A bibliometric analysis of measures for controlling slope and watershed erosion from 2010 to 2019

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Abstract. The bibliometric method is a scientific method that uses mathematical and statistical methods to quantitatively analyze all knowledge carriers, which can effectively grasp the subject knowledge context. Controlling slope and watershed erosion has received wide attention from scholars from various countries. So the bibliometric method was employed to evaluate the global scientific production of measures for controlling slope and watershed erosion from 2010 to 2019 and sought the characteristics of publication outputs and tendencies from the articles. The basic data were obtained from the Science Citation Index Expanded from the Web of Science. The several aspects were analysed including document language, annual outputs and distribution of journals, subject, authors, highly cited papers as well as frequency of author keywords. The results showed that annual output of the related scientific articles kept a steady rise from 2013 to 2019. Chinese Academy of Sciences, NorthWest A&F University and Ministry Water Resources were mainly research institutes, which have published a lot of articles. In addition, Jean Poesen, from University of Mekelle, was the most productive author who has published 28 articles in the field of controlling slope and watershed erosion. The keywords of articles on controlling slope and watershed erosion were also analysed by using scientometric indexes. By analysing frequency of keywords in 10 periods, the current research emphases were discovered. The result showed that “Soil erosion”, “Runoff” and “Erosion” are the top 3 author keywords in this field. And the “soil-erosion” always was the top 1 keywords in the research of watershed erosion. Through analysis of the keywords, it can be known that soil erosion in the plains, simulation of erosion, and the impact of climate change on erosion are research hotspots.

1. Introduction
With the continuous increase in the number of production and construction projects, a large number of vegetation has been occupied or destroyed, which has increased soil erosion and left hidden disasters [1]. The ecological and environmental problems caused by soil erosion have attracted more and more attention from all academic circles. Nearing et al. [2] proposed that erosion reduces the productivity of farm soils and causes water quality problems due to the accumulation of sediment and agricultural chemicals in waterways. Chen et al. [3] found that we cannot judge water erosion degree just from annual rainfall, but also should be paid to the specific rainfall variables and distributions. Yue et al. [4] found that soil erosion by water affects soil organic carbon storage and changes the exchange of...
carbon dioxide flux with atmosphere. Yan-Ping et al. [5] used linear programming method to explore the integrated management model for controlling soil-water erosion. Krasa et al [6] found that sewage waters and reservoirs play a major role in the triggering the eutrophication.

Bibliometrics takes the literature system and the characteristics of bibliometrics as the research objects, and uses quantitative methods to study the distribution structure of the literature in the subject field. Lin et al. [7] analyzed the pluripotent stem cell articles screened by Science Citation Index Expanded using five bibliometric indicators: total number of papers, number of independent papers, number of collaborative papers, number of first author papers, and number of corresponding author papers. Li et al. [8] proposed a scientific paper evaluation method based on text mining and reference frequency, combining bibliometrics and content analysis for quality evaluation. Ahmad et al. [9] conducted an in-depth analysis of academic works published in the field of big data and found the most frequently cited articles, citation trends, author trends, and research trends in related fields within a specific time frame. Liang et al. [10] used bibliometrics to obtain computer science and management information systems, which are the two core disciplines that promote big data and business intelligence related research. Ho et al. [11-14] have done a lot of effective works in the field of bibliometrics, and many of bibliometrics indexes in this paper are drawn from their work.

This article uses Web of Science published by the American Institute of Scientific Information as the database. Then, we obtain research samples through search strategy, and conduct research. This paper analyzes the research related to soil control slope and watershed erosion from 2010 to 2019 based on the self-compiled Excel bibliometric software.

2. Data sources and methods

The analysis provided in this study is based on the Science Citation Index Expanded (SCI-EXPANDED) database of Web of Science Core Collection from Thomson Reuters (updated on 21 August 2020). Because of the serious soil erosion in slope land and watershed, this paper selects the soil protection measures of slope land and watershed as the research object of bibliometrics. On the basis of reading the relevant literature of soil erosion in recent 10 years, this paper writes two sub-search strategies: (I) ("soil erosion*" or "soil loss*") and ("hill*" or "*sloping*" or "*slope*") and ("control*" or "treatment*" or "countermeasure*"); (II) ("soil erosion*" or "soil loss*") and ("watershed*" or "catchment*" or "basin*") and ("control*" or "treatment*" or "countermeasure*"). Then, using "and" of logical symbol to combine the above two sub-search strategies into the final search strategy: ("soil erosion*" or "soil loss*") and ("hill*" or "*sloping*" or "*slope*") and ("control*" or "treatment*" or "countermeasure*") or ("soil erosion*" or "soil loss*") and ("watershed*" or "catchment*" or "basin*").

The search result shows that there are 2030 documents from 2010 to 2019 in the database of Web of Science Core Collection. Then, we import the data of 2030 documents into the self-compiled Excel software by the language of Visual Basic to analyze.

3. Results and discussions

3.1. Characteristics of publication outputs during 2010-2019

97.7 % of 2030 publication cases are published in English (1,984 cases), followed distantly by Portuguese (20 cases), Chinese (10 cases), Spanish (6 cases), French (5 cases), Polish (2 cases), Croatian (1 cases), Czech (1), German (1 cases). As shown in Figure 1, the publication has some different types, such as article, review and so on. This article further chooses the article to carry on the research and the number of articles is 1786. To obtain an overview of controlling slope and watershed erosion research, the annual number of articles from 2010 to 2019 is displayed in Figure 2.
As shown in Figure 2, the number of controlling slope and watershed erosion article increases from 111 in 2010 to 280 in 2019. The overall trend of articles in the past 10 years has been increasing. However, the number of articles decreases from 2011 to 2012. From 2017 to 2018, the number of articles increased by 41 articles, which was the fastest growing year. In addition, we further studied the characteristics by year of publication outputs from 2010 to 2019, as shown in Table 1. The change trend of author number per article (AU/TP) is relatively gentle, and the range of change is maintained between 4.1 and 5.5.

| PY  | TP  | AU  | AU/TP | NR   | NR/TP | PG  | PG/TP |
|-----|-----|-----|-------|------|-------|-----|-------|
| 2010| 111 | 459 | 4.1   | 4717 | 42.5  | 1258| 11.3  |
| 2011| 137 | 658 | 4.8   | 6720 | 49.1  | 1596| 11.6  |
| 2012| 126 | 549 | 4.4   | 6271 | 49.8  | 1437| 11.4  |
| 2013| 134 | 585 | 4.4   | 6178 | 46.1  | 1510| 11.3  |
| 2014| 161 | 730 | 4.5   | 8762 | 54.4  | 1873| 11.6  |
| 2015| 170 | 859 | 5.1   | 9376 | 55.2  | 2105| 12.4  |
| 2016| 204 | 987 | 4.8   | 11589| 56.8  | 2534| 12.4  |
| 2017| 211 | 1058| 5.0   | 12680| 60.1  | 2665| 12.6  |
| 2018| 252 | 1337| 5.3   | 15297| 60.7  | 3206| 12.7  |
| 2019| 280 | 1527| 5.5   | 17281| 61.7  | 3691| 13.2  |
| Total|1786| 8749| 4.8   | 98871| 53.6  | 21875|       |

PY: publication year; TP: total articles; AU: author number; AU/TP: author number per article; PG: page count; NR: cited reference count; PG/TP: page count per article; NR/TP: cited reference count per article.

3.2. Distribution of institutes and authors
The top 20 most productive institutes for total articles are shown in Table 2. From 2010 to 2019, The top 10 most productive institutions are Chinese Academy of Sciences (382, 21.4%), Northwest A&F University (173, 9.7%), Ministry Water Resources (92, 5.2%), Beijing Normal University (91, 5.1%), University of Chinese Academy of Science (88, 4.9%), USDA ARS (65, 3.6%), Katholieke Universiteit Leuven (51, 2.9%), Beijing Forestry University (39, 2.2%), CSIC and US Geological Survey (34, 1.9%). The number of top 3 most productive institutions publish papers is 647, accounting
for 36.3% of the total papers. In particular, the number of articles issued by the Chinese Academy of Sciences ranks first, and the number of articles issued by the Chinese Academy of Sciences accounts for 21.4% of the total number of articles issued in this field.

Table 2. The top 10 most productive institutions during 2010-2019. (The evaluation indicators are cited from [11]).

| Institute                          | TP    | TPR (%) | SPR (%) | CPR (%) | FPR (%) | RPR (%) |
|------------------------------------|-------|---------|---------|---------|---------|---------|
| Chinese Academy Sciences           | 382   | 1(21.4)| 1(5.1)  | 1(24.4) | 1(9.2)  | 1(8.0)  |
| Northwest A&F University           | 173   | 2(9.7) | 3(2.2)  | 2(11.1) | 2(5.3)  | 2(4.6)  |
| Ministry Water Resources           | 92    | 3(5.2) | 34(0.4) | 3(6.0)  | 53(0.2) | 52(0.2) |
| Beijing Normal University          | 91    | 4(5.1) | 3(2.2)  | 5(5.6)  | 3(2.6)  | 3(2.8)  |
| University Chinese Academy Sciences| 88    | 5(4.9) | 102(0.0)| 4(5.8)  | 124(0.1)| 115(0.1)|
| USDA ARS                           | 65    | 6(3.6) | 7(1.1)  | 6(4.1)  | 5(1.1)  | 6(1.1)  |
| Katholieke University Leuven       | 51    | 7(2.9) | 7(1.1)  | 7(3.2)  | 5(1.1)  | 7(0.9)  |
| Beijing Forestry University        | 39    | 8(2.2) | 2(2.5)  | 9(2.1)  | 4(1.4)  | 4(1.3)  |
| CSIC                               | 34    | 9(1.9) | 6(1.5)  | 13(2.0)| 14(0.6) | 13(0.6) |
| US Geological Survey               | 34    | 9(1.9) | 102(0.0)| 8(2.3)  | 22(0.4) | 20(0.4) |

TP: total articles; TPR (%): rank total articles; SPR (%): rank single institution articles; CPR (%): rank inter-institutional collaborative articles; FPR (%): rank first author articles; RPP (%): rank corresponding authored articles.

Table 3 listed the top 10 most active authors producing articles on controlling slope and watershed erosion research, the number and rank of total publications, first-author articles, and corresponding-author articles. In general, the top 10 authors contributed 198 articles with a proportion 11.08% to total articles. Jean Poesen, from University of Mekelle, was the most productive author, who wrote 29 articles.

Table 3. The top 10 most productive authors during 2010-2019. (The evaluation indicators are cited from [12]).

| Authors       | TP | TPR | FP | FPR | RP |
|---------------|----|-----|----|-----|----|
| Poesen, J     | 29 | 1   | 0  | 64  | 1  |
| Shi, ZH       | 22 | 2   | 3  | 20  | 12 |
| Fu, BJ        | 21 | 3   | 1  | 44  | 9  |
| Cerda, A      | 20 | 4   | 2  | 36  | 1  |
| Zhang, GH     | 20 | 5   | 8  | 1   | 12 |
| Li, ZB        | 20 | 6   | 0  | 64  | 7  |
| Zheng, FL     | 17 | 7   | 0  | 64  | 13 |
| Li, ZW        | 17 | 8   | 6  | 5   | 9  |
| Mu, XM        | 16 | 9   | 0  | 64  | 10 |
| Gao, P        | 16 | 10  | 1  | 44  | 1  |

TP: total articles; TPR: rank total articles; FP: first author articles; FPR: rank first author articles; RP: corresponding authored articles.
3.3. Research emphasis: keywords

The title and key words of an article usually contained the key information that the paper would most emphasize to readers. The subjective focus and hot topics can be found from the substantive words in title and keywords. However, words in title have some prepositions, articles and common words such as “on”, “in”, “the”, and “during” were discarded, as they were meaningless for further analysis. In this paper, keywords are chosen as subject of the research. The 10 most frequently used substantives in author keywords were grouped in 3 periods (Table 4). “Soil erosion” ranked first and was the most frequent word used in the analysis of words. The controlling measure of water erosion and slope land research status is studied by this paper. Thus, the second rank of keywords is “runoff”. This article was written by Poesen, who has made outstanding contributions in the field of controlling slope and watershed erosion. As shown in Table 4, 2010-2019R means that a total of 1786 articles were published in this field, including the keyword of soil erosion appeared in 402 articles, accounting for 22.5% of the total number of articles posted. Then, the 10-year research sample is sliced for 2-3 years to obtain 3 research keyword samples. The result shows that soil erosion, runoff, erosion, and soil loss have always been research hotspots in the field of soil erosion.

Table 4. The top 10 keywords during 2010-2019.

| Author keywords | TP 2010-2019R | 2010-2012R | 2013-2015R | 2016-2019R |
|-----------------|----------------|------------|------------|------------|
| Soil erosion    | 402 1          | 1          | 24.9       | 22.4       | 21.6       |
| Runoff          | 159 2          | 2          | 8.8        | 9.2        | 8.8        |
| Erosion         | 118 3          | 3          | 6.7        | 6.9        | 6.4        |
| Soil loss       | 89 4           | 5          | 5.1        | 4.3        | 5.3        |
| Sediment yield  | 82 5           | 4.6        | 3.2        | 5.8        | 4.5        |
| Loess plateau   | 72 6           | 4          | 2.7        | 3.2        | 5          |
| Sediment        | 52 7           | 2.9        | 2.9        | 3.7        | 2.5        |
| Land use        | 50 8           | 2.8        | 1.1        | 3.7        | 3.1        |
| Rainfall simulation | 46 9  | 2.6      | 1.1        | 2.8        | 3.1        |
| Soil conservation | 41 10       | 2.3        | 4          | 32         | 11         |

TP: total articles; P: paper; R: rank.

4. Conclusions

In this study on quantitative analysis and statistics of SCI papers related to controlling slope and watershed erosion, we obtained some significant points on the worldwide research trends throughout the period 2010-2019. This paper depicted a systematically structural picture, as well as information on history and current situation of the controlling slope and watershed erosion research. In recent years, more and more institutes, and researchers were engaged in the research. From 2010 to 2019, the overall trend of document on controlling slope and watershed erosion was increasing, and the number of articles accounted for 87.94% of the total document. By analyzing the distribution of author keywords, it could be inferred that the important topics in the field of controlling slope and watershed erosion were on soil erosion, climate change and runoff. The results show that the bibliometric method is helpful to realize the statistics of the research status and provide help for the subsequent research in this field.
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