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STRATEGIES FOR WATERSHED MANAGEMENT AND PLANNING: A BIBLIOMETRIC ANALYSIS

Su Havzası Yönetimi ve Planlaması için Stratejiler: Bibliyometrik Bir Analiz

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ABSTRACT

In the twentieth century, governance approaches to watershed planning evolved in response to environmental challenges. The paper highlights the importance of watersheds and explores methodologies used in global watershed planning over the last decade, focusing on popular methods and their rationale. Through a systematic literature review of 10,154 publications, using ENDNOTE X9 for citation management (Bramer, 2018), and VOSviewer ver.1.6.18 software (Van Eck and Waltman, 2018) to prioritize publications, the study identified the most cited publications related to "Watershed", "Planning", and "Management". From these, publications aligning with study objectives underwent comprehensive review, totaling 270. Commonly used methods, such as "Integrated Watershed Management Planning" and geographic information systems techniques like morphometric indices, overlap weighting, and Analytic Hierarchy Process (AHP), emerged as prevalent findings.

Anahtar Kelimeler
Havza yönetimi ve planlaması, Bibliyometrik analiz, VOS görüntüleyici

ÖZ

Yirminci yüzyılda havza planlamasına yönelik yönetişim yaklaşımları, potansiyel çevresel sorunlara yanıt olarak zaman içinde gelişmiştir. Çalışma öncelikle havza kavramına vurgu yapmaktadır. Küresel bilim camiasında son on yılda havza planlamasında kullanılan metodolojileri, özellikle en çok tercih edilen yöntemlere ve bunların popülerliğinin ardındaki gerekçelere odaklanarak araştırmaktadır. Bilim dünyasındaki önemli indekslerin incelenmesini içeren sistematik bir literatür taraması yapılmış ve toplam 10.154 yayın analiz edilmiştir. Sistematik literatür taramasında, bibliyografik atıf yönetim aracı olarak ENDNOTE X9 kullanılmıştır (Bramer, 2018). Ayrıca, seçilen 10.154 yayın arasından ilk okunacak yayınların seçimi için, VOSviewer ver.1.6.18 yazılımı (Van Eck ve Waltman, 2018) kullanılarak "Havza", "Planlama" ve "Yönetim" kavramlarıyla ilgili olan ve en fazla atıf alan yayınlar belirlenmiştir. Bu çalışmada, bilim dünyasının en kapsamlı taranan indekslerinden birinden arama yöntemleri kullanılarak toplam 10.154 yayın seçilmiştirBu yayınların başlıkları, anahtar kelimeleri ve özetleri incelenmiş, çalışmanın hedefleriyle uyumlu olanlar, kapsamlı bir incelemesi için seçilmiştir. Bu tam metin incelemesi sırasında, kullanılan yaygın yöntemleri belirlemek için 270 yayın değerlendirilmiştir. Özellikle, en sık atıfta bulunulan yayınları incelemek için ilk olarak VOS görüntüleyici programı kullanılmıştır. Tam metin incelemelerinin bulguları, "Entegre Havza Yönetim Planlaması" ve morfometrik endeksler, örtüşme ağırlıklandırma ve Analitik Hiyerarşi Süreci (AHP) olmak üzere coğrafi bilgi sistemleri tekniklerinin kullanımı gibi yöntemlerin kayda değer bir yaygınlığını ortaya koymuştur.

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1. Introduction

The watershed has gained widespread recognition as the appropriate analytical framework for addressing numerous challenges in water resources planning and management (e.g., Green and Alby, 1997). The effective governance of watersheds to deliver a diverse range of ecological and human benefits is a vital worldwide concern. Human activities have brought about substantial changes in rivers, lakes, wetlands, and groundwater systems, impacting the capacity of these systems to offer crucial watershed services (Osenberg and Schmitt, 1996). Watersheds do possess some ability to absorb and react to disruptions while preserving their fundamental structure and functions (Boltz et al., 2019).

During the 20th century, the significance of watershed management and planning has grown considerably due to a range of environmental challenges (Mirci et al., 2010). In parallel with this growing importance, watershed management and planning have become progressively complex. In developed nations like Western European countries and the United States of America (USA), watershed planning extends well beyond water-related applications (Madani, 2010). In developing countries, basin planning, and management have primarily centred on water use, but comprehensive basin planning studies have gained prominence in recent years (Sing and Frevert, 2006). Nevertheless, many of the environmental processes and socio-economic activities taking place within a watershed system are inherently too intricate, dynamic, and spatially diverse to be comprehensively monitored and fully comprehended (Ohl et al., 2007). With population growth, human expansion into natural systems appears inevitable, as expanding communities require more extensive water resources to support various developmental activities within the watershed (Tejwani, 1993).

Basin (Alm. Becken, Fr. Bassin, Eng. Basin) is defined as a large-area depression of the earth (İzbırak, 1992). The concept of basin is used in many different meanings today. Concepts such as coal basins, mining basins, agricultural basins, water basins, petroleum-natural gas basins, etc. are names that depend more on the usage characteristics of this unit. In this respect, they are rather areas that have economic qualities and are open to change over time. Basin definitions made in terms of physical geography, on the other hand, are not relative and cover units that maintain their characteristics for a long time. In basin definitions developed in terms of physical geography, geological-geomorphological and hydrographic characteristics are emphasized. For example, according to Ardos and Pekcan (1997), a basin is a depressed area which is generally the result of tectonic movements. The margins of the basins are often faulted and some of them are subsidant in character. On the margins of some basins, there are massifs (as in the Paris Basin and Ergene Basin). Biricik (2009) defines a basin as an area surrounded by mountains or high hills, hollow in the middle and relatively wide. A place that has basin characteristics with its structural features may also have hydrographic basin characteristics with the settlement of the river network over time. These definitions indicate that the concept of basin has 3 different meanings in terms of physical geography. These are geological basins, geomorphological basins and hydrographic basins.

The concept of geological basin is the place where young strata deposited on old depressions extend as if making a depression towards a wide area. More precisely, the units in which the formations show a proper sequence from old to new as you go from the higher areas forming the frame to the base and their tectonic-stratigraphic formations are related to each other, meet a basin in the geological sense. Tectonic basins are usually framed by old massifs and other old terrains. In the basal parts, third and fourth time terrains are generally located. Tectonic basins are divided into different types such as graben basins, subduction basins and tectogen basins. Most of the basins in Turkey fit the definition of geologic basin concept. Examples such as Ergene Basin, Iğdır Basin, Konya Basin, Ulaş Basin, İnegöl Basin, Çoruh Basin, Narman Basin, Gediz Basin, Büyük Menderes Basin, Küçük Menderes Basin are just a few of them (Garipağaoğlu, 2012). The new strata at the base of the basin are usually found as uncurled. However, the old basic land at the bottom can be found broken in accordance with the fractures. These new layers covering the old land may be inclined towards the center of the basin (İzbırak, 1977). Geomorphologic Basin; this type of basin has a flat or nearly flat bottom and a frame higher than the basin bottom, usually consisting of plateaus or mountains. The basin floor, which corresponds to one of the main units of geomorphology in the geomorphological sense, can be seen deeply cleaved areas and hills. In addition, the plains at the base can sometimes be narrow; sometimes they can expand to form a plain. The plateaus and mountains surrounding the basin may be very high at the basin floor, or the difference in elevation between the floor and the surrounding area may be insignificant. Geomorphologic basins may be of fluvial, glacial or karstic origin (Garipağaoğlu, 2012). Hydrographic Basin is the area where all the tributaries of a river flow together and the boundaries of this area are the water division line of the river that forms the basin (Atalay, 2016). In other words, the area drained by a river is called a river basin (Omernik and Bailey, 1997). Accordingly, hydrographic basins are divided into two as outflowing (exorheic) and inflowing (andorheic). The rivers in outflow areas reach the sea and discharge their waters into the sea.

However, rivers in inward flowing areas cannot reach the sea. The reasons why rivers are inward flowing are that they are located in closed basins or they are subject to arid climatic conditions (Hoşgören, 2013).

Basin-scale planning is quickly becoming a crucial approach for bridging human development opportunities with the well-being of the planet's biodiversity and achieving meaningful outcomes. The data utilized for defining land use within the basin holds significance. In formulating suitable land use plans, it is imperative for all nations to thoroughly assess their existing resources and identify their potential for development. Determining appropriate methods, approaches, and policies in this regard is essential (Van Lier, 1998).

Bibliometric analysis, as introduced by Kessler (1963), is a commonly employed method to unveil the progression of science by examining scientific literature published in reputable sources. Such studies have been conducted to trace the development of various subjects, including business research (Khan et al., 2021), health issues (Bouchart et al., 2015), Earth sciences (Pham-Duc et al., 2023), GIS applications (Tian et al., 2008) and environmental operations (Dhamija and Bag 2020). Furthermore, a similar approach has gained recognition in the field of environmental ecology, encompassing research on topics such as the ecological restoration (Guan et al., 2019), climate and environmental science trade-offs (Björnberg et al., 2017). Surprisingly, there is a notable absence of studies mapping the evolution of research in the field of watershed planning and management.

This study primarily has focused on conducting bibliometric analysis of the watershed concept implications with watershed planning and management. Subsequently, it has explored the methodologies employed in watershed planning over the last decade within the global scientific community, identifying the most preferred methods and the rationale behind these preferences.

2. Dataset and Methodology

In the systematic literature review, the ENDNOTE X9 utilized as the bibliographic citation management tool (Bramer, 2018). Additionally, for the selection of publications to be read first among the 10,154 chosen publications, those with the highest number of citations and related to the concepts of "Watershed," "Planning," and "Management" were identified using the VOSviewer ver.1.6.18 software (Van Eck and Waltman, 2018).

In this study, a total of 10,154 publications were chosen using search methods from one of the most extensively scanned indexes in the scientific world. Notably, these indexes included Ebscohost (23 publications), Emerald Insight (500 publications), Google Scholar (864 publications), JSTOR (420 publications), ProQuest (1,000 publications), PubMed (550 publications), Sage Journals (114 publications), Scopus (6 publications), ScienceDirect (1,000 publications), Taylor and Francis (1,000 publications), Web of Science (WoS) (2,361 publications), and Wiley Online Library (200 publications). This selection process was limited to the last decade due to the overwhelming number of publications available in these indexes. Such limitations were imposed because, without them, thousands of publications would be retrieved in these indexes.

During the search in the world's primary citation indexes for scientific and academic research, the queries included "Methods used in watershed management and planning" and "Methods used in basin management and planning." This approach was necessary because the term "basin" was used interchangeably with "watershed" in different publications. In some cases, "basin" was referred to as "basin," and in others, it was referred to as "watershed." This duality in terminology usage prompted the search to be conducted in both ways to ensure comprehensive coverage of relevant publications. This process is illustrated in Figure 1.

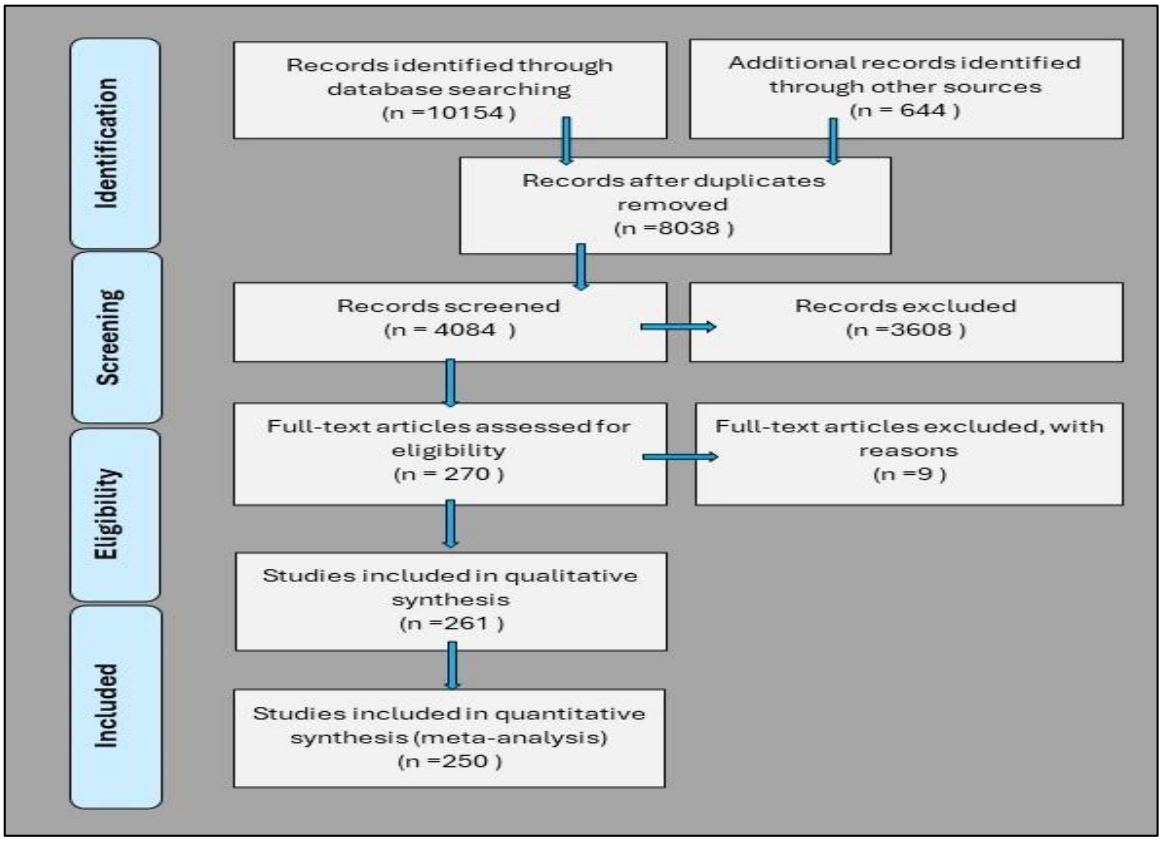

Figure 1. The Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) flow diagram (After Page et al., 2021).

3. Results and Discussion

This research involved searching scientific literature, retrieving pertinent data, and obtaining relevant resources through the application of appropriate screening techniques. Subsequently, a series of analyses were conducted, which were categorized into three primary domains (a) structural analysis, (b) keyword analysis and (c) co-citation analysis. The primary criteria established for structurally analysing the dataset encompass the following aspects: "year," "document type," "research area," "country," "language," and "author" (Table 1).

Table 1. The keyword and its definition used in the structural analysis throughout the study.

Keyword	Definition
"Year"	indicates the number of publications on the topic in years.
"Document type"	encompasses various publication categories, such as journals, books, book chapters, papers, articles, reviews, and more.
"Research area"	provides a detailed categorization of publications according to specific fields, as per the WoS classification (e.g., watershed, management, planning, sustainability, etc.).
"Country"	indicates the countries where the articles have been published.
"Language"	refers to the language in which the publications are written.
"Author"	identifies the authors who have contributed to the most cited publications on the subject

3.1 Field of Science

The necessary literature review regarding the research area was conducted. Accordingly, the science fields were extracted from the dataset. A total of 3608 publications related to this topic were discovered. The identification of science fields resulted from the assessment of the sources using analytical instruments (Table 2).

Table 2. Showing the distribution of science fields.

Science Fields	Count
Environmental Sciences Ecology	1681
Water Resources	1520
Engineering	938
Geology	608
Science Technology Other Topics	232
Agriculture	223
Meteorology Atmospheric Sciences	203
Remote Sensing	150
Physical Geography	132
Computer Science	111
Marine Freshwater Biology	100
Geography	76
Other	597

3.2 Country Distribution

The analysis indicates that a significant proportion of these studies are conducted in developed countries. Significantly, in developed countries, planning efforts often revolve around the preservation of natural resources and the pursuit of enhanced sustainability. The main context suggests that the focus or central theme of the planning efforts in developed countries is the preservation of natural resources and sustainability. The awareness and commitment to these principles in developed countries are driven by their capacity to allocate substantial budgets for sustainability and resource planning. Conversely, underdeveloped countries face limitations in allocating adequate budgets for resource planning and management. An examination of studies related to this topic, conducted on a country-by-country basis, revealed that the highest number of studies were carried out in the United States. The United States recorded 953 publications, with China closely following at 821 publications. Iran conducted 317 publications, while India contributed 273 publications. Additionally, Australia and Canada produced 206 and 200 publications, respectively (Table. 3).

Table 3. Showing the distribution of countries.

Country Distribution	Count
USA	953
China	821
İran	317
İndia	273
Australia	206
Canada	200
Germany	148
England	129
Brazil	127
İtaly	121
Spain	110
Sound Korea	108
Turkey	103
France	87
Other	636

It has been analyzed that the majority of the studies on watershed management are in developed countries. Especially in developed countries, it is seen that planning is evaluated within the scope of protection of natural resources and it is aimed to ensure more sustainability. In this context, it has been effective that developed countries are conscious about publication. This is due to the fact that such countries can allocate enough budget for sustainability and resource planning. The underdeveloped countries, on the other hand, cannot allocate enough budget for the planning and management of resources.

3.3. Annual Analysis of Publications

An examination of the study's publications over time revealed a notable upward trend, indicating a significant increase in recent years. Notably, 2021 stood out as the year with the highest number of studies, totalling 404 publications. In 2022, there was a slight decrease in the number of publications compared to 2021 (as shown in Table. 4). This trend is unsurprising, especially given the growing prominence of natural resource conservation and sustainability concerns in recent years.

In recent years, there has been an increase in publications on basin planning and water resources management. The main reasons for this are increasing population needs, exhaustibility of natural resources, excessive and unconscious use, misuse of water and pollution. In particular, the importance of sustainable use of natural resources, people's awareness of nature and international agreements make the issue of basin planning a focal point. drought and global climate changes, the effects of which we see today are severe, are another factor that can be counted in this regard.

Table 4. List of publications per year with percentage values.

Publication Year	Number of Publication	Percentaga	Publication Year	Number of Publication	Percentaga
2021	408	11.216	2004	39	1.083
2020	362	10.022	2002	36	0,999
2022	350	9.606	2001	34	0,944
2019	315	8.745	2006	32	0,888
2018	314	8.717	2003	30	0,833
2017	267	7.413	1998	24	0,666
2016	233	6.469	1999	23	0,639
2015	191	5.303	1995	18	0,5
2014	159	4.414	2000	16	0,444
2013	146	4.053	1997	15	0,416
2011	113	3.137	1994	11	0,305
2010	104	2.887	1991	9	0,25
2012	94	2.610	1993	9	0,25
2009	79	2.193	1996	9	0,25
2007	72	1.999	1992	6	0,167
2005	42	1.166			

The analysis revealed that, over time, the subject remains consistently popular, with minor fluctuations. Figure 5 clearly illustrates the ongoing prominence of this topic. However, there was a decline in the number of publications in 2022, as indicated in Figure. 2.

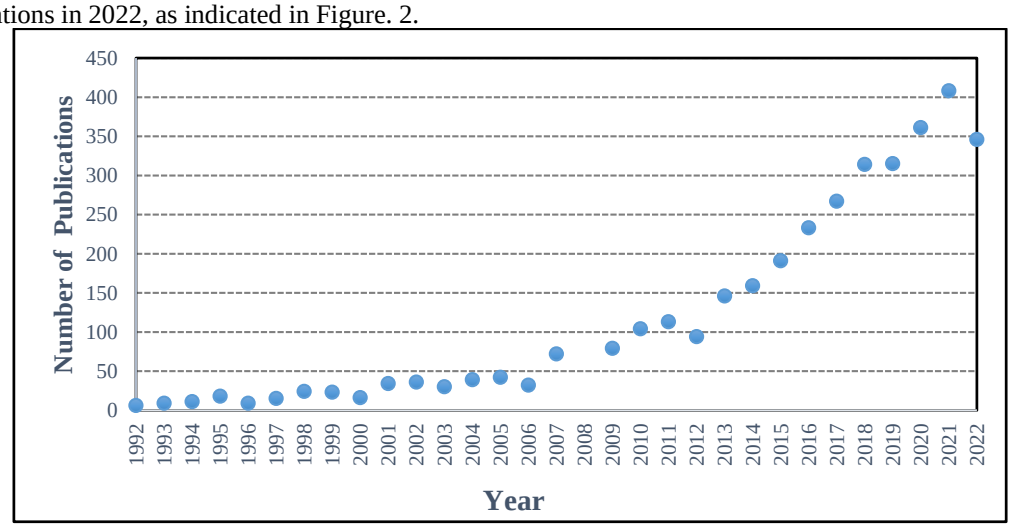

Figure 2. Number of publications per year.

3.4. Publication Type

The database contains 8 distinct document types related to the conducted studies. Table 3 presents an overview of these document types. Their distribution indicates that articles make up the majority at 83%, followed by papers at 13%. Review articles, book chapters, and abstracts each represent less than 1% of the total. It is noteworthy that some same publications may appear in more than one document, leading to variations in the numbers based on the document type (Table. 5).

Table 5. Allocation of publications based on document categories.

Document Type	Number of Publication
Article	3121
Proceeding Paper	480
Review Article	84
Early Access	43
Book Chapter	36
Data Paper	6
Editorial Material	4
Retracted Publication	1

3.5. Distribution of Language Use

The analysis revealed that the publications were written in 13 different languages. Upon categorizing these publications by their respective writing languages, it becomes evident that English predominates at 97.89%, with Spanish following at 0.85%, and Portuguese at 0.611%. This data underscores the prevalence of English as the primary language used for these publications. Furthermore, when we examine the countries where these studies are published, it is worth noting that China, with 821 publications, has a writing language distribution that accounts for less than 1% of all the publications analysed (Table.6).

Table 6: Distribution of language use globally with percentage values.

Language	Number of Publication	Percentaga
English	3532	97.890
Spanish	29	0.805
Portuguese	22	0.611
French	7	0.194
Croatian	5	0.139
Polish	4	0.111
Chinese	2	0.056
German	2	0.056
Czech	1	0.028
Hungarian	1	0.028
Russian	1	0.028
Turkish	1	0.028
Ukrainian	1	0.028

3.6. Citation Frequency

An analysis of studies focusing on Basin Methods and Methodologies utilized in WoS database reveals that the publication with the most extensive citation record is attributed to Huang GH (2016), specifically the work entitled "Crop Planning and Water Resource Allocation for Sustainable Development of an Irrigation Region in China Under Multiple Uncertainties (J. J. Huang, Li, Yin, & McBean, 2016).” The paper has accumulated 48 citations and is accompanied by 45 references (Table. 7).

Table 7. Distribution of publications and their frequencies.

Author	Number of Publication	Percentaga	Year
Huang GH	28	0.777	2016
Pourghasemi HR	28	0.777	2016
Pradhan B	27	0.750	2019
Singh VP	26	0.722	2019
Wang H	24	0.666	2019
Huang Q	20	0.555	2019
Zhang Q	20	0.555	2013
Li YP	19	0.527	2016
Liu Y	18	0.500	2017
Pham BT	17	0.472	2019

Pourghasemi HR (2016) has contributed an article titled "GIS-Based Groundwater Potential Mapping in Iran Using Augmented Regression Tree, Classification and Regression Tree, and Random Forest Machine Learning Models," which stands out with a remarkable 345 citations and is supported by 95 references. Khosravi et al. (2019) explores "A Comparative Evaluation of Flood Susceptibility Modelling Using Multi-Criteria Decision-Making Analysis and Machine Learning Methods," garnering 258 citations, while Singh VP (2019) has authored "Mapping of Groundwater Potential: A Novel Hybrid Intelligence Approach," which has received 104 citations. Wang H (2019) presents "Spatio-Temporal Characteristics of Drought Structure Across China Using the Integrated Drought Index," cited 59 times. Huang Q. (2019) contributes "A Robust Method for Non-Stationary Flow Estimation Based on the Improved EMD-SVM Model," which has received 110 citations. Furthermore, Zhang Q (2013) investigates "Spatial-Temporal Relationships Between Temperature and Precipitation Regimes: Effects of Temperature-Dependent Changes on the Hydrological Cycle," accumulating 89 citations. Li YP (2016) adds to the discourse with the article "Crop Planning and Water Resource Allocation for Sustainable Development of an Irrigation Region Under Multiple Uncertainties in China," which has also been cited 48 times.

3.7. Publication Keywords

Keyword analysis is a process that involves the examination of terms used in publications related to basin management and planning within the Web of Science (WoS) database. This analysis revealed a total of 14,743 distinct keywords employed across 3,608 publications. Notably, a network map featuring 479 keywords was constructed based on the criterion of each keyword being utilized in at least 10 publications, as depicted in Figure 3.

These 479 keywords were categorized into five distinct clusters, each distinguished by a different colour, with key terms of significance appearing larger than others. The interconnections between keywords in the map signify the degree of their association, and the cumulative link strength denotes the overall number of interrelationships among these keywords.

The first cluster, depicted in red, encompasses 144 keywords, with the pivotal term "management" having the highest number of links (NL: 425) and the most substantial total connection power (TLS: 2540). The second cluster, in green, comprises 117 keywords, with the central keyword being "model" (NL: 411; TLS: 2013). The third cluster, represented in blue, contains 92 keywords, and the term "river-basin" holds the utmost significance (NL: 396; TLS: 1986). The fourth cluster, rendered in yellow, consists of 76 keywords, and the primary keyword is "basin" (NL: 375; TLS: 1681). Finally, the fifth cluster, depicted in purple, comprises 50 keywords, with "land use" as the central keyword (NL: 302; TLS: 1273).

It is important to note that certain keywords, such as remote sensing, weighted registration, morphometric analysis, and land use sustainability, have recently gained prominence among researchers and have been excluded from the keyword network map. Figure 9 provides a visual representation in the form of a word cloud containing all 14,743 keywords used in this analysis (Figure. 4).

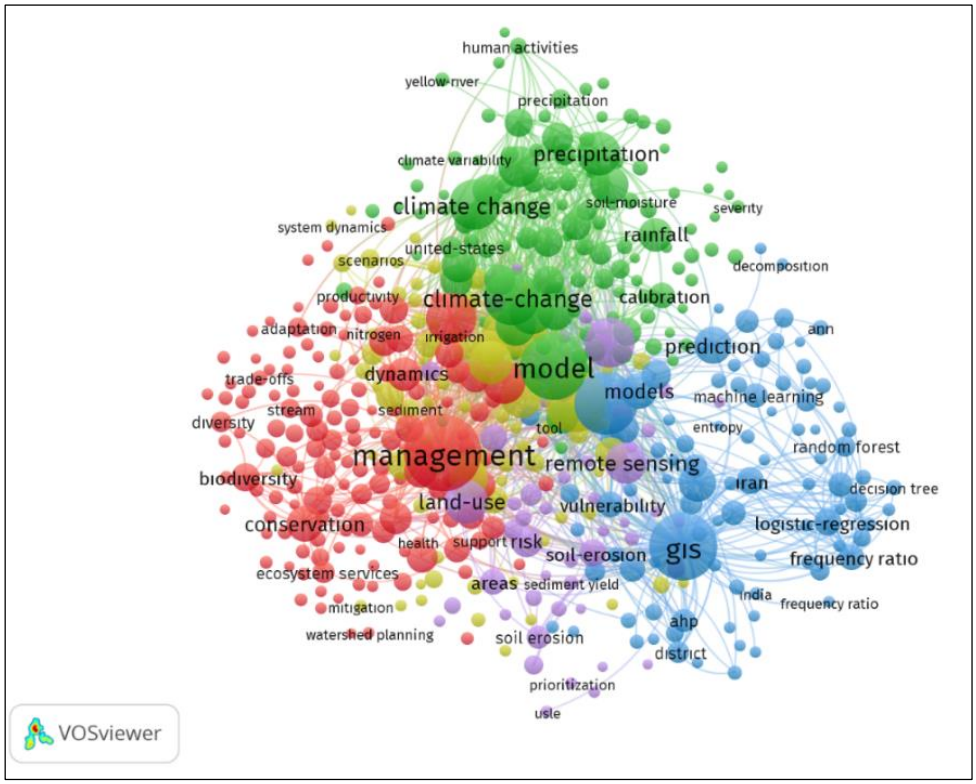

Figure 3. Source title and keywords-based network visualization diagram.

Figure 4. Word cloud for the research topic.

In the presented word cloud, the prominence of words related to watershed management and planning is visually represented, with larger text indicating the greater preference for these terms among researchers. Among the keywords favoured by researchers, notable ones include "model" (Number of Keywords [n]: 669; Total Link Strength [TLS]: 3469), "management" (n: 487; TLS: 2540), "analysis" (n: 184; TLS: 611), "land" (n: 164; TLS: 915), "water" (n: 161; TLS: 802), "support" (n: 149; TLS: 871), "system" (n: 148; TLS: 825),

"planning" (n: 119; TLS: 559), "process" (n: 94; TLS: 627), "resources" (n: 81; TLS: 391), "river" (n: 66; TLS: 274), "groundwater" (n: 61; TLS: 359), and "change" (n: 40; TLS: 273).
The top 20 keywords preferred by the author(s) are as follows: "management," "water," "analysis," "change," "land," "planning," "system," "groundwater," "model," "process," "resources," "river," "support," "assessment," "cover," "ecosystem," "flood," "frequency," "risk," and "surface." These keywords represent the central themes and topics of interest in the realm of basin management and planning.

3.8. Scientific Source Analysis

To create a scientific publication, authors are required to access and thoroughly review foundational publications related to their specific subject matter. This practice establishes a vital link between the intended publication and the existing literature. In essence, referencing fundamental sources when creating a publication enhances the overall quality of the resultant work, as emphasized by Şimşek and Küçükesmen (2019).
In the course of this analysis, a total of 132,282 sources were referenced across 3,608 publications. The resulting network map comprises 450 sources, which were selected based on the criterion of being cited in at least 35 publications, designating them as the most frequently cited sources in the field of basin management and planning, as illustrated in Figure 5.

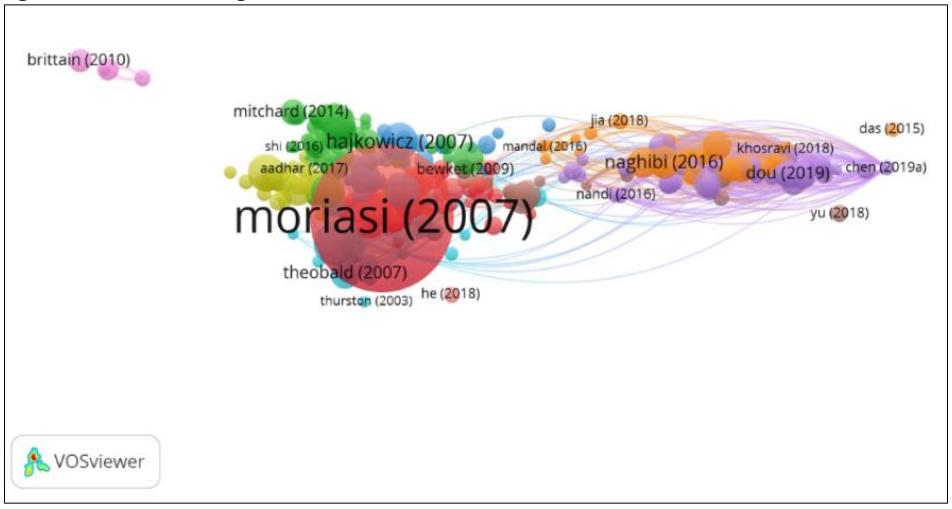

Figure 5. Source Analysis Network Map in Publications.

These 450 sources have been categorized into ten distinct clusters, each identified by a unique color, with pivotal resources appearing more prominently than others. The links between these resources represent their interconnections, and the cumulative connection strength reflects the total number of associations among these sources. Furthermore, the number of citations demonstrates the significance of a source relative to others.
In the first cluster, depicted in red, 98 sources are present. The most crucial source within this cluster is the publication by Moriasi et al. (2007) titled "Model Evaluation Guidelines for Systematic Quantification of Accuracy in Watershed Simulations", which boasts 41 links, a total link strength of 74, and an impressive 6,882 citations. This source is regarded as foundational among the referenced materials.
The second cluster, illustrated in green, encompasses 72 resources. The primary source in this cluster is Raymond et al. (2009) article, "Mapping Community Values for Natural Capital and Ecosystem Services," which features 14 links, a total link strength of 29, and 404 citations. This source holds particular significance, especially in the development of ecosystem-based decision-making methodologies.
In the third cluster, presented in blue, 71 resources are included. The principal source within this cluster is the publication by Hajkowicz and Collins (2007), titled "A Review of Multiple Criteria Analysis for Water Resource Planning and Management," with 24 links, a total link strength of 39, and 438 citations. This source plays a central role in the domain of water resource planning and management, particularly with regard to multiple criteria analysis.
This source serves as a fundamental tool for addressing decision-making challenges through the creation of multi-criteria decision-making and planning studies. Moving on to the fourth cluster, depicted in yellow, it comprises 52 resources. The pivotal source within this cluster is the work by Tsakiris, Pangalou, and Vangelis (2007), titled "Regional Drought Assessment Based on The Reconnaissance Drought Index (RDI)." This source features 9 links, a total link strength of 10, and 438 citations. In this study, the Reconnaissance Drought Index (RDI), a novel index, was introduced, alongside the commonly used Standardized Precipitation Index (SPI)

and the decimals method. The new index offers significant advantages by incorporating potential evapotranspiration as an additional meteorological parameter, distinct from precipitation.

The fifth cluster, represented in purple, comprises 41 sources. The principal source in this cluster is Termeh et al. (2003) article titled "Flood Susceptibility Mapping Using Novel Ensembles of Adaptive Neuro Fuzzy Inference System and Metaheuristic Algorithms," featuring 5 links, a total link strength of 82, and 393 citations. This work addresses the issue of flood and inundation through a hybrid model incorporating the fuzzy logic method.

The top 10 most frequently referenced sources in the context of methods used in basin management and planning, along with their citation and link power metrics, are as follows:

1) Moraiasi (2007) with 6,882 citations and a total link strength of 74.
2) Leitao (2002) with 560 citations and a total link strength of 70.
3) Tsakiris (2007) with 438 citations and a total link strength of 10.
4) Hajkowich (2007) with 438 citations and a total link strength of 39.
5) Naghibi (2016) with 408 citations.
6) Raymond (2009) with 404 citations and a total link strength of 29.
7) Theobald (2007) with 292 citations and a total link strength of 120.
8) Dou (2019) with 244 citations and a total link strength of 198.
9) Termeh (2018) with 243 citations and a total link strength of 393.
10) Britattain (2010) with 176 citations and a total link strength of 2.

These sources represent the most favored and impactful references in the field of methods applied in watershed management and planning.

3.9. Journal Analysis

The co-citation method quantifies the relationship between two publications by considering how often they are jointly cited, as determined through the analysis (Şimşek and Küçükesmen, 2019). Through the examination of affiliated journals employing the common citation approach, it was ascertained that 4,131 journals received citations across 3,608 publications. The network map, comprising 134 journals selected from the larger pool of 4,131 journals, based on the criterion of being cited in at least 10 publications, is presented in Figure 6.

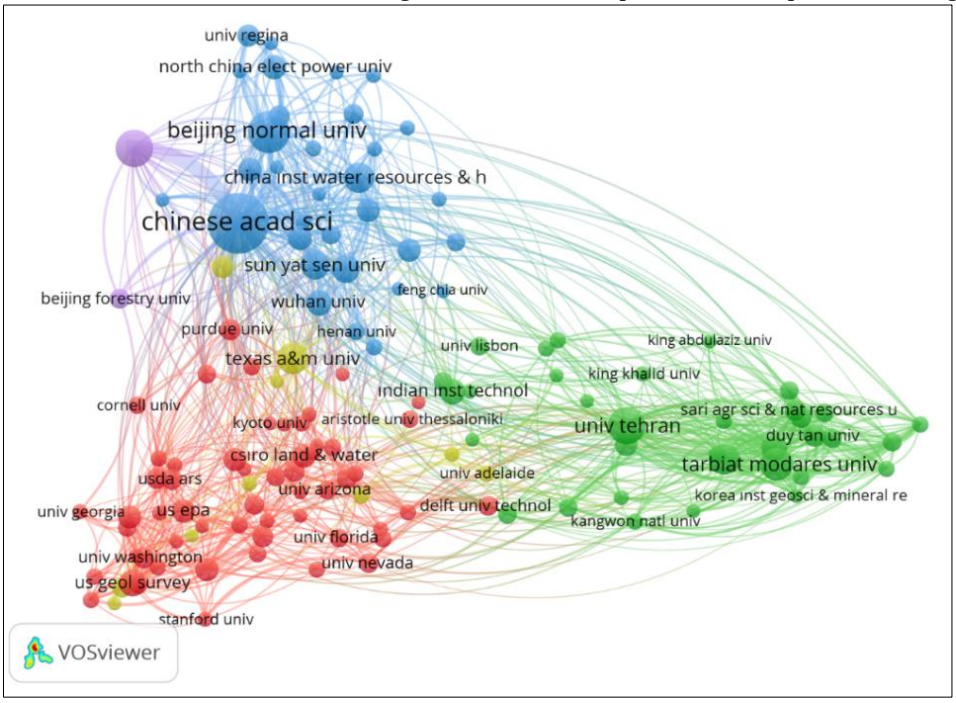

Figure 6. Journal Analysis Network Map in Publications.

These 134 journals are categorized into five distinct clusters, each distinguished by a unique colour, with the more prominent journals appearing larger than others. The interconnections between journals signify their associations, and the cumulative link strength indicates the overall number of interrelated journals. Furthermore, the number of citations reflects the significance of these journals in the context of methods and bibliometric analyses employed in basin management and planning.

In the first cluster, represented in red, 56 journals are featured. The journal "US Geological Survey" stands out as the most crucial one, with 132 links and a total link strength of 1,434.46. This journal holds a primary position in the field of methods and bibliometric analyses used in watershed management and planning.
The second cluster, represented in green, encompasses 34 journals. The primary journal in this cluster is "Tarbiat Modares University," with 133 links and a total link strength (TLS) of 3,159.69.
Moving on to the third cluster, marked in blue and consisting of 32 journals, the most significant journal is "Chinese Academia Sci," with 133 links and an impressive total link strength (TLS) of 7,800.52.
In the fourth cluster, depicted in yellow and containing 10 journals, the central journal is "Texas E&M University," with 133 links and a total link strength (TLS) of 1,873.00.
The fifth cluster, denoted in purple and including only two journals, features "Chinese Acad. Sci" as the most prominent, with 133 links and a total link strength (TLS) of 4,063.41.
The ranking of the top 10 most cited journals in the context of watershed methods within the Web of Science (WoS) is as follows:

1) "Chinese Acad. Sci" (Total Link Strength [TLS]: 7,800.52)
2) "Tarbiat Modares Univ. J." (TLS: 3,159.54)
3) "Beijing Norm. Univ. J." (TLS: 3,058.89)
4) "Tehran Univ. J." (TLS: 2,753.84)
5) "China Inst. Water Research" (TLS: 2,066.30)
6) "Texas A&M Univ. J." (TLS: 1,873.00)
7) "Yellow Agr. Sci" (TLS: 1,532.76)
8) "US Geol Survey" (TLS: 1,434.46)
9) "North China Elect Power J." (TLS: 1,048.04)
10) "Beijin Forestry J." (TLS: 801.80).

These journals are recognized as the most frequently cited and influential publications in the context of watershed methods, as assessed within the WoS database.

3.10. Author Analysis

Author analysis, conducted through co-authorship analysis, accentuates the interrelationships among authors by establishing connections between the source documents and the references they receive, as articulated by Kumar (2015). Subsequent to the analysis, an aggregate of 79,565 authors were identified within the context of 3,608 publications. Figure 12 illustrates the network map constructed from a subset of 706 authors, culled from the broader population of 79,565 authors, based on the criterion of their inclusion in a minimum of 20 publications (Figure. 7).

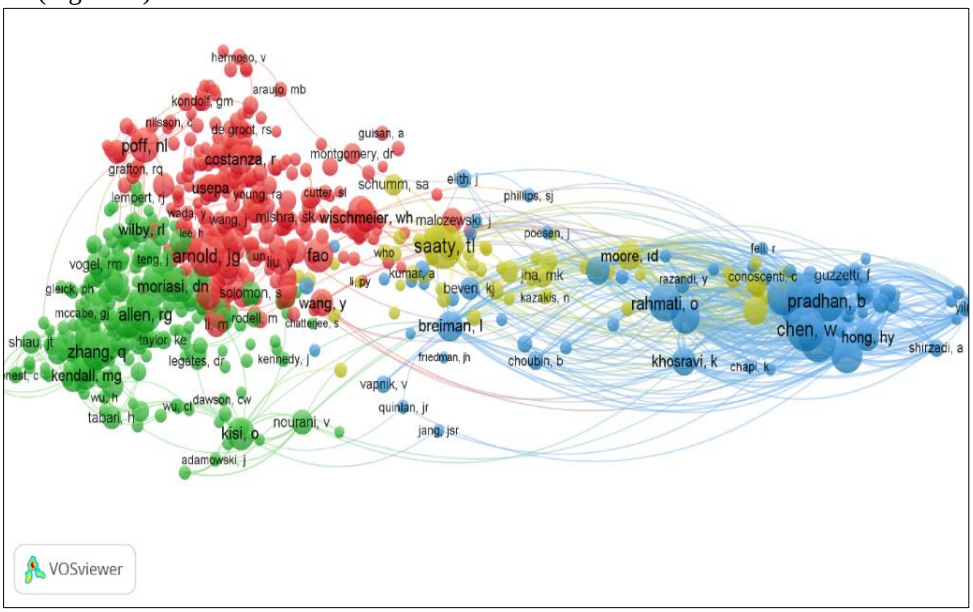

Figure 7. Authorship Analysis Network Map.

The 79,565 authors have been segregated into four distinct clusters, each represented by a unique color, with the most prominent author(s) within these clusters depicted as larger entities. The link count among authors signifies their associations, while the total link strength indicates the overall number of interconnected authors.

Furthermore, the number of citations reflects the level of recognition authors have garnered within the context of the watershed method based on the Web of Science (WoS) database.

The initial cluster, depicted in red, encompasses 297 authors. Notably, "Arnold, J. A" emerges as the preeminent author, with 497 links, a total link strength (TLS) of 2,729, and 227 citations. The objectives of this research were to ascertain the evaluation techniques, both statistical and graphical, for proposed models pertaining to watershed management. This included the review of reported value ranges and corresponding performance ratings for the proposed statistical models. The overarching aim was to establish guidelines for model evaluation based on the review results and project-specific considerations. All of these goals revolved around the simulation of river flow and the transport of sediment and nutrients. Consequently, the analysis led to the proposition of three quantitative statistics: Nash-Sutcliffe efficiency (NSE), percentage bias (PBIAS), and the ratio of the root mean square error to the standard deviation of the measured data (RSR), in addition to graphical data.

The second cluster, characterized by its green colour, encompasses 271 authors. Among them, "Zhang, Q" stands out as the most preeminent author within this cluster, with 384 links, a substantial total link strength (TLS) of 2,495, and 196 citations. This study places particular emphasis on addressing the efficiency of water use and resolving uncertainties inherent in the modelling of agricultural water management systems. To tackle the intricate challenges associated with this focal point, a novel approach is introduced—namely, the robust fractional programming (RFP) method, which integrates fractional programming with robust optimization techniques. The overarching objective is to enhance agricultural water use efficiency, especially in the presence of uncertainties. The RFP method is specifically designed to handle information characterized by high degrees of uncertainty, for which known probability distributions are lacking. Furthermore, it extends the capabilities of robust optimization methods in dealing with problems related to rate optimality. To validate its efficacy and practicality, the RFP method is applied to a long-term agricultural water resources management problem situated in the arid region of northwestern China, characterized by significant challenges related to water scarcity and low water use efficiency, hampering local development. The approach leads to the formulation of benefit and risk-aware plans aimed at adjusting crop patterns. The study concludes that the developed approach is not only applicable to the specific context but also has the potential to be employed in other optimization scenarios aimed at enhancing resource utilization efficiency under conditions of uncertainty.

The third cluster, represented in blue, comprises 76 authors. "Chen, W." emerges as the most prominent author within this cluster, with 277 links, an extensive total link strength (TLS) of 9,140, and 256 citations. The primary objective of this study is the creation of a landslide risk map, achieved through the utilization of three distinct data mining techniques: an adaptive neuro-fuzzy inference system (ANFIS-FR), a generalized additive model (GAM), and a support vector machine (SVM) integrated with the frequency ratio, all of which are employed for landslide susceptibility mapping.

The fourth cluster, denoted by its yellow hue, encompasses 62 authors. Among these, "Saaty" takes the central stage as the most significant author, boasting 406 links, an impressive total link strength (TLS) of 2,957, and 287 citations. The core objective of this research paper is to exemplify the efficacy of leveraging Geographical Information Systems (GIS), the Remote Sensing method, and multi-criteria tools in the delineation of potential groundwater (GW) zones within the Kuttiyadi River basin (KRB) situated in Kerala, located in the northwestern region of India. In order to unravel the geohydrological structure of the KRB and its associated behaviour concerning GW potential, a series of thematic layers are initially established. These thematic layers encompass aspects such as geomorphology, geology, slope, soil composition, lineament density, and drainage density. Subsequently, these thematic layers, along with their attributes, are assigned appropriate weights following the Saaty scale, considering their relative importance in relation to the presence and potential of groundwater. The assigned weights and characteristics of these layers are subjected to normalization using the Analytical Network Process (ANP) methodology. Thereafter, the selected thematic maps are amalgamated within the GIS framework using the weighted overlay method, culminating in the creation of the ultimate groundwater exploration zone map. Additionally, (Table. 8) presents a list of the ten most frequently cited authors in this field of study.

The most frequently cited and highly influential author in this methodology is "Arnold, J.Q." (NC: 227; TLS: 2729), emerging as the standout figure. The ranking of the top nine most frequently cited authors within the literature-based watershed method includes "Zhang, Q." (NC: 196; TLS: 2495), "Chen, W." (NC: 256; TLS: 9140), "Saaty, L." (NC: 289; TLS: 2957), "Breiman, L." (NC: 124; TLS: 2572), "Person, Him." (NC: 140; TLS: 2122), "Rahmati, O." (NC: 190; TLS: 6148), "Proff, N. L." (NC: 161; TLS: 2230), "Pradhan, B." (NC: 223; TLS: 7766), and "Pham, B. T." (NC: 185; TLS: 6231).

Table 8 Distribution of authorship characteristics regarding their number of links (NL), number of citation (NC) and total link strength (TLS).

Author	Number Of Links (NL)	Number Of Citation (NC)	Total Link Strength (TLS))
Arnold, J.Q.	497	227	2729
Zhang, Q.	384	196	2495
Chen, W.	277	256	9140
Saaty, L.	406	289	2957
Breiman, L.	381	124	2572
Kisi, O.	250	140	2122
Rahmati, O	331	190	6148
Proff, N. L.	368	161	2230
Pradhan, B.	270	223	776
Pham, B. T.	241	185	6231

4. Conclusion

The realm of basin/watershed management has undergone significant evolution over time, shaped by diverse perspectives and adopted in varying ways by numerous institutions and organizations. Over the past century and a half, the rise in global population, escalating demands and needs, and intensified anthropogenic pressures have underscored the paramount role of water as a foundational component within basins. This paradigm shift has prompted extensive research and deliberation, focusing on the requisite for energy production and the quantified utilization of water resources.

Historically, the nascent phase of basin management studies, particularly in the United States, was primarily concentrated on the facets of water allocation, distribution, and agricultural applications. However, after the Second World War, changing environmental conditions and the introduction of anthropogenic factors catalysed a substantial increase in the significance of watershed management. During this phase, conferences, symposia, declarations, and forums emerged as pivotal catalysts in redefining the approach to watershed management. Emerging challenges such as escalating environmental degradation, intensified pollution levels, and heightened concerns for water and resource scarcity in select regions of the world further galvanized this discourse, finding expression in numerous global gatherings.

The present research brought about a systematic literature review and the creation of a curated compilation of publications designed to meet the research objectives. An exhaustive scan of 10,150 international publications was conducted, and a meticulous reduction process employing systematic elimination methods resulted in a refined selection of 250 publications. These chosen publications were subjected to comprehensive full-text analyses, culminating in the presentation of the most frequently employed methods in contemporary scientific discourse. Notably, of the publications included in this analysis, a mere 76 were authored by geographers, predominantly utilizing advanced information technologies such as Geographic Information Systems (GIS) and Remote Sensing (RS) software—a reflection of the influence of recent advancements in technology on research methodologies.

Recent developments in watershed/basin planning have emphasized the imprudence of relying solely on a single method or model. A conspicuous gap in current publications is the prevalent practice of singular model utilization, often omitting comparative analyses. This narrow focus does not align with the multifaceted nature of basin planning and management, where technological tools should complement alternative models.

Incorporating geographers, who possess intricate knowledge of the land and can adeptly bridge the gap between natural processes and human dynamics, is paramount during the planning phase.

Upon conducting a systematic literature review, a discernible trend emerges: the prominent utilization of various models, particularly those rooted in Geographic Information Systems (GIS) techniques. Furthermore, artificial neural network methods, machine learning models, Soil and Water Assessment Tool (SWAT) models, integrated models, and morphometric analysis-based models have witnessed widespread application. It's worth noting that the driving force behind these endeavours predominantly comprises environmental engineers.

These studies frequently exhibit a predominantly desk-bound approach, yet it's imperative to underscore the necessity of on-site observations to validate planned strategies and optimize basin planning outcomes. Incorporating real-world data through on-site assessments is crucial for robust and effective planning processes.

As a result of the bibliomtrical analysis, it was seen that the studies of geographers on the subject of basin planning are limited. it was also concluded that there is a limited number of studies on the subject in Turkey. This gap needs to be filled because geographers know and define the space better than an engineer in space planning. Geography should be directed to this field more than other sciences in human-space planning.

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