Advanced Logistic Systems – Theory and Practice, Vol. 18, No. 2 (2024), pp. 87-96.
https://doi.org/10.32971/als.2024.020

WATER RESOURCES IN COMMONWEALTH OF INDEPENDENT STATES COUNTRIES: A LITERATURE REVIEW

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Abstract: *Research on the assessment of water resources in agricultural regions is a prominent area of study. These resources are vital for many arid and agricultural areas, including those in the Commonwealth of Independent States (CIS). This paper provides a comprehensive review of research trends, analysing scientific production and published articles on water resources in CIS countries from 2000 to 2023. We collected, reviewed, and analysed 163 publications from the Scopus database meeting our selection criteria. The bibliometric analysis revealed publications in English (149) and Russian (15), annual publication counts, document types, top papers, journals, funding sponsors, subject categories, and affiliations by country and institution. We also examined co-authors and keyword co-occurrence to identify knowledge clusters in the literature. The analysis highlighted the need for international research to enhance scientific exchange on this topic. Long-term, continuous research and sustainable development of water resource concepts are essential for future agricultural, water management integration supplemented with parts of water transport. This study may inspire new trends in agricultural development, focusing on irrigation efficiency, water distribution, and climate change within a sustainable circular economy.*

Keywords: *water resources, CIS countries, research trend, literature review, water transport*

1. INTRODUCTION

Water resources should be targeted to specific sites within certain soil zones and delivered timely according to crop requirements [1]. Water is essential for agriculture, energy production, and maintaining healthy ecosystems. Climate change, population growth, and land-use changes influence water availability and quality, making water management crucial for ensuring water security across all sectors [2].

By 2030, 59% of the world's population will live in urban areas, increasing water demand, especially in water-stressed regions like the Middle East and North Africa [3]. Climate change will elevate water and energy consumption across industries, including households [4]. The United Nations predicts the world population will reach 10 billion within the next

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century, with most growth in urban areas, posing a significant challenge for water, energy, and food (WEF) security [5]. Creating effective irrigation systems requires selecting high-performance equipment and technology, considering rational water and energy use, regional adaptation, environmental safety, and soil fertility [6]. Decentralizing water management to community-based associations and investing in innovative technologies can lead to more equitable and efficient water distribution [7]. Improved irrigation water conveyance and application efficiency are essential for better water management [8].

Central Asia's agriculture relies on both rainfed and artificial irrigation systems. Prioritizing water-saving irrigation, agricultural runoff management, optimized crop layouts, organic fertilizers, drought-resistant crops, and agricultural technology training can improve yields [9]. Integrated automated control systems can further enhance irrigation efficiency [10]. Water use payments could reform interstate economic relations [11], and reuse of collector-drainage water for irrigation, after treatment, is crucial [12]. Digital technologies, remote sensing, and GIS can enhance irrigation design and monitoring [13, 14].

Bibliometric analysis identifies cognitive structures and intellectual relationships by examining documents, authors, countries, journals, and institutions [15]. This study aims to provide systematic methods for acquiring transparent bibliographic information and identifying relevant topics for social, economic, and environmental sustainability [16]. It also explores trends in international research on irrigation water and distribution in the Commonwealth of Independent States.

2. LITERATURE REVIEW

In this section, the core part of the research, i.e., the process of literature review is detailed.

2.1. Trend of publications on irrigation water and water distribution in CIS countries

In many arid and agricultural regions, the relationship between irrigation water and water distribution has a wide range of scientific implications. Total of 163 papers published between 2000 and 2023 on irrigation water and water distribution issue in CIS countries.

In this review, the scientific articles consist of two periods of development: introduction (2000–2018) and stable growth (2019–2023).

The introduction period (see Figure 1) includes 47 publications (28.83% of the total), highlighting the initial interest in irrigation water and water distribution in agricultural lands. These studies address the environmental problem-solution relationship, emphasizing the need for improved water management to reduce the gap between water demand and supply, particularly through water saving and conservation in irrigated agriculture [17]. Energy costs account for up to 65% of a water utility's annual budget [18], linking irrigation water issues with electricity (hydropower), and intersecting with security, economics, and politics. Rational water resource distribution is crucial for sustainable water management, especially in Central Asia, which is vulnerable due to irrigation expansion and climate change [1, 19]. Improved water allocation requires better irrigation conveyance, distribution, and application efficiency through best practices, along with market liberalization and infrastructure development [8, 20]. Adjusting inflow rates, cut-off times, and irrigation scheduling is essential [21].

To enhance irrigation management, water distribution must target specific soil zones and align with crop requirements [1, 22]. Developing models for irrigation scheduling and analysing their impact can aid in optimizing management strategies [23, 24]. Early season crop maps can facilitate water saving by modifying allocation plans within irrigation subsystems [22]. Current regional water management issues include inflexible scheduling, low application efficiency, inadequate infrastructure, limited management options, and insufficient data [24]. Additionally, international regulations for equitable transboundary water distribution are needed [3]. Research is also focused on creating reliable impervious screens for irrigation canals using geo-composite materials [25].

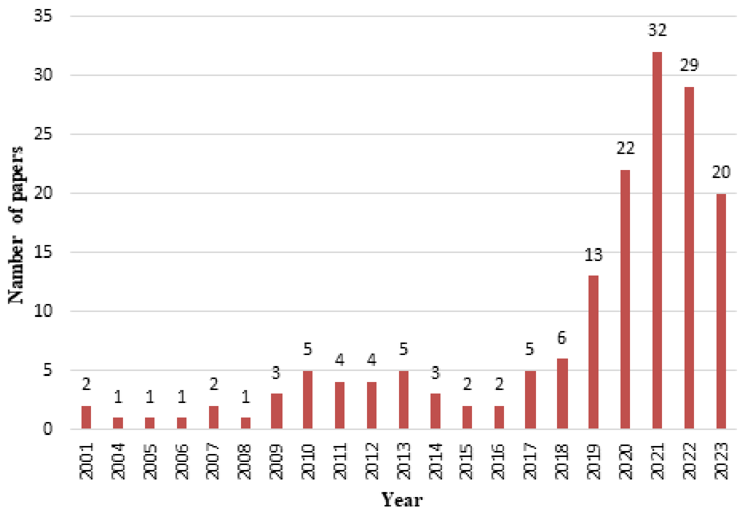

Figure 1. *Annual production of articles on the topic during the period 2000-2023 in CIS countries.*

Stable Growth Period, with 116 documents (71.17% of the total), marks significant scientific interest and growth in this field. In 2021, the highest number of publications (32) was recorded, followed by 2022 (29), indicating continuous growth. Research topics during this period include climate change adaptation in irrigated agriculture [26], optimization of ecologically safe water management under resource shortages [27], evaluation of sprinkler irrigation efficiency [2], development of optimal irrigated land regimes [28], minimizing seepage in irrigation canals [13], and smart systems for water measurement and control in open canals [29].

2.2. Journals on irrigation and water distribution in CIS countries

The review provides an overview of journals and knowledge topics related to this academic field [30]. There was a distribution of the total output across 76 journals published in 39 countries based on the communication patterns of the scholars. Of these, 15 journals published 85 (56.67%) papers, and the remaining 65 (43.33%) papers were published in other journals. There are 58 journals which published a minimum of 1 and higher number of papers during the aforementioned period. Among the 15 journals, "Irrigation and Drainage Systems" had the highest number of publications with 110, followed by "Environment International" with 96 papers, "Agricultural Water Management" with 65 papers, and "Journal of Irrigation and Drainage Engineering" with 61 papers in this field.

2.3. Authors and their affiliated country

Our research found that 160 authors from 39 countries conducted studies on irrigation water and water distribution over the period 2000-2023. 15 authors have published more than 3 papers. Among them, Khitrov, N. B. reigned with 5 publications, followed by Bocharnikov, V. S. with 5, Lamers, J. P. A. with 4, Kozinskaya, O. V. with 4 papers, Denisova, M. A. with 4 papers, Tischbein, B., Martius, C., Maisuradze, M. V., Kravchenko, E. I., Ibrakhimov, M., Gorokhova, I. N., Conrad, C., Chen, X., Bocharnikova, O. V. and Abdullaev, I. each with 3 research papers. Among this list of top authors, seven are from Russia, one from Uzbekistan, one from Germany, one from Kazakhstan, and one from China. Institutions are classified according to the quality of the articles they publish [31]. Over the period of 23 years, 160 different institutions cooperated to publish 331 papers related to irrigation water and water distribution in CIS countries. Our analysis of the top 15 institutes' publications on irrigation water and water distribution allowed us to determine the influential and productive institutions in this field (Figure 2). Of the 15 institutions, Tashkent Institute of Irrigation and Agricultural Mechanization Engineers National Research University is first (27), Russian Academy of Sciences is second (14), Zentrum für Entwicklungsforschung (8) and Siberian Branch, Russian Academy of Sciences is third (8), Urgench State University (6), RUDN University (6), Federal State Educational Institution of Higher Education (6), Dokuchaev Soil Science Institute RAAS (6), Chinese Academy of Sciences (6) is fourth (30), Research Institute of Irrigation and Water Problems (5) and Peter the Great St. Petersburg Polytechnic University is fifth (5).

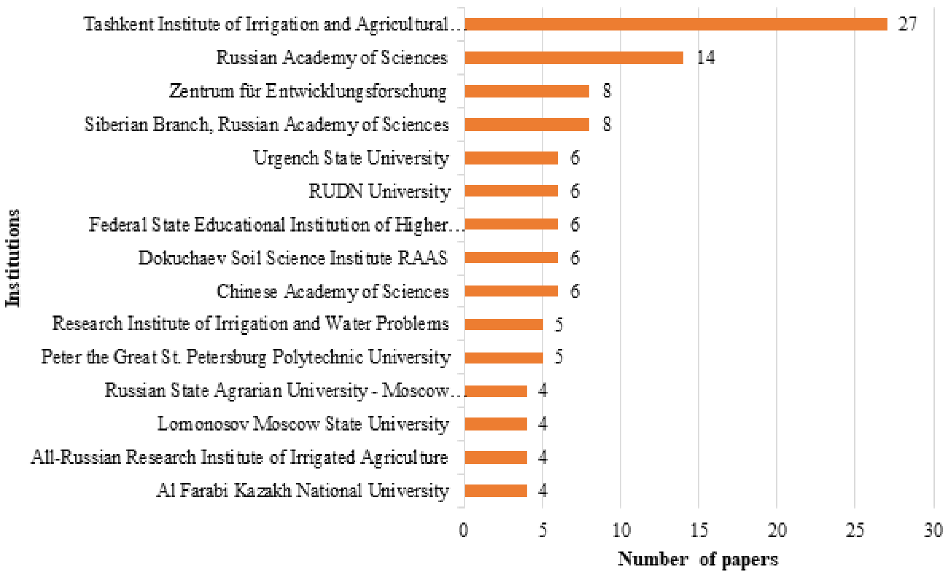

***Figure 2.** List of top institutions in publication activity on irrigation water and water distribution.*

The number of publications from the sixteen most productive countries in the field of irrigation water and water distribution research between 2000 and 2023. Among them, the Russian Federation dominated with 90 publications, followed by Uzbekistan (50), Germany

(15), Kazakhstan (14), China (11), Azerbaijan (7), Japan (5), United States (5), Armenia (4), Pakistan (4), Portugal (4), Tajikistan (4), Israel (3), Belgium (2), Egypt (2), and Iran (2).

Research concerning the fifteen most cited papers available on irrigation water and water distribution in the CIS countries: [7], [8], [10], [17], [19], [20], [21], [22], [24], [32], [33], [34], [35] and [36]. Almost 770 citations were given to the 15 papers. The first 15 top-cited papers consist of one book chapter, ten research articles, and four conference papers. In this list of most cited papers, the introduction (2000–2018) has 14 papers, and the stable growth (2019–2023) has 1 paper.

3. DISCUSSION

The objectives of this study were to analyse the existing knowledge on water resources and identify the most impactful scientific articles and research areas through a systematic review. The scientometric analysis showed that the majority of significant studies on water resources were published in the last five years. Between 2000 and 2023, the annual production of articles in CIS countries experienced two developmental periods: introduction (2000–2018) and stable growth (2019–2023). The introduction period focused on the environmental problem-solution relationship, while the stable growth period saw increased importance of water resources research post-USSR collapse, with strengthened academic output on various topics.

In the CIS countries, the Russian Federation leads in top institutions, authors, countries, and funding sponsors for water resources research, with Russian scientific organizations publishing 90 (40.91%) of the articles. This dominance is due to the presence of numerous prestigious research centres and universities in Russia.

[37] noted that climate change in Central Asia has led to alternating dry and wet years, making agriculture vulnerable. Traditional irrigation methods are ineffective under severe droughts or heavy rains, necessitating adaptation. The Global Water Partnership's 2013 Water, Climate, and Development Programme for Caucasus and Central Asia included a project in Uzbekistan's Fergana Valley to explore agricultural adaptation to climate change.

Rising food demand has driven global agricultural expansion, straining resources [38]. In Armenia's Ararat Valley, growing water demand for irrigation and fish farming, combined with reduced groundwater recharge, increases stress on local resources [39]. Population growth threatens global food security, as seen in Kazakhstan, where water shortage and soil alkalization limit wheat and barley yields [40]. Despite various measures, sustainable water use remains a challenge in Kazakhstan [41].

Irrigation is crucial for food security in Kyrgyzstan, but water resources are underutilized [42]. In South Armenia, water quality issues impact residents due to heavy metal pollution in irrigation water [43]. Unequal irrigation water availability in Central Asia's Khorezm region leads to disparities in agricultural revenues, emphasizing the need for fair distribution considering population density [44].

Climate change necessitates modifying traditional land-use systems, with irrigation as a solution to reduced crop yields from higher temperatures and soil moisture loss [45]. Increasing water demand and climate change pose significant challenges to global water scarcity and agricultural policies [46]. Groundwater use for irrigation is a major issue, with rivers and ponds being critical for crop irrigation in arid regions [47]. Efficient water use is essential in arid regions, where low application efficiency increases water losses and costs [48].

In the Commonwealth of Independent States effective water transport systems are critical for sustaining agriculture, supporting economic activities, and adapting to climate change [2]. However, several challenges hinder the optimization of these systems [17]. Aging infrastructure leads to inefficiencies and significant water losses, necessitating urgent modernization and maintenance [25]. Climate change causes water management issues with altered precipitation patterns and extreme weather events, requiring adaptive measures to ensure consistent water availability [17]. Additionally, fragmented policies and lack of coordination among governmental and non-governmental stakeholders further complicate effective water transport [3].

Emerging trends in addressing these challenges include the adoption of modern technologies such as automated control systems, remote sensing, GIS, and data analytics to enhance efficiency and reliability [22]. There is also a growing focus on sustainability, with practices aimed at minimizing water losses, using renewable energy for pumping, and recycling treated wastewater for irrigation. International research collaborations are increasingly recognized as essential for facilitating knowledge exchange, sharing best practices, and developing innovative solutions to water transport challenges [29].

Solutions for improving water transport in CIS countries involve upgrading canals, pipelines, and other conveyance systems with impermeable materials and automated control gates to reduce seepage and optimize water regulation [42]. Utilizing remote sensing and GIS for real-time monitoring of water flow and identifying inefficiencies, along with automated systems to optimize water distribution, can significantly enhance efficiency [6]. Adopting high-efficiency irrigation methods, such as drip and sprinkler systems, reduces water usage while maintaining crop yields. Developing integrated water management policies that involve all stakeholders, including local communities and international organizations, can improve coordination and effectiveness. Additionally, providing training for farmers and water managers on modern irrigation techniques and efficient water management practices can enhance system adoption and functionality [34].

High-quality water is becoming a strategic resource, requiring significant investment in water-management systems [42]. The interconnectedness of water, energy, food, and the environment highlights the need for integrated, sustainable approaches to manage these resources [38], [49], [50].

Overall, this study aims to maintain water resources in agricultural lands. Analysing 163 publications from 2000 to 2023, the research covers issues like moisture deficiency, salinization, water pollution, land reclamation, and irrigation management in the CIS, especially Central Asia. Of these, 68 publications specifically addressed water resources in Central Asia, indicating a strong focus on the region's challenges with limited water supplies and the need for rational distribution.

4. SUMMARY

This study analysed irrigation water and water distribution research hotspots and potential directions in CIS countries from 2000 to 2023 using bibliometric methods based on the Scopus database. We collected, reviewed, and analysed 163 publications, from this amount the relevant referred ones can be found in the literature part. The analysis revealed that 50.92% of the papers were research articles, followed by conference papers (39.26%), book chapters (7.36%), review papers (2.45%), and retracted papers. The period from 2019 to 2023 showed stable growth, with 71.17% of the total documents published during this time, peaking at 32 publications in 2021, followed by 29 in 2022.

The Russian Federation contributed the most publications, followed by Uzbekistan, Germany, Kazakhstan, China, Azerbaijan, the United States, Japan, Tajikistan, Portugal, Pakistan, Armenia, Israel, Belgium, Egypt, and Iran. Climate change in the CIS countries, exacerbated by global warming, has led to the accelerated melting of glaciers and reduced water supplies. The lack of technical monitoring and rational water distribution threatens future water availability, impacting agriculture, human health, livestock, and causing political and economic difficulties. Inadequate data exchange and lack of international cooperation contribute to these challenges.

The primary audience for this paper includes agricultural producers, policymakers, academic researchers, government agencies, and the public. Addressing these issues can lead to more international collaborative projects and publications, not only in irrigation water and water distribution but also in other related fields. Enhanced international research and scientific exchange, especially between emerging and developed countries and among stakeholders, will benefit the management of irrigation water and water distribution.

ACKNOWLEDGEMENTS

The creative team is grateful to the USAID Central Asia's Regional Water and Vulnerable Environment Activity for technical and financial support in the framework of the Young Scientists Competition.

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