06.00.00 — QISHLOQ XO‘JALIGI FANLARI
https://iau-jaesa.uz/article/ikmqx3doaohc/
https://doi.org/10.5281/zenodo.21360650
UDC 631.67:005.52

# BIBLIOMETRIC ANALYSIS OF WATER USE PLANNING AND SUSTAINABLE IRRIGATION STRATEGIES FOR THE PERIOD 1989–2024

**Gulnora Rakhmatullaeva**[1]
**Rustam Muradov**[2]
[1] “Tashkent Institute of Irrigation and Agricultural Mechanization Engineers” National research university
[2] Swiss Agency for Development and Cooperation SADC
*Corresponding author:*
g_raxmatullayeva@tiiame.uz

***Abstract.*** *The management and planning of water resources have become crucial in addressing global challenges such as population growth, industrial expansion, and climate change. This study presents a bibliometric analysis of 53 Scopus-indexed publications on water use planning and water management between 1989 and 2024. Using the Scopus database and bibliometric tools such as VOSviewer and Excel, we identified publication trends, top contributing authors, countries, and journals. The results show a steady increase in research activity after 2005, with major contributions from China, the United States, India, and Iran. This analysis provides valuable insights for researchers and policymakers aiming to improve sustainable water resource management worldwide. The bibliometric analysis revealed that international research on water use planning and water management would greatly benefit from broader scientific collaboration, continuous long-term studies, and the sustainable integration of water planning and management concepts into future environmental and agricultural policies.*

***Keywords:*** *water use planning, water management, irrigation, sustainability; climate change.*

***Annotatsiya.*** *Suv resurslarini boshqarish va rejalashtirish aholi sonining o‘sishi, sanoatning kengayishi hamda iqlim o‘zgarishi kabi global muammolarni hal etishda muhim ahamiyat kasb etmoqda. Ushbu tadqiqotda 1989–2024-yillar oralig‘ida suvdan foydalanishni rejalashtirish va suv resurslarini boshqarish mavzulariga bag‘ishlangan Scopus bazasida indekslangan 53 ta ilmiy nashrning bibliometrik tahlili amalga oshirildi. Tahlil Scopus ma’lumotlar bazasi hamda VOSviewer va Excel kabi bibliometrik vositalar yordamida bajarildi. Natijalar 2005-yildan keyin ushbu yo‘nalishdagi ilmiy tadqiqotlar soni barqaror ravishda oshib borganini ko‘rsatdi. Eng katta ilmiy hissalar Xitoy, Amerika Qo‘shma Shtatlari, Hindiston va Eron olimlari tomonidan qo‘shilgan. Olingan natijalar butun dunyo miqyosida suv resurslaridan barqaror foydalanishni takomillashtirishga intilayotgan tadqiqotchilar va siyosat ishlab chiquvchilar uchun muhim ilmiy ma’lumotlarni taqdim etadi. Bibliometrik tahlil shuni ko‘rsatdiki, suvdan foydalanishni rejalashtirish va suv resurslarini boshqarish sohasidagi xalqaro tadqiqotlar ilmiy hamkorlikni kengaytirish, uzluksiz uzoq muddatli*

*tadqiqotlarni olib borish hamda suvni rejalashtirish va boshqarish konsepsiyalarini kelajakdagi ekologik va qishloq xo'jaligi siyosatlariga barqaror integratsiya qilish orqali yanada rivojlantirilishi mumkin.*

***Kalit so'zlar:*** *suvdan foydalanishni rejalashtirish, suv resurslarini boshqarish, irrigatsiya, barqaror rivojlanish, iqlim o'zgarishi.*

***Аннотация.*** *Управление и планирование водных ресурсов стали важнейшими направлениями в решении глобальных проблем, таких как рост населения, расширение промышленности и изменение климата. В данном исследовании представлен библиометрический анализ 53 публикаций, индексируемых в базе данных Scopus, посвящённых вопросам планирования водопользования и управления водными ресурсами за период с 1989 по 2024 годы. С использованием базы данных Scopus и библиометрических инструментов, таких как VOSviewer и Excel, были выявлены тенденции публикационной активности, наиболее продуктивные авторы, страны и научные журналы. Полученные результаты показывают устойчивый рост исследовательской активности после 2005 года, при этом наибольший вклад в развитие данной научной области внесли Китай, Соединённые Штаты Америки, Индия и Иран. Проведённый анализ предоставляет ценную информацию для исследователей и лиц, принимающих решения, заинтересованных в совершенствовании устойчивого управления водными ресурсами на мировом уровне. Результаты библиометрического исследования свидетельствуют о том, что дальнейшее развитие международных исследований в области планирования водопользования и управления водными ресурсами требует расширения научного сотрудничества, проведения непрерывных долгосрочных исследований, а также устойчивой интеграции концепций водного планирования и управления в будущую экологическую и аграрную политику.*

***Ключевые слова:*** *планирование водопользования, управление водными ресурсами, ирригация, устойчивое развитие, изменение климата.*

## 1. INTRODUCTION

Water is one of the most vital natural resources essential for sustaining life, economic development, and environmental balance. In recent decades, increasing population, industrialization, urban expansion, and climate change have significantly intensified the global demand for water [1]. This situation has made water use planning and water management central issues in achieving sustainable development goals (SDGs)[2], particularly Goal 6 - "Clean Water and Sanitation." Effective management of water resources is not only a technical challenge but also a socio-economic and political priority for many countries. Water use planning refers to the systematic allocation and regulation of water resources to meet competing demands among agricultural, industrial, domestic, and environmental sectors [3]. Meanwhile, water management involves the implementation of policies, technologies, and governance frameworks aimed at ensuring the efficient and equitable use of water [4]. The growing frequency of droughts, floods, and groundwater depletion highlights the urgent need for integrated and adaptive management approaches [5].

Bibliometric analysis serves as a powerful method to evaluate scientific progress, detect emerging themes, and identify leading countries, authors, and institutions contributing to water-related research. Unlike narrative reviews, bibliometrics provides a quantitative overview of scientific publications, offering insights into research dynamics, collaboration networks, and thematic evolution.

This study aims to perform a comprehensive bibliometric analysis of global publications related to water use planning and water management from 1989 to 2024 based on Scopus-indexed data. By examining publication trends, most influential authors, countries, journals, and keywords, this research seeks to uncover the development trajectory and future directions of water management studies. The findings are expected to support policymakers, environmental planners, and researchers in formulating strategies for sustainable water governance and resource efficiency worldwide[6].

## 2. MATERIALS AND METHODS

In this review, publications related to regional knowledge and research on water-use planning were analyzed. The study was conducted using the Scopus bibliographic database, one of the most widely used and credible scientific sources[7]. The search covered the period from 1989 to 2024, focusing on studies addressing the development of water-use plans across different countries as well as Japan, Canada, China, Iran, Spain, Brazil, Pakistan, India, Egypt, Australia, and Germany. The keywords “water use planning” and “water management” were applied to identify relevant documents. The analysis was performed in September 2025. A total of 53 publications from different countries were selected to examine the major challenges and methodologies in water-use planning. Data extraction and analysis were carried out using CSV files, Microsoft Excel 2021, RIS format, VOSviewer, and mapping diagrams.

### 2.1. Article selection and inclusion criteria.

During the search process, relevant data such as the keyword “water use” and all English-language articles were collected and organized into an electronic spreadsheet. The inclusion criteria were as follows: Keyword: “water use”; Document type: article; Time range: 1989–2024; Subject areas: Environmental Science, Agricultural and Biological Sciences; Countries: Japan, Canada, China, Iran, Spain, Brazil, Pakistan, India, Egypt, Australia, Germany, and CIS member states; Deadline for inclusion: September 1, 2025. These criteria guided the selection of publications to ensure consistency and scientific relevance throughout the analysis.

### 2.2. Bibliometric analysis

The data obtained in CSV format were uploaded into Microsoft Excel and subsequently analyzed using bibliometric techniques. Before the analysis, all data were carefully checked for errors or inconsistencies. The reviewed publications were examined to identify the most relevant studies and the most active authors contributing to this field. According to the results ranked as the most prolific author with three publications [8].

The selected publications were evaluated and classified according to several parameters, including the number of papers per year, document type, list of articles,

top journals, major funding sponsors, subject categories, and distribution by country and institution. Finally, co-authorship and keyword co-occurrence analyses were performed to explore the knowledge structure and research trends by identifying clusters of the most frequently used keywords in the literature.

**2.3. Development of water-use planning methods.**

This review pays special attention to the development and improvement of water-use planning methods within the different region. Emphasis was placed on identifying innovative approaches, methodological frameworks, and tools that enhance the efficiency, adaptability, and sustainability of regional water management systems.

## 3.RESULTS

### 3.1 Trend of publications on internal water resources

In many arid and agricultural regions, the relationship between Internal water resources and irrigation water has a wide range of scientific implications. Total of 53 papers published between 1989 and 2024 on Internal water resources issue in different countries. In this review, the scientific articles consist of three periods of development: introduction (1989–2006), slightly growth (2007–2017) and stable growth (2018–2024). Introduction period. The first period consists of s10 publications, representing 18.87% of the total. The results show that the interest in the Internal water resources To increase the yield and productivity of wheat in water-scarce land, (T7) was adopted. A 3-year field experiment was conducted. The alternative deficit strategy achieved maximum net financial return under land and water-limited conditions [9]. In this paper, the MOPECO model is presented as a tool for guiding optimal production plans and irrigation management strategies. This model will help farmers, extension services, and other agents analyze, make decisions, and optimize water management [10]. to analyze the impact of policies in other countries with water scarcity and apply them to adopt sustainable agricultural strategies [11].

Slightly growth period. This period shows 25 documents representing 43.39% of the total, with a growth that marks the scientific interest in this field of research.

Stable growth period. The last period represents the key to exponential growth, grouping 14 documents (26.41% of the total). In 2018, the highest number of publications was reached during the period of analysis with 6, followed by the year 2013 (with 4, making it a constant growth field (Fig 1).

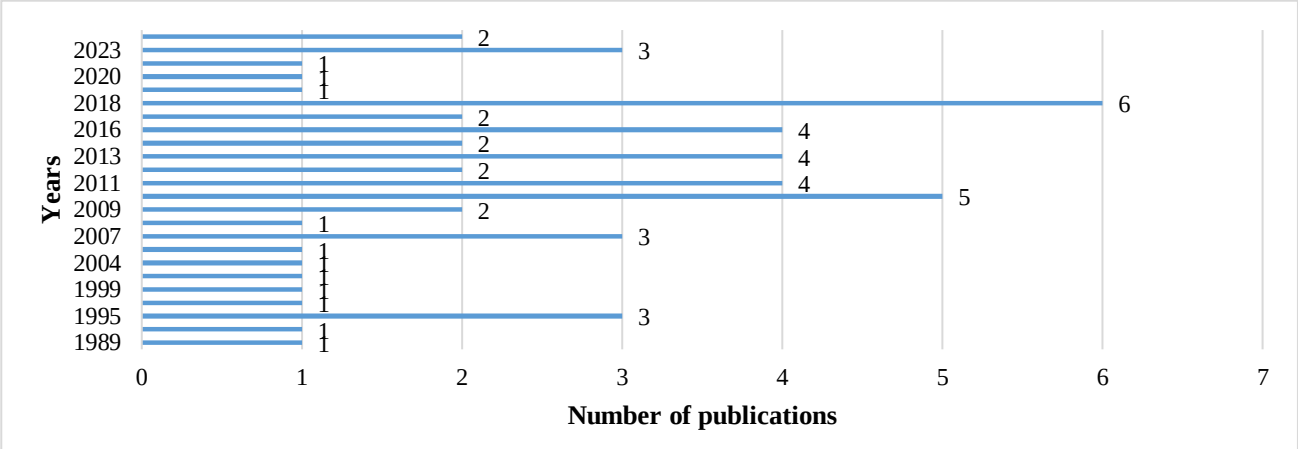


***Figure 1. Annual production of articles on Internal water resources during the period 1989-2024***

### 3.2 Authors and their affiliated country

Our research found that 168 authors from 22 countries conducted studies on Internal water resources over the period 1989-2024. Figure 2 shows 10 authors who have published more than 16 papers. Among them, [12] reigned with 3 publications, followed by Brumbelow[13], K. with 2, Singh, R[14]. with 2, Abbaspour, K.C[15]. with 1, ,Aiad. Y. and Ahmadzadeh. H[16]. each with 1 research papers.

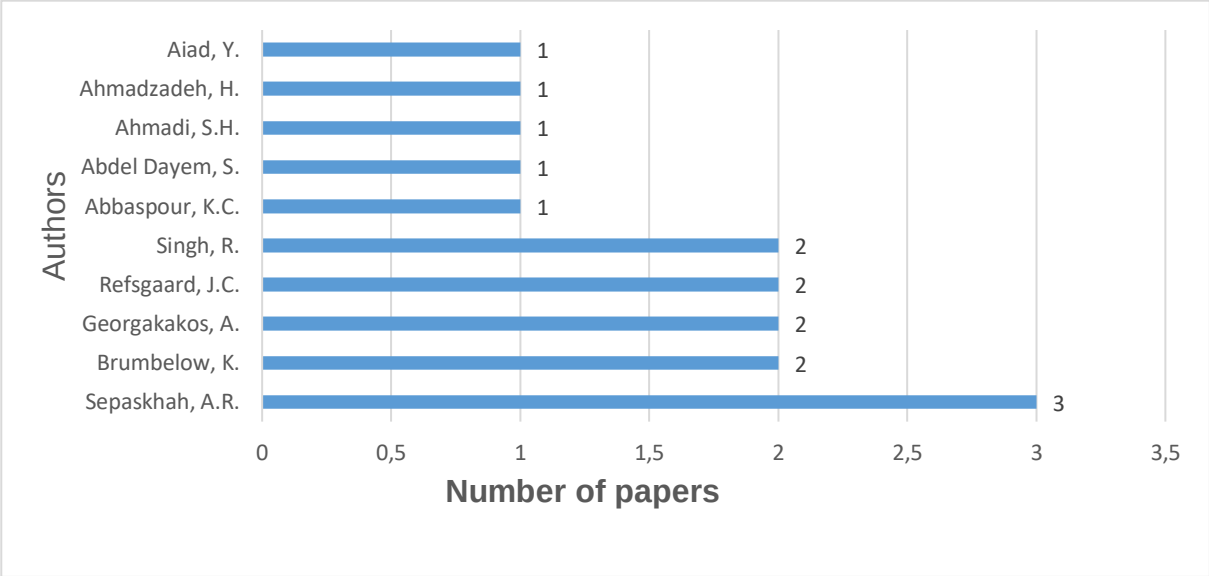


***Figure 2. List of top authors published on Internal water resources***

Institutions are classified according to the quality of the articles they publish In the period for 36 years, 112 different institutions cooperated to publish 53 papers related to internal water resources in differt countries [16]. Our analysis of the top 8 institutes' publications on internal water resources allowed us to determine the influential and productive institutions in this field [17]. As indicated in Figure 3, of the 8 institutions, fourteen of them were from Qatar and only one from Indian. Between these, "Texas A&M University and Shiraz University " occupies the first position in record rank (4 records), followed by Indian Institute of Technology Kharagpur (3 records) and College of Engineering (3 records).

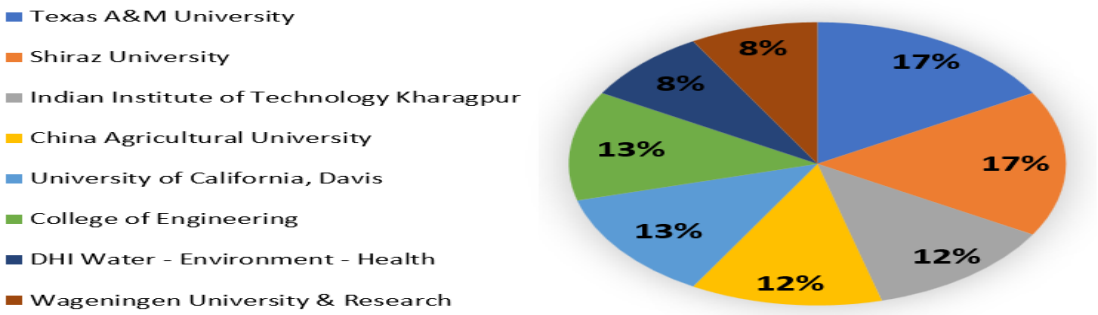


Figure 3. List of top institutions on Internal water resources

### 3.3 Top countries on Internal water resources

The number of publications ten most of productive countries in the field of Internal water resources research between 1989 and 2024. Among them, United States," dominated with 15 publications, followed by India 10, China 8, Iran 8, Spain 4, Brazil 3, Canada 3, Netherlands 3.

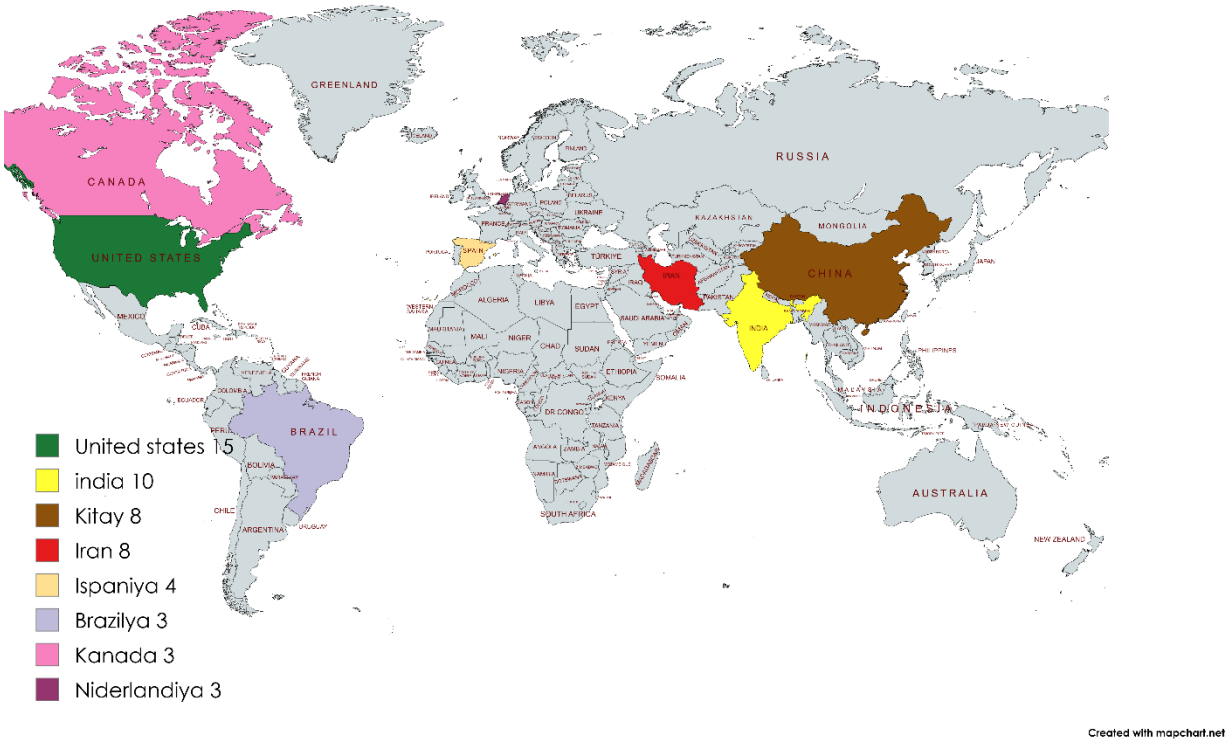


*Figure 4. List of top countries on Internal water resources*

### 3.4 Top cited papers on Internal water resources

Given is in the Table 1 which presents data concerning ten the mostly cited papers on Internal water resources in the different countries. Almost of citations given to 15 papers from the Table 2. First 15 top cited papers are consisting all 1161 articles.

**Table 1. List of top cited publications Internal water resources**

| *No.* | *Title* | *Journal* | *Corresponding author* | *PY* | *TC 2000-2022* | *Doc.type* |
|---|---|---|---|---|---|---|
| *1.* | Effects of deficit irrigation on yield, water productivity, and economic returns of wheat | Agricultural Water Management | M.H., Ali, Md Hossain; | 2007 | 239 | Article |
| *2.* | An improved water use efficiency of cereals under temporal and spatial deficit irrigation in north China | Agricultural Water Management | Taisheng.T. | 2010 | 209 | Article |
| *3.* | MOPECO: An economic optimization model for irrigation water management | Irrigation Science | José Fernando. | 2004 | 111 | Article |
| *4.* | Modeling wheat yield and crop water productivity in Iran: Implications of agricultural water management for wheat production | Agricultural Water Management | Faramarzi. | 2010 | 102 | Article |
| *5.* | Water productivity of maize in the US high plains | Irrigation Science | Trout . | 2017 | 97 | Article |

| No. | Title | Journal | Corresponding author | PY | TC 2000-2022 | Doc.type |
|---|---|---|---|---|---|---|
| 6. | Using the SWAT model to assess the impacts of changing irrigation from surface to pressurized systems on water productivity and water saving in the Zarrineh Rud catchment | Agricultural Water Management | Ahmadzadeh. | 2016 | 96 | Article |
| 7. | A multistage irrigation water allocation model for agricultural land-use planning under uncertainty | Agricultural Water Management | Dai. | 2013 | 91 | Article |
| 8. | An interval multi-objective programming model for irrigation water allocation under uncertainty | Agricultural Water Management | M.W. | 2018 | 81 | Article |
| 9. | Logistic model application for prediction of maize yield under water and nitrogen management | Agricultural Water Management | A.R., | 2011 | 69 | Article |
| 10. | Hydrological modelling of a small watershed using MIKE SHE for irrigation planning | Agricultural Water Management | R.P., | 1999 | 66 | Article |

* PY – Published year, * TC – Total citation

## 3.5 . Keyword and co-authorship network

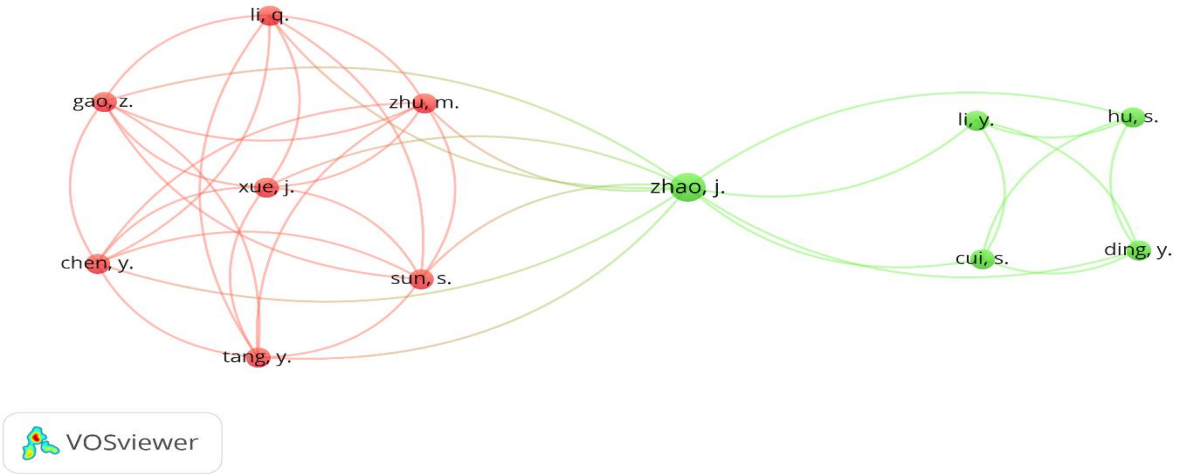


***Figure 5. Network map of top co-authorships based on the total link strength.***

No-authorship, keyword co-occurrences, citations, bibliographic coupling, and co-citation maps can be generated using VOSviewer based on bibliographic data. File formats supported include .txt, ris, and .csv from databases such as Scopus. The raw file was imported into VOSviewer and a map of co-authorship and keyword co-occurrences (shown in Figure 5, 6) were created using the software. The co-authorship analysis resulted in a network of 159 authors. Only authors having a minimum of two publications on the topic of water use were included.

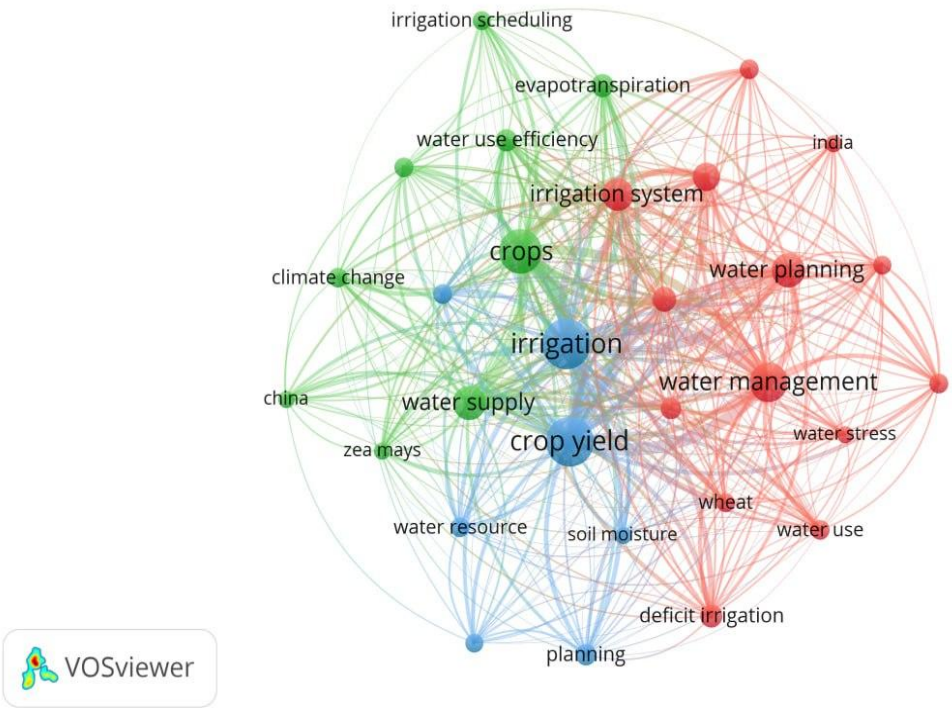


***Figure 6. Network map of top keywords based on the total link strength***

The analysis yielded 1107 keywords. After excluding the general keywords with a low relevance score and those with low occurrence (by default, a minimum of 60 occurrences of a keyword is selected, to strengthen the co-occurrence results), 30 items were finally identified. Based on the total link strength, each resulting keyword is sketched in a node, creating a network map of all keywords. Figure 6 shows the network map of the top 15 authors' keyword co-occurrence. The size of the node reflects the keyword's degree of importance. There are 30 items distributed over 3 clusters: cluster 1 (crop yield, defict irrigation, india, irrigation system, productivity, soil moisture, water conservation, water management, water planning, water productivity, water resources, water stress, water use, wheat, yield response ), cluster 2 (china, climate change, crop production, crops, cultivation, evapotranspiration, irrigation, irrigation scheulding, optimization, water supply, water use efficiency, zea mays), cluster 3 (decision making, planning, water resource).

## 4.DISCUSSION

The bibliometric analysis of 53 Scopus-indexed publications on water use planning and water management from 1989 to 2024 revealed four major thematic clusters that define the evolution of global irrigation and water management research. These clusters differ in methodological focus, research depth, and policy relevance, reflecting how the field has diversified over the past three decades. The first cluster, field experiments on partial irrigation (8 papers), represents empirical studies evaluating the effects of reduced irrigation on crop performance and soil-water relations. Most experiments were conducted in arid and semi-arid regions such as China, Iran, and India, where water scarcity is a key limitation. Findings show that partial irrigation can maintain stable yields while reducing total water use by 30–40%,

which highlights its potential for optimizing water efficiency without compromising food security.

The second cluster, comparing full versus deficit irrigation on cereals and wheat (5 papers), analyzes yield response functions under different irrigation regimes. These studies compare the physiological and agronomic effects of full and deficit irrigation on major cereal crops. Results indicate that deficit irrigation, when properly timed and monitored, can achieve up to 85–90% of maximum yield while saving considerable water resources. This approach is increasingly recognized as a sustainable practice in water-stressed agricultural zones.

The third cluster, economic return and crop yield modeling (18 papers), integrates hydrological, agronomic, and economic perspectives. This is the largest thematic group, focusing on modeling tools such as Aquacrop, DSSAT, and SWAT to simulate crop yield, water productivity, and financial returns. Studies in this cluster demonstrate that integrating economic optimization into irrigation planning leads to more rational water allocation and higher resource-use efficiency.

The fourth cluster, others, consists of 24 papers covering topics such as water policy, climate adaptation, sustainability frameworks, and institutional governance. This cluster reflects the increasing relevance of interdisciplinary approaches linking hydrology, policy, and socio-economic systems. After 2015, with the adoption of the UN Sustainable Development Goals (SDGs), publications in this area have increased significantly, emphasizing the importance of cross-sectoral cooperation and adaptive water governance.

Overall, the analysis demonstrates a clear transition from small-scale field experiments to broader integrated frameworks combining technology, modeling, and policy perspectives. The diversity of research directions suggests that sustainable water management depends on both innovative irrigation practices and holistic socio-economic strategies. Strengthening data-driven approaches, international collaboration, and long-term monitoring will be essential for achieving future progress in global water resource management.

**Table 2. Thematic Clusters and Key Research Streams in Irrigation Studies**

| Cluster | Dominant Keywords | Number of Articles | Key References (Author, Year) |
|---|---|---|---|
| **Field experiments on partial irrigation** | deficit irrigation; water productivity;drip irrigation; irrigation treatment; deficit irrigation; cotton yield; full irrigation, pomegranate orchard;nitrogen, winter wheat, semi-arid;deficit irrigation; peach trees; nitrogen fertilization; direct-seeded rice; | 8 | Ali & Hoque, 2007<br>Trout & DeJonge, 2017<br>Rao, Tanwar , 2016<br>Parvizi et al., 2014<br>Sepaskhah ;2006;<br>Rufat, Josep, 2016<br>Bonfim-Silva, 2014<br>Deelstra et al., 2018 |
| **Comparing full vs deficit irrigation on cereals or wheat** | deficit irrigation; water-use efficiency; deficit irrigation, cereals; yield; water use efficiency (WUE); sweet corn; green bean; actual crop yield; | 5 | Du, Kang, Sun, 2010<br>Author details missing from available preview<br>Sun et al., 2022<br>Teshome et al., 2023<br>Panda & Inamdar, 2012 |
| **Economic return and crop yield modeling** | economic optimisation model; irrigation water use; water-scarcity; | 19 | Ortega-Álvarez, 2004.<br>Faramarzi, Yang, 2010<br>Ahmadzadeh, 2016 |

| Cluster | Dominant Keywords | Number of Articles | Key References (Author, Year) |
|---|---|---|---|
| | simulation model,basin-scale irrigation multistage irrigation water allocation interval numbers; uncertainty; logistic model; maize yield prediction irrigated arid lands, crop yield, salinity, optimisation model, water allocation; optimization, costs & returns; AquaCrop model; irrigation schedules; full or deficit irrigation; lanning-level irrigation schedules; crop planning, agronomic yield; linear programming; cropping pattern; irrigated crop acreages; stochastic modelling; water-saving irrigation, crop yield; wheat; potato; earth observation; | | Dai & Li, 2013<br>Li et al., 2018<br>Sepaskhah, 2011<br>Kandil et al., 1995<br>Reca, Roldán, 2001<br>Gilley & Supalla, 1989<br>Kale & Lokhande, 2017<br>Mancosu, Spano, 2016<br>(Brumbelow, 2007<br>Fazlali &Shourian, 2018<br>Prasad, Umahesh 2011<br>Asghari ,Shulstad, 1991<br>Ganji & Kaviani, 2013<br>Li & Zhao, 2025<br>Jaafar, Karimi, 2024 |
| **others** | hydrological modelling; water requirement; summer maize; water scarcity, stochastic optimisation, water savings; crop yield; “evapotranspiration”, “crop coefficient value engineering; life-cycle cost; internal processes; hardware; climate change; spatial soil variability; remote sensing; economic indicators; soil water characteristics; fuzzy credibility constraints; regression models; sunshine hours; future climate scenarios; water scarcity; deficit irrigation;canal-command systems, AISSUM; system development; sodic groundwater, safe SAR value; farmland management; groundwater table depth; agricultural drought risk; | 23 | Singh, S, 1999<br>Yang, Gao, Shi, 2013<br>Schütze , 2010<br>Mason, Rufí-Salís,2019<br>Bezerra, da Silva, 2012<br>El-Nashar, 2022<br>Styles & Grismer, 2008<br>Soltani, Khalilian, 2020<br>Fulton et al., 2011<br>Soppe & Perry, 2010<br>Patil & Rajput, 2009<br>Wang C., & Huo Z, 2023<br>Singam,Kamasani, 2013<br>Miranda ,Cooke, 2018<br>Gunacti, 2018<br>Thorsen, 1997<br>Singh, 1995<br>Kaledhonkar et al, 2012<br>Huang, Cheng, 2018<br>Gul et al., 2024<br>Todisco et al., 2009 |

The bibliometric clustering presented above reveals four distinct, interconnected research streams that collectively shape scientific thinking on irrigation management, irrigation strategies, and water use optimization in agriculture. These clusters show the evolution from field-based agronomic experiments to advanced modeling, economic optimization, and climate-adapted water distribution systems, reflecting the pressures on freshwater resources and the need for data-driven planning in irrigated agriculture.

**1. Field experiments on partial and deficit irrigation**

The first cluster studies partial irrigation in field conditions. It is dominated by studies focusing mainly on cotton, wheat, orchards and rice. It introduces key terms such as partial irrigation, water efficiency, drip irrigation, nitrogen fertilization, semi-arid conditions and strong agronomic trends. Empirical experiments show that continuous controlled water reduction, combined with optimized nutrient management or efficient irrigation practices, can maintain acceptable yields. Within this cluster, crop responses to water stress are species-specific, with cotton and pomegranate showing relatively

high tolerance limits. Overall, this body of literature emphasizes physiological responses, soil-water dynamics, and crop-water relationships and provides a solid evidence base for further modeling research.

**2. Comparative evaluation of full irrigation and deficit irrigation in cereal crops.** The second cluster examines the balance between full irrigation and variable deficit irrigation regimes, with a reduced focus on cereal crops, particularly wheat, maize and sweet corn. The dominant keywords are water use efficiency (WUE), yield, actual yield and green bean/sweet corn, and the main focus is on determining the yield per unit of water used. Studies such as Du et al. (2010), Sun et al. (2022) and Teshome et al. (2023) consistently show that moderate deficit irrigation increases WUE without significantly reducing yields, especially in semi-arid regions.

This cluster builds a comparative evidence base supporting flexible irrigation scheduling, arguing that optimal water allocation requires consideration of crop sustainability and resource efficiency.

**3. Economic returns, optimization and productivity modeling**

The third cluster – the largest and most diverse – has significant implications for field-based, model-based, and analytical support systems. Dominant keywords include economic optimization models, simulation frameworks, logistic models, uncertainty-based allocation (interval numbers, stochastic modeling), yield prediction, and irrigation planning.

This body of research (e.g., Ortega-Alvarez, 2004; Faramarzi and Yang, 2010; Ahmadzadeh, 2016; Li et al., 2018; Jaafar and Karimi, 2024) has led to the evaluation of irrigation strategies at the farm, economic, watershed, and integrated levels. The overall conclusion of this cluster is that economic returns and water productivity can be maximized by dynamic, model-based water allocation strategies, especially in times of water scarcity.

This research stream offers robust tools for policy development, cropping pattern optimization, and long-term irrigation planning, demonstrating significant progress toward systematic and sustainable water management systems.

**4. Broader research on hydrology, remote sensing and climate-responsive water management.** A fourth cluster composed of diverse elements. Includes research on hydrological modelling, remote sensing, climate change impacts, channel systems, groundwater dynamics and risk-based tools. The set of keywords - water demand, evapotranspiration, soil spatial variability, AISSUM systems, climate scenarios, salinity, drought risk and value engineering - includes the integration of engineering, earth observation and environmental sciences into irrigation research.

Key works (e.g., Singh, 1999; Mason and Rufi-Salis, 2019; Fulton et al., 2011; Huang and Cheng, 2018; Gul et al., 2024) demonstrate the growing reliance on remotely sensed evapotranspiration and large-scale hydrological analyses. This cluster highlights the importance of technological innovation and system-wide monitoring in addressing future water scarcity, salinity, and climate variability. This cluster broadens the disciplinary scope of irrigation research, linking agronomy, hydrology, and climate modeling.

## 5.LIMATATIONS

The limitation of this study is that the analysis was based only on Scopus-indexed publications from 1989 to 2024. This method was selected to avoid potential formatting challenges that might arise when using data from multiple sources. However, this strategy restricts the study to English-language papers available in Scopus, thereby excluding relevant literature from other databases and in different languages. Future research could address this limitation by incorporating data from a range of databases and considering literature published in multiple languages.

## 6.CONCLUSION

This bibliometric study analyzed 53 Scopus-indexed publications related to water use planning and water management from 1989 to 2024. The results demonstrate that scientific interest in this field has grown significantly since 2005, coinciding with global awareness of water scarcity, climate change, and the need for sustainable resource management. The analysis identified four main thematic clusters that together reflect the evolution and diversification of water management research over the past three decades.

The first cluster, field experiments on partial irrigation, provided practical insights into optimizing limited water supplies under arid conditions. These studies proved that moderate water reduction can sustain acceptable yields while conserving substantial water volumes, making it an essential approach for dryland agriculture. The second cluster, comparing full versus deficit irrigation on cereals and wheat, showed that strategic deficit irrigation can achieve high yield efficiency with reduced water input, supporting sustainable intensification goals in agriculture.

The third and most extensive cluster, economic return and crop yield modeling, integrated biophysical and economic models to optimize water productivity and profitability. These studies highlight the growing importance of simulation tools and decision-support systems for efficient water allocation and sustainable crop management. The fourth cluster, encompassing policy, climate adaptation, and sustainability studies, emphasized governance mechanisms, adaptive management frameworks, and international collaboration as key elements for achieving long-term water security. Overall, the bibliometric results indicate a gradual transition from purely agronomic and technical studies to integrated, multidisciplinary approaches that combine environmental, economic, and policy perspectives. Future research should focus on the development of intelligent irrigation systems, real-time monitoring networks, and cross-sectoral policy frameworks that support climate-resilient water governance. Strengthening international cooperation, sharing open-access data, and expanding long-term field observations will be essential for addressing the global challenges of water management and for supporting sustainable development in both developed and developing regions.

**Acknowledgments**

The authors express their sincere appreciation to the PhD course “Bibliometric Research and Scientific Writing,” organized under the leadership of Dr. Bakhadir Mirzaev, Rector of the Tashkent Institute of Irrigation and Agricultural Mechanization

Engineers, National Research University. Special thanks are extended to Zulfiya Kannazarova for her valuable guidance and supervision throughout the course.

## REFERANCES

1. W. Musie and G. Gonfa, 'Fresh water resource, scarcity, water salinity challenges and possible remedies: A review', *Heliyon*, vol. 9, no. 8, p. e18685, Aug. 2023, doi: 10.1016/j.heliyon.2023.e18685.
2. J. Evaristo *et al.*, 'Water woes: the institutional challenges in achieving SDG 6', *Sustain. Earth Rev.*, vol. 6, no. 1, p. 13, Nov. 2023, doi: 10.1186/s42055-023-00067-2.
3. Y. Liu, F. Li, and Y. Zhao, 'Optimal allocation and application of water resources based on real water saving in a region with intensive human activity', *J. Environ. Manage.*, vol. 373, p. 123848, Jan. 2025, doi: 10.1016/j.jenvman.2024.123848.
4. C. Ceseracciu *et al.*, 'Innovative governance for sustainable management of Mediterranean coastal aquifers: Evidence from Sustain-COAST living labs', *Environ. Sci. Policy*, vol. 167, p. 104038, May 2025, doi: 10.1016/j.envsci.2025.104038.
5. A. Elsaidy, E. A. Yimer, Y. Mogheir, M. Huysmans, L. Villani, and A. Van Griensven, 'Groundwater drought and anthropogenic amplifiers: A review of assessment and response strategies in arid and semi-arid areas', *Sci. Total Environ.*, vol. 978, p. 179406, May 2025, doi: 10.1016/j.scitotenv.2025.179406.
6. B. U. Ngene, C. O. Nwafor, G. O. Bamigboye, A. S. Ogbiye, J. O. Ogundare, and V. E. Akpan, 'Assessment of water resources development and exploitation in Nigeria: A review of integrated water resources management approach', *Heliyon*, vol. 7, no. 1, p. e05955, Jan. 2021, doi: 10.1016/j.heliyon.2021.e05955.
7. A. Durán-Sánchez, J. Álvarez-García, and M. D. L. C. Del Río-Rama, 'Sustainable Water Resources Management: A Bibliometric Overview', *Water*, vol. 10, no. 9, p. 1191, Sept. 2018, doi: 10.3390/w10091191.
8. A. R. Sepaskhah, S. Fahandezh-Saadi, and S. Zand-Parsa, 'Logistic model application for prediction of maize yield under water and nitrogen management', *Agric. Water Manag.*, vol. 99, no. 1, pp. 51–57, 2011, doi: 10.1016/j.agwat.2011.07.019.
9. M. H. Ali, M. R. Hoque, A. A. Hassan, and A. Khair, 'Effects of deficit irrigation on yield, water productivity, and economic returns of wheat', *Agric. Water Manag.*, vol. 92, no. 3, pp. 151–161, 2007, doi: 10.1016/j.agwat.2007.05.010.
10. J. F. Ortega, J. A. De-Juan, J. M. Tarjuelo, and E. López Mata, 'MOPECO: An economic optimization model for irrigation water management', *Irrig. Sci.*, vol. 23, no. 2, pp. 61–75, 2004, doi: 10.1007/s00271-004-0094-x.
11. M. Faramarzi, H. Yang, R. Schulin, and K. C. Abbaspour, 'Modeling wheat yield and crop water productivity in Iran: Implications of agricultural water management for wheat production', *Agric. Water Manag.*, vol. 97, no. 11, pp. 1861–1875, 2010, doi: 10.1016/j.agwat.2010.07.002.
12. A. R. Sepaskhah, A. Azizian, and A. R. Tavakkoli, 'Optimal applied water and nitrogen for winter wheat under variable seasonal rainfall and planning scenarios for

consequent crops in a semi-arid region', *Agric. Water Manag.*, vol. 84, no. 1–2, pp. 113–122, 2006, doi: 10.1016/j.agwat.2006.01.008.

13. K. Brumbelow and A. Georgakakos, 'Consideration of climate variability and change in agricultural water resources planning', *J. Water Resour. Plan. Manag. - ASCE*, vol. 133, no. 3, pp. 275–785, 2007, doi: 10.1061/(ASCE)0733-9496(2007)133:3(275).
14. B. Singh, J. Boivin, G. Kirkpatrick, and B. Hum, 'Automatic irrigation scheduling system (AISSUM): Principles and applications', *J. Irrig. Drain. Eng. - ASCE*, vol. 121, no. 1, pp. 43–56, 1995, doi: 10.1061/(ASCE)0733-9437(1995)121:1(43).
15. K. C. Abbaspour, E. Rouholahnejad, S. Vaghefi, R. Srinivasan, H. Yang, and B. Kløve, 'A continental-scale hydrology and water quality model for Europe: Calibration and uncertainty of a high-resolution large-scale SWAT model', *J. Hydrol.*, vol. 524, pp. 733–752, May 2015, doi: 10.1016/j.jhydrol.2015.03.027.
16. H. Ahmadzadeh, S. Morid, M. Delavar, and R. Srinivasan, 'Using the SWAT model to assess the impacts of changing irrigation from surface to pressurized systems on water productivity and water saving in the Zarrineh Rud catchment', *Agric. Water Manag.*, vol. 175, pp. 15–28, 2016, doi: 10.1016/j.agwat.2015.10.026.
17. M. Song, R. Wang, and X. Zeng, 'Water resources utilization efficiency and influence factors under environmental restrictions', *J. Clean. Prod.*, vol. 184, pp. 611–621, May 2018, doi: 10.1016/j.jclepro.2018.02.259.