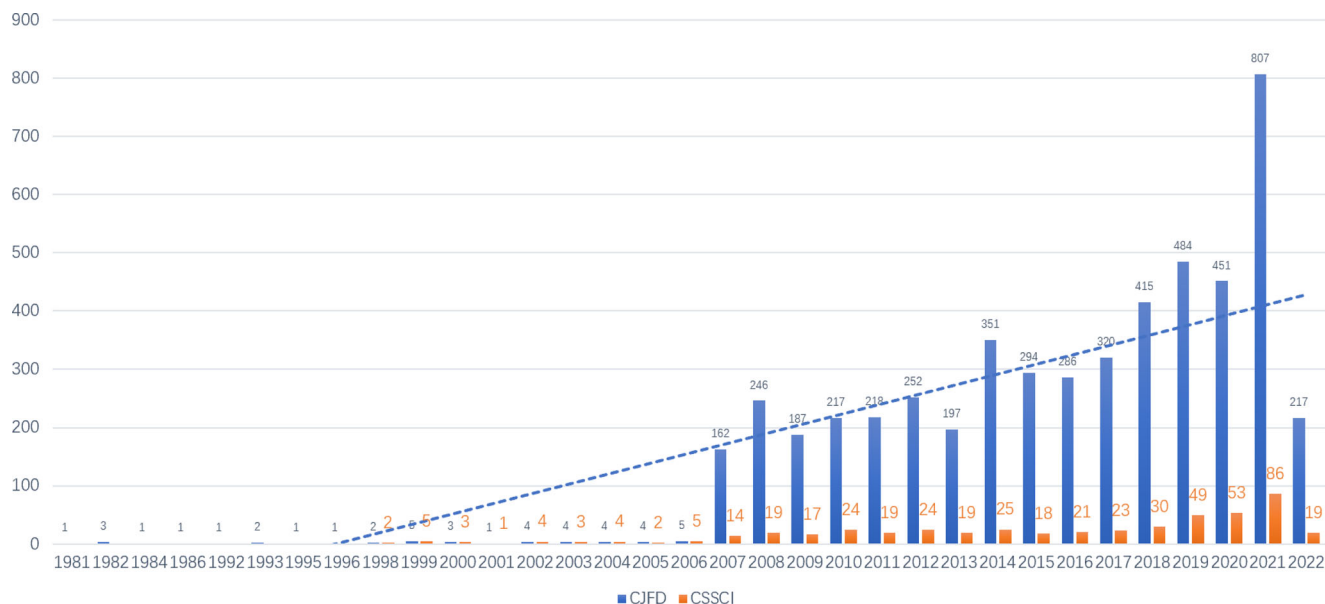


Fig. 7 Comparison of the annual quantity of Chinese grand canal literatures in CJFD and CSSCI databases (1981–2022).

of waterway transportation but also a kind of regulation, knowledge, and cultural system (Sun and Yi, 2019).

Three knowledge trends of the grand canal study are identified. Firstly, “Beijing-Hangzhou grand canal” (129), “cultural heritage” (116), “canal culture” (84), “protection” (64), “ancient canal” (56) are the top 5 keywords with high co-occurrence frequency in CJFD database. Secondly, there are three stages of grand canal study in CJFD database. From 1998 to 2005, the studies focus on the water repairment and governance of grand canal with representative high-frequency keywords included “regulation”, “deposit”, “water environment”, “water resource”. From 2006 to 2011, the research themes expand to ecology, landscape, and tourism with representative high-frequency keywords changed to “landscape architecture”, “canal city”, “linear tourism space”, “landscape design”. From 2012 to 2021, more Chinese experts turn their research attention to the in-depth exploration of the integration of culture and economy, thus, “canal culture”, “canal culture belt”, “canal heritage” become high-frequency keywords.

After running CiteSpace, some knowledge clusters of China grand canal literature are found in CJFD databases (Modularity Q value is 0.7283), and highly consistent (Mean Silhouette is 0.9045) (see Fig. 8). The cluster ranking biggest is “canal” (#0) with 199 articles mostly published in 2012. Followed by “grand canal” (#1) with 186 articles in 2009, and “Beijing-Hangzhou grand canal” (#3) with 68 articles in 2010. The object of study of these three clusters is basically the same, only the name of the canal has some differences in certain periods. Liu (2012) is the literature with the highest cited frequency, which describes the importance of establishment of the discipline of “canal science”. The construction of the South-to-North Water Diversion Project is integrated with the functions of trans-basin water diversion, waterway regulation, cultural relics protection, leisure, and recreation, in order to extend heritage utilization to heritage industries. The second largest cluster (#2) contains 71 articles studying “culture of region names”. Li (2020) discusses that the placenames of the canal are part of the canal culture, which records the heavy history. It is crucial to excavate the rich culture of region names, to establish the database of geographical names of canals, in order to promote the construction of the grand canal cultural belt. There are several clusters point to the cities where the Grand Canal flows through, like cluster (#4) Hangzhou, cluster (#5) Yangzhou, cluster (#7) Jining, cluster (#10) Jiangsu, and cluster (#13) Wuxi.

Visual analysis of grand canal literatures in CSSCI from cultural economy perspective

Analysis of time and space distribution. Chinese Social Sciences Citation Index (CSSCI), developed by the Chinese Social Science Research and Evaluation Center of Nanjing University, is a landmark project in the field of humanities and social sciences evaluation in China. In terms of influence, it is the most authoritative in paper collection and literature citations in the field of Chinese social sciences. The articles are of better quality to be selected than the CJFD database. Only two literatures were included in the CSSCI database in the field of the cultural economy in 1998, and the annual number of literatures was under five in the following 7 years (see Fig. 9). However, taking 2006 as the node, the annual number of published articles reached 30 in 2018, a six-fold increase compared with the past. From 2019 to 2021, the number of published articles upgraded rapidly to 86 literatures in 2021. The surge in the number of documents reflects that grand canal research in the field of cultural economy is being paid more and more attention by domestic experts.

For the distribution of research institutions, mainly includes the Nanjing Museum (15 articles), College of Architecture and Urban Planning of Tongji University (9 articles), School of History of Capital Normal University (7 articles), School of Architecture of Southeast University (7 articles), School of Humanities and Social Development of Nanjing Agricultural University (5 articles). Among them, three institutions located in Jiangsu province, and two institutions located in Beijing and Shanghai respectively. There are many types of research institutions, including museums, universities of architecture, history, humanities, environment, and even business schools.

For the leading scholars, Lu from the Chinese Academy of Agricultural Civilization of Nanjing Agricultural University contributes five articles. Lu and Wang (2019) puts forward three relationships of tension to grasp to move towards a public cultural space of grand canal cultural heritage: inheritance and reconstruction, sinking and rising, national mobilization, and deep cultivation of public opinion. Chen Xibo from Canal Culture Research Institute of Beijing Wuzi University, Sun Jinghao from History Department of East China Normal University also contributes five articles, respectively. For example, Chen et al. (2011) analyze Tongzhou’s new town construction and canal cultural heritage protection. Sun (2019) discusses the complicated

grand canal as a world heritage site provide broad development space for the tourism industry; “Protect the heritage, dig the canal culture” puts forward that the development and protection of the canal should be promoted simultaneously.

National and regional culture development planning. China’s grand canal research from the perspective of culture economy officially emerged in 2008. In this year, the work of the protection of China’s Grand Canal and the application for world heritage status was officially launched. In the following 6 years, an abundant of articles are published successively in order to promote the success of the World Heritage list application of China’s grand canal. Such as the *Discussion of Tong Hui River, the northern section of Grand Canal from a world heritage perspective* (Que, 2009); *The strategies for the conservation and management of Grand Canal in the context of world heritage* (Wang and Zhu, 2010); *Domestic canal problems in heritages conservation* (Mao, 2011).

Increasingly important speeches made by the leaders of government on grand canal culture have elevated the topics of heritage inheritance, cultural belt construction, and regional space planning to a new height, which has greatly stimulated the enthusiasm of Chinese scholars for the studies of the grand canal. In 2014, China’s grand canal was recognized by UNESCO World Heritage Committee and inscribed on the World Heritage list (Xinhua, 2014), and more articles have been published in the field of cultural economy. In 2015, Fan Jianhua emphasized that the 13th five-year plan had an important impact on the development of China’s cultural industry which promoted the belt development strategy to become the new trend of the development of China’s cultural industry in the new period (Fan, 2015). This paper summarizes seven key cultural belts in China, including “the Belt and Road”, “the economic and cultural industry belt of the pearl river”, “the cultural belt of the central plain of the Yellow River”, “the economic and cultural industrial belt around Bohai bay”, etc. Among these, as one of the most influential world cultural heritage sites, Beijing-Hangzhou grand canal flows through the most developed eastern region of China, and its superior geographical environment and unique, precious historical and cultural values not only create the formation of “Beijing-Hangzhou grand canal culture belt”, but also make it become the core of China’s cultural industry development. In 2016, the project of “three culture belts” proposed at first by the Beijing cultural relics department aimed to implement integrated protection of the cultural heritage of the Great Wall culture Belt, Grand Canal Culture Belt, and Xi Shan Culture Belt, so as to implement the coordinated development strategies of “capital economic circle” with Beijing-Tianjin-Hebei three regions (Hu, 2018). And this project is written into the *Plan for Strengthening the Construction of the National Cultural Center in Beijing During the 13th Five-year Plan Period* by the Beijing municipal people’s government in 2016.

On May 9, 2019, *Planning Outline for Grand Canal Cultural Protection, Inheritance and Utilization* was issued. Beijing, Tianjin, Hebei, Shandong, Henan, Anhui, Jiangsu, Zhejiang, and other 8 provinces (cities) are included in the construction scope of the Grand Canal Cultural Belt. In December, the General Offices of the CPC Central Committee and The State Council issued the Plan for the Construction of the Great Wall, the Grand Canal, and the Long March National Cultural Park. At present, the eight provinces and cities along the route are speeding up the planning and construction of the Grand Canal cultural belt and national cultural park. Since then, related studies have been published, showing a climax.

Conclusion and further research

Two-fold discussions. As a relatively young discipline of research, efforts were made in a comprehensive review of previous research articles on the grand canal culture belt, in order to systematically summarize the characteristics of the research. By using CiteSpace to conduct a scientometric survey and visual analysis of literature, this paper constructs a knowledge evolution map of global grand canal research from the perspectives of time series, research topics, discipline distributions, and research trends, and further explores the development of grand canal research in the perspective of cultural economy. Some conclusions can be summarized into two-fold discussions:

- (1) International grand canal research gradually extended the discussions from water conservancy to the cultural economy with Chinese scholars’ positive contributions.

The research content of the grand canal includes three levels: first, the physical geography content refers to the natural environment brought by its excavation and smooth flow; second, the historical phenomenon including political and economic pattern changes, the relationship between the regional differences and the governance models; thirdly, the humanistic modality in the canal area refers to people’s lifestyle, cultural inheritance, social psychology, etc. International canal research mainly focuses on the fields of water quality management and ecological development. Since 2007, there are increasing international discussions on China’s grand canal since Chinese scholars’ publications are included in the WoS database since 2008. Especially in 2016, the International Journal of Sustainable Development and World Ecology published a special issue respectively, which includes 12 articles from China. Among the top five high-frequency citations, four papers are from Chinese scholars. When a large number of relevant literatures are cited by other researchers, they are frequently adopted in oceanography, meteorology & atmospheric sciences, climate change, water resources and other disciplines according to “citation topics” report of WoS database (see Table 3).

The themes and knowledge clusters of Chinese canal studies experience three-stage development. In the first stage (1998–2005), governance and repairment of the grand canal water ecology is the main focus; In the second stage (2006–2011), canal ecology, landscape, and tourism begin to emerge; In the third stage (2012–current), more in-depth exploration of culture, economy, and integration of this two disciplines of grand canal attracts the most attention. What is worth mentioning is that 11 articles on the Grand Canal of China from the web of Science are illustrated by social sciences, and three articles from arts and humanities. And two articles on the Venice Canal of Italy are also discussed from an arts and humanities perspective. Moreover, the articles on the Grand Canal of China are also highly cited by the discipline of hospitality, leisure, sport & tourism (Table 3). Thus, the topics of international grand canal research are no longer confined to the science disciplines like environmental sciences and ecology but gradually extend to social science fields like arts and humanities.

- (2) High diversity and exploitability of culture, national and regional cultural development planning, play two major contributing factors for grand canal culture belt research in the field of cultural economy.

“Beijing-Hangzhou grand canal”, “cultural heritage”, “canal culture”, “protection”, and “ancient canal” are the top 5 keywords with high co-occurrence frequency in the CJFD database. The

Table 3 Top five citation topics of seven different research objects of canal literatures in WoS database (1976–2022).

Grand Canal, China	Venice Canal, Italy	Panama Canal, Panama	Colorado River, USA	Nile Delta, Egypt	Nicaragua Canal, USA	Welland Canal, Canada
Citation topics	Citation topics	Citation topics	Citation topics	Citation topics	Citation topics	Citation topics
Value	Value	Value	Value	Value	Value	Value
Oceanography, Meteorology & Atmospheric Sciences	Medieval & Early Modern History	Soil Science	Paleontology	Water Resources	Forestry	Herbicides, Pesticides & Ground Poisoning
6.223	Mechanics	Forestry	Ocean Dynamics	Climate Change	8.140	3.60
Tourism	Testing & Maintenance	Entomology	Water Resources	Contamination & Phytoremediation	3.40	
Climate Change	Remote Sensing	Marine Biology	Phylogenetics & Genomics			
6.153	3.40	3.2	Zoology & Animal Ecology			
Forestry	Paper & Wood Materials Science	Zoonotic Diseases				
3.2	3.87	1.258				

Grand Canal Research Institute of Liao Cheng University carries out the rich canal studies of 51 articles. In addition, “Culture heritage” ranks first with the highest frequency of occurrence in the field of the cultural economy in the CSSCI database from 1998 to 2022, and it also becomes a high-frequency knowledge cluster. Nanjing Museum carries out the most canal studies in the field of cultural economy. Lu Lu from the Chinese Academy of Agricultural Civilization of Nanjing Agricultural University contributes the most of five articles. Jiangsu province provides a great contribution to grand canal culture belt studies. According to *The Information Document on Heritage Canal*, issued at the World Heritage meeting held in Ontario, Canada in September 1994, canal heritage can be evaluated from four aspects: technology, landscape, economy, and society. Canal culture is not only a regional culture but also developed as a unified culture. The protection and utilization of the canal’s cultural heritage is a reflection of the strong national power and cultural confidence. As a part of Chinese culture, the canal has a strong symbolic significance and supports the national identity. Therefore, some scholars believe that: “This cultural belt reflects the integration of traditional Chinese culture, showing the distinctive characteristics of the integration of various cultural circles from all aspects, and condensing the essence of Chinese civilization.

Chinese national and regional cultural planning has greatly stimulated the enthusiasm of Chinese scholars for the studies of the grand canal. Since the grand canal is not only included in the national five-year planning of cultural industry to affect and even change the development and trend of Chinese society but also plays as the connecting point of “One Belt and One Road” to provide historical and theoretical support for improving China’s international status and building the future international order. Management control through planning is also adopted frequently in the management and protection of other international canals. *Operational Guidelines for the Implementation of the World Heritage Convention* were published in February 2005. The Convention calls for a “proper management plan” or other document-based management system for each declared property. For example, Hadrian’s Wall World Heritage Site Management Plan (1996–2001) was the first World Heritage Site in the UK to complete a Management Plan in 1996. The first and second rounds of revision were conducted in 2002 and 2008 respectively. The Rideau Canal World Heritage Site Management Plan was revised in 2005 with the aim of establishing long-term and strategic conservation and management objectives for the Canal Heritage, and formulating legal policies based on public participation.

Further research. Although the amount of literature on Chinese canal research is increasing year by year, and the fields involved in grand canal research are also expanding significantly. However, through sorting out the essence content of relevant literature, it can be found that the value mining of canal research in China is not deep enough, especially in the field of cultural economy. In order to solve the shortcomings of grand canal culture belt research at the present stage, this study summarizes the following problems and research directions to be further discussed and studied:

- (1) Increase the multidisciplinary perspective of research and strengthen the cooperation of researchers based on the analysis of keywords and research institutions, two obvious limitations can be found:

On the research field perspective, grand canal research could be expanded into more disciplines and wider areas. In the past two decades, China’s domestic research topics have been dominated by water conservancy and ecology. Subject headings like water quality protection, sediment treatment, and river planning have been repeatedly mentioned, while the

research related to other fields such as culture and economy has not achieved breakthrough development until the last 5 years. From the perspective of culturology, economics, geography, management, sociology, anthropology, political science, and other interdisciplinary research, in-depth exploration of canal tourism research worth to be implemented, with the help of tourism to promote the creative transformation and innovative development of canal culture. From a regional perspective, there are few outstanding articles published by scholars and institutions except in Beijing and Jiangsu. A high-quality cooperation network has not been formed in China. In fact, Beijing-Hangzhou Grand Canal flows through many provinces in the central and eastern regions of China. As President Xi Jinping has stressed, protecting the grand canal is the common responsibility of all regions along the grand canal. In the future, it is hoped that more cities and regions will participate in the overall work of protecting, inheriting, and utilizing the grand canal.

- (2) Transfer the theoretical research results into canal heritage protection and development practice to fully develop the value of the canal.

China's grand canal has been summarized into four basic values: hydrologic conditions, ecological environment, heritage connotation, and cultural economy. More domestic scholars begin to affirm that the value excavation of the grand canal should not be limited to the protection and utilization of its ecological function, but put more effort to develop its soft value potential under the background of cultural and social significance. With the calling for "protection and development of cultural heritage", the scholars should deeply understand the important influence of social background and political policies on grand canal research, and take the initiative to shoulder the mission and responsibility of scientific research while firmly grasping the development requirements. To build the grand canal of China into a world-class cultural canal, economic canal and ecological canal will be the best contribution of contemporary Chinese people to the ancient canal flowing for more than 2500 years.

Data availability

Data will be made available on request.

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Competing interests

The author declares no competing interests.

Ethical approval

This article does not contain any studies with human participants performed by any of the authors.

Informed consent

This article does not contain any studies with human participants performed by any of the authors.

Additional information

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