International Journal of Environmental Impacts
Vol. 8, No. 3, June, 2025, pp. 457-465
Journal homepage: http://iieta.org/journals/ijei

Water Demand Management Models in Agriculture: A Literature Review

Juan Francisco Mercado-Arias[1], Fátima Maciel Carrillo-González[2*], Bartolo Cruz Romero[3], Sandra Quijas[4], Rosa María Chávez-Dagostino[1], Luis Martin Dibene-Arriola[1]

[1] Department of Biological Sciences, University Centre of the Coast, University of Guadalajara, Puerto Vallarta 48280, Mexico
[2] Department of Exact Sciences, University Centre of the Coast, University of Guadalajara, Puerto Vallarta 48280, Mexico
[3] Landscape Ecology and Society Laboratory, University Centre of the Coast, University of Guadalajara, Puerto Vallarta 48280, Mexico
[4] Biodiversity and Ecosystem Services Laboratory, University Centre of the Coast, University of Guadalajara, Puerto Vallarta 48280, Mexico

Corresponding Author Email: fatima.carrillo@academicos.udg.mx

https://doi.org/10.18280/ijei.080304

Received: 11 February 2025
Revised: 12 March 2025
Accepted: 26 March 2025
Available online: 30 June 2025

Keywords:
agriculture development, water management, water sustainability, PRISMA

ABSTRACT

This research aims to analyze the evolution of water management models in agriculture and determine whether these models align with Integrated Water Resources Management (IWRM). Using the PICO framework question: How have water management models evolved over time and whether their implementation in the agricultural sector has complied with IWRM principles, comparing Latin America with other regions? Articles in English or Spanish were included, while reviews, book chapters, books, and conference papers were excluded. The search was performed in Web of Science (WOS) and SCOPUS in April 2024, with 68 selected for detailed reviews. The methodology of each study was evaluated to identify key trends in IWRM. Results were synthesized, highlighting the influence of water crises in geographic areas, particularly in countries within the tropics. A trend towards basin-level analysis, like the basic management unit, was observed. Additionally, there was an increase in water models incorporating the three approaches of IWRM by the end of the second decade of the 21st century.

1. INTRODUCTION

Effective water management is essential for achieving sustainability amid rising demand and the challenges posed by climate change [1]. The impacts of climate change are linked to an increase in the frequency and intensity of extreme weather events, such as floods and droughts. Integrated Water Resources Management (IWRM) serves as a key strategy to address this challenge through improved planning and allocation of water resources, particularly during periods of heightened climate variability [2].

Water management is a global concern, as this resource is essential for human survival and economic, social, and environmental activities. Beyond its role in public well-being, water is an element in maintaining ecosystem stability, regulating climate patterns, supporting biodiversity, and sustaining agricultural and industrial production. The growing demand for freshwater, coupled with the increasing impacts of climate change, highlights the urgency of adopting integrated and sustainable management strategies.

In developing countries across continents such as Asia, Africa, and Latin America, particularly in regions facing water scarcity, water management is severely compromised by anthropogenic factors that negatively impact both the quantity and quality of available resources. Industrial and agricultural discharges, linked with rapid population growth and urban expansion, aggravate water pollution and overexploitation. These challenges not only threaten water security but also intensify socio-economic inequalities and environmental degradation [3].

Addressing these issues requires a multifaceted approach that includes community participation, the implementation of strong water policies, and transboundary cooperation. Strengthening regulatory frameworks, investing in infrastructure for water treatment and distribution, and promoting conservation initiatives are essential steps toward ensuring a more equitable and resilient water management system. Without immediate action, the consequences of poor water governance will continue to escalate, further risking global sustainability [4].

In response to these challenges, innovative strategies have been developed to optimize water planning, distribution, and utilization. These management models aim to ensure water security, a concept that encompasses resource availability, equitable access, and adequate quality for various uses. Water security is crucial for reducing community vulnerability to scarcity, promoting sustainable development, and mitigating conflicts arising from unequal distribution.

However, achieving efficient water management remains a complex challenge. Factors such as climate change, population growth, and evolving water demands make resource planning and modeling increasingly difficult. Additionally, each region faces unique conditions that influence water availability, necessitating adaptive approaches and context-specific strategies [5].

The need for actions to improve water management efficiency is evident from data showing that while the global population has tripled over the last century, water consumption has increased six times [6]. The competition for water availability is a growing issue, particularly in regions where water resources are limited, leading to conflicts among various water users [7]. Irrigated agriculture, one of the largest water consumers, is especially vulnerable to poor management and planning [8]. In Latin America, particularly in Mexico, agriculture is estimated to consume up to 76.3% of available freshwater [9]. Thus, agricultural development must be sustainable, balancing soil and water use to maintain environmental system quality without compromising long-term agricultural productivity [10]. IWRM must be grounded in a holistic approach that harmonizes social, environmental, and economic dimensions. This entails designing water management models that prioritize the preservation of water availability for future generations while simultaneously promoting social well-being through equitable access to the resource, protecting associated aquatic and terrestrial ecosystems, and fostering sustainable economic development [11].

Despite growing scientific attention to water assignment, research tends to focus on economic aspects, overlooking environmental and social factors essential for sustainable development [12]. The objective of this study is to analyze scientific production related to water management models and their implementation in the agricultural sector, to determine whether this research has incorporated IWRM approaches to promote more sustainable and efficient water management. This study aims to guide water management model planning for sustainable agricultural development, demonstrating how scientific research has evolved from considering one or two aspects of water management to adopting a holistic perspective aligned with IWRM's triad of approaches which are social equity, economic efficiency and environmental sustainability [13].

2. METHODS

2.1 PRISMA method

The systematic literature review on water management models was based on the following question using the PICOT search strategy, which structures searches effectively and establishes research boundaries [14]: How have water management models evolved over time and whether their implementation in the agricultural sector has complied with IWRM principles, comparing Latin America with other regions? In addition to this central question, three complementary questions were derived: What is the main measurement scale in the evaluation or planning of water management models? What types of models predominate in the development of water management? And which countries conduct the most research on water management? These auxiliary questions helped contextualize and deepen the understanding of different approaches and advances in global water management.

Latin America was selected as the focus of this study because, as in the rest of the world, water resources are essential for regional development. Additionally, the region faces significant challenges in scientific development, particularly in the production and dissemination of high-quality research. Among the main limitations is restricted access to funding, which hinders the ability to conduct comprehensive studies and reduces opportunities for publication in high-impact journals [15].

This situation is further exacerbated by political instability, which influences government support for institutions and affects the availability of funds and resources for research [16]. In this context, understanding how scientific progress develops and its scope in a critical issue such as water management is essential for this study.

The PRISMA method was used to guide the research, ensuring transparency and replicability in each phase [17]. The databases selected for the search were SCOPUS and Web of Science (WOS); these two databases were selected over the others due to their reliability and coverage, as well as their ability to provide a controlled search environment. While Google Scholar offers a broader range of publications, it also contains a significant amount of grey literature and non-peer-reviewed material. In the database selected using the equation and keywords described in Table 1. The choice of these keywords aimed to identify primarily agricultural regions, a sector that belongs to the primary group and is the largest consumer of blue water [18]. The term 'blue water' refers to surface and groundwater stored in aquifers, lakes, reservoirs, and other bodies with water available for use [19]. Additionally, the problem of water scarcity and its counterpart, water security, were considered within the framework of water management models.

Table 1. Database search strategy

SCOPUS	WOS
TITLE-ABS-KEY ("Water manage*" OR "Water use*" OR "Hydrological model*") AND TITLE-ABS-KEY ("Water security" OR "Water scarcity") AND TITLE-ABS-KEY ("land use" OR "land-use" OR "water policy") AND TITLE-ABS-KEY ("Agriculture" OR "Irrigation")	TS = ("Water manage*" OR "Water use*" OR "Hydrological model*") AND TS = ("Water security" OR "Water scarcity") AND TS = ("Land use" OR "Land-use" OR "water policy") AND TS = ("Agriculture" OR "Irrigation")

2.2 Selection process and data synthesis

In identification phase, inclusion and exclusion criteria were defined as the first filter to guide the selection of relevant publications for the study. The inclusion criteria selected only scientific articles that contained at least one search term in the title, abstract, and/or keywords, and were written in English or Spanish. The exclusion criteria ruled out review articles, book chapters, books, conference papers, and articles without full access. Only journal articles were selected due to the quality and rigor with which scientific contributions are reviewed. While conference papers have greater dissemination, they typically have lower rejection rates and focus on newness and research clarity, often undergoing single-blind review [20]. Our primary reason for this selection is to analyze the evolution of management models over time rather than just their innovations.

The literature review focused exclusively on the two most widely used languages in scientific production in Latin

America and internationally, facilitating comparisons with studies from other regions. While Brazil is the country with the highest scientific output in the region, both in this and other fields [21], the lack of proficiency in Portuguese led to the exclusion of articles in this language. This decision aims to minimize potential biases that could compromise the interpretation of key concepts while translating texts.

From the articles obtained in the previous process, in the screening phase the abstract and methodology were reviewed to ensure that the study considered at least one of the three approaches governing integrated water management models, thereby limiting the review to studies relevant to the research (Figure 1). The results were excluded during the screening process because, after reviewing the abstracts of the articles, the application of water management models was not identified. Specifically, we refer to studies that assess water use in an economic sector and include variables associated with the IWRM framework to meet its concept. Consequently, studies focusing solely on the impact of climate variability, land use, and water quality were discarded.

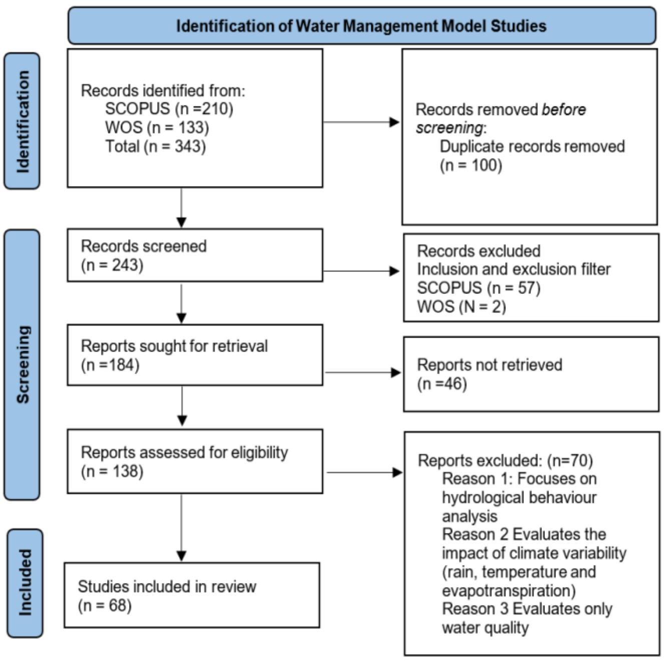

Figure 1. PRISMA 2020 flow diagram, adapted for study [22]

The metadata from the selected publications were compiled in a spreadsheet, including the title and year of publication, each assigned a unique identifier (ID). Relevant data were extracted from the articles, such as the country where the study was conducted, the variables evaluated, the type of model used, the scale of analysis, and the IWRM framework to which the model belongs to (social equity = social; economic efficiency = economic; environmental sustainability = environmental). Additionally, the level of water stress or the index Falkenmark was obtained for each country, based on the data presented by Ruess (2015), which relies on population figures from 2002. This indicator defines the total renewable water resources available per capita in a given region and classifies water availability (D) into the following categories: Extreme Scarcity (D < 1,000 m^3 /capita/year), Critical Scarcity (1,000 ⩽ D < 1,700 m^3 /capita/year), Low Availability (1,700 ⩽ D < 5,000 m^3 /capita/year), Medium Availability (5,000 ⩽ D < 10,000 m^3 /capita/year), and High Availability (D > 10,000 m^3 /capita/year) [23].

Cross-analyses between variables were performed to answer secondary questions, such as identifying the predominant scale of evaluation, the evolution of water management research and its recurring focus in studies and analyzing the link between countries with water issues and their scientific output.

In this systematic review analysis, studies were categorized based on the type of model used. Models classified as "Tools" are those used for the simulation, analysis, or optimization of water supply and demand. Another category, "Water Policy" focuses on developing and implementing policies and regulatory frameworks for water management. Lastly, models classified as "Practice" refer to specific methods applied in targeted locations to enhance the efficiency and sustainability of water supply.

Ultimately, a bibliometric analysis was conducted on keywords related to water management models, with a specific focus on the agricultural sector. For this purpose, a bibliometric network map was used to graphically represent the interconnections among the reviewed studies, thought VOSviewer software [24].

3. RESULTS AND DISCUSSIONS

3.1 Scale of analysis

The 44% of studies used the basin as analysis scale (Figure 2), which is the accepted management unit for the development of water strategies [25, 26]. Watershed delineation is a key mechanism in water governance, as it enables resource management through an approach that considers the specific environmental and social conditions of each territory. This framework helps the participation of various stakeholders in decision-making processes, including local communities, governmental agencies, and civil society organizations. By aligning management strategies with the natural hydrological boundaries, this approach promotes a more integrated and sustainable use of water resources.

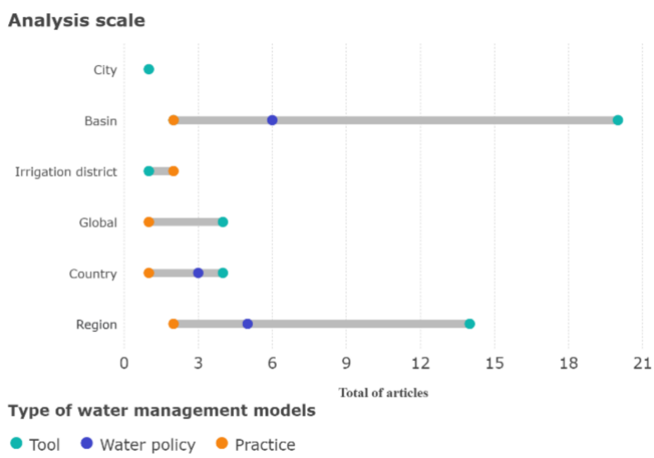

Figure 2. Category of water management models and analysis scale

However, despite its advantages, watershed-based delineation can lead to conflicts when natural boundaries do not align with jurisdictional divisions established by governmental entities. In many cases, administrative and political frameworks are based on criteria that do not necessarily reflect the natural dynamics, resulting in overlapping authorities, discrepancies in resource allocation, and challenges in interinstitutional coordination. These discrepancies can hinder effective water management and create tensions among different governance levels.

To address these challenges, it is essential to develop governance strategies that foster cooperation among jurisdictions and promote integrated management mechanisms. Strengthening coordination between local, national, and international stakeholders can contribute to a more equitable and efficient distribution of water resources, reducing conflicts and enhancing long-term sustainability [27].

The remaining 38 articles are distributed across five different types, such as cities, irrigation districts, worldwide, country, and regional scales. In another analysis, it was found that over 50% use models as Tools, the most frequent category, 28% employ them as practices, and the remaining 21% use them as policies. This result could be associated with the screening process applied in Prisma, where conferences and books were excluded, and gray literature, which often addresses public policy topics in informational resources, was not considered.

3.2 Geographic distribution

The representation of scientific production on water management was cross-referenced with the number of publications per country, and evaluated using the Falkenmark indicator [28], which assesses surface runoff and population data from 2002.

The analysis of 68 publications reveals references to 23 different countries, with 21 studies focusing on nations in Asia (Figure 3). According to the Falkenmark indicator, Indonesia is the only country not classified as water-stressed, while all others face absolute water scarcity. Europe follows in publication count, with 16; however, the Falkenmark indicator shows that most countries in this continent face water scarcity, except for Greece, which is at a low level of water stress. The Americas have a total of 15 publications, with the United States leading with nine publications; 7.3% of the records are from Latin America. Like the United States, the remaining American countries are not under water stress, except for Mexico, which is reported to be in scarcity according to the Falkenmark indicator. Africa and Oceania recorded five and one publications, respectively, with Africa facing scarcity and absolute scarcity across its territory. The remaining 10 publications were excluded as they were global or cross-border studies. A significant trend highlights the relationship between scientific research focused on water management models and the issue of water scarcity, particularly in countries located in tropical and subtropical climatic regions. This correlation suggests that these areas, which are highly exposed to climatic variability and extreme events such as prolonged droughts and severe floods, have become a priority in water management research.

It is important to highlight that a country's economic development directly influences its scientific production. The promotion or limitation of this activity depends on the specific social, economic, and political context. A high GDP is often associated with greater investment in Research and Development (R&D), which supports a more robust scientific output. In Latin America, for example, a lack of focus on teacher training practices linked to research has shown a tendency to reduce scientific productivity [29].

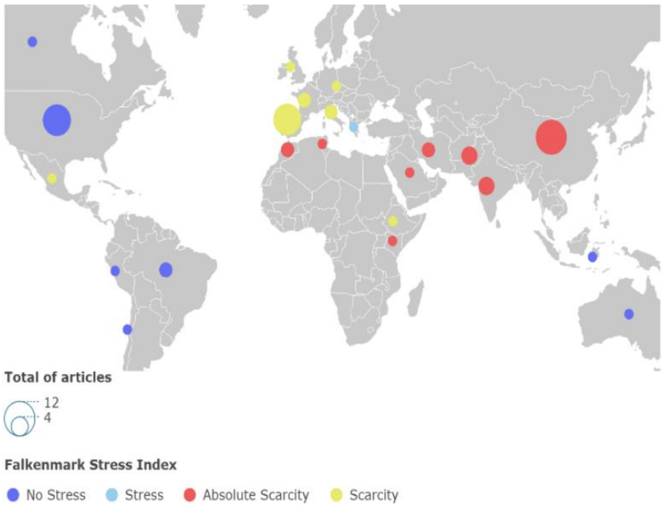

Figure 3. Published articles and their relationship with the water stress index Falkenmark

This difference in resource allocation and educational approaches may explain why countries such as China, the United States, and several European nations have significantly higher scientific production compared to Latin America.

The increasing pressure on water resources in these regions is partly driven by rising demand due to multiple factors, including population growth, urban and agricultural expansion, and industrial development. These drivers have underscored the need to develop models capable of assessing and optimizing water allocation to ensure equitable access and long-term sustainability.

Furthermore, studies in these areas aim to identify innovative solutions that integrate technological, regulatory, and community-based approaches to enhance water resilience, mitigate the adverse effects of climate change, and guide development toward achieving water security.

3.3 Analysis of management models

The evolution of research on the technical and methodological approaches of water management models was analyzed to determine if the three approaches of integrated water management were addressed during the assessment, optimization, and simulation of the equitable distribution process of water resources among different uses. A review of articles published over 21 years (2003-2024) was conducted. The number of publications with an economic-social focus was 26, with this focus dominating during the first 12 years with a total of 9 publications (Figure 4).

After 2015, there is a marked dominance of the economic-social focus, with 23 out of 26 publications analyzed for this study period. This trend may be related to the fact that agriculture, industry, and municipal water provision are the primary stakeholders in blue water utilization, leaving the general population in the tertiary group [18]. Water market models, where a price is assigned to water, are commonly used in several countries worldwide, although results vary, complicating their application [30]. These types of models aim to improve water use efficiency by increasing its price, thereby encouraging users to prefer crops with higher economic value or that require less water [9].

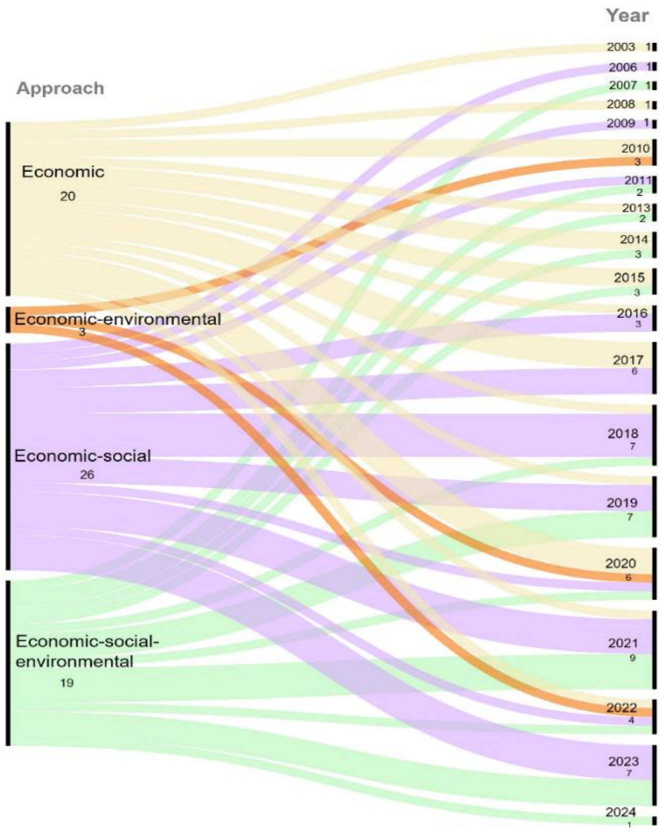

Figure 4. Published articles concerning IWRM approaches
The number below the year corresponds to the number of publications per year

While the economic-environmental link shows limited recurrence, the economic-social-environmental triplet in the last decade shows increased participation, reporting 14 out of 19 records (Figure 4).

Additionally, the concept of water footprint, both green and blue, is a common evaluation parameter across numerous studies. However, its definition shows uncertainty in evaluating water resource allocation models. This is because it refers to the volume withdrawn according to the source for consumption in a socio-economic activity, without concern for balancing the water requirements of the environmental system. Although there are records where a volume planned for the environment, known as environmental flow, is considered, it should represent 80% of the flow to avoid impacting ecosystem structure and function, leaving 20% for socio-economic activities [31, 32]. Additionally, Hatamkhani et al. [12] mention that water allocation models have used economic objectives, but environmental factors are often disregarded or only considered to a limited extent.

3.4 Analysis of associated terms and models

The following is a selection of studies that apply various terms, indices, and indicators to evaluate and plan water management in agriculture.

The analysis identified three main clusters derived from a dataset of 863 keywords, applying a minimum occurrence threshold of six times in distinct articles. As a result, a total of 38 relevant keywords were obtained. Figure 5 illustrates these three major groups, each represented by a different color. The size of each concept indicates its frequency of occurrence within the analysis. "Water management" occupies a central position within the network, strongly associated with analogous terms such as "water use" and "water supply," both linked to critical issues such as land-use change and climate change.

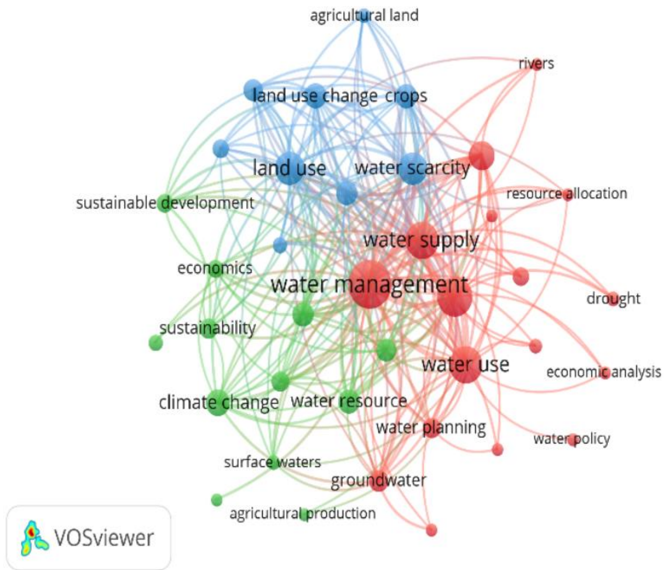

Figure 5. Bibliometric map by keywords

One of the main challenges identified in the literature is climate change adaptation, given that precipitation and temperature variability significantly impact water yield. These fluctuations affect water availability for agriculture, compelling farmers to adopt innovative practices to ensure productivity. However, in certain scenarios, the implementation of new strategies is insufficient to counteract negative effects, leading to increased production costs, higher food prices, and a decline in both quality and availability [33].

The second major issue identified is land-use change, which, driven by various factors, alters the conditions of natural vegetation, thereby affecting water availability. Multiple processes, such as reductions in evapotranspiration and infiltration, contribute to this phenomenon, with increased surface runoff being one of the primary causes. These findings highlight the importance of natural landscape conservation as a key strategy for water resource management. However, ongoing debate persists regarding the role of vegetation with high evapotranspiration in promoting regional precipitation and its subsequent effect on water production within specific watersheds [34].

These approaches encompass different perspectives on IWRM and are implemented through various models. These studies highlight the interactions among different water users, employing specific methodologies that enhance the understanding of their dynamics and needs (Table 2).

Another proposal for future studies after of this review, based on identified gaps, is to use different databases with a larger number of publications in Spanish to gain a better understanding of the situation in Latin America. The current research yielded very few articles from this region, indicating a possible underrepresentation of research conducted in these countries. This approach could enrich the analysis and provide a more comprehensive and contextualized view of water management in Latin America, a region facing significant challenges in this area.

Table 2. Review of indices and their relation to IWRM approach

Index and Indicator	Reference	Model Type	IWRM Approach	Year
Efficiency Indices derived from DEA	[35]	Mathematical	Economic	2010
Water Use per Resource (WUPR or Criticality Index)	[36]	Conceptual	Economic-Environmental	2010
Water Stress Index (WSI)	[37]	Mathematical	Economic-Social	2011
Water Stress	[38]	Conceptual	Economic-Social-Environmental	2011
Agricultural Self-sufficiency Index	[39]	Mathematical	Economic	2013
Groundwater Intensity Index (GI)	[40]	Mathematical	Economic	2015
Irrigation Vulnerability Index	[41]	Computational	Economic	2017
Green Water Scarcity Index and Blue Water Scarcity Index	[42]	Computational	Economic-Social	2017
Water Footprint Sustainability Assessment (WFSA)	[43]	Computational	Economic-Social	2018
Exploitation Index	[44]	Conceptual	Economic-Social-Environmental	2019
Drought Index	[45]	Conceptual	Economic	2020
Water Economic Productivity (EWP)	[46]	Conceptual	Economic	2021
Water Use Efficiency (WUE) and Water Productivity (WP)	[47]	Mathematical	Economic-Social	2021
Water Security Index (WSI)	[48]	Computational	Economic-Social-Environmental	2021
Synthetic Degree, Sustainability Index, and Degree of Approximation to Ideal Target Value (AD)	[49]	Computational	Economic-Social-Environmental	2021
Palmer Drought Severity Index	[50]	Mathematical	Economic-Environmental	2022
Water Security Index	[51]	Mathematical	Economic-Social-Environmental	2022
Blue Water Scarcity	[31]	Conceptual	Economic-Social-Environmental	2023

4. CONCLUSIONS

This systematic literature review on water management models has provided a comprehensive overview of methodologies, revealing the approaches employed in different regions worldwide. The research identified that the watershed is the fundamental unit accepted for water resource management. Scientific development has focused on creating methodologies and tools for assessing water resources and their use in productive activities. However, a crucial question remains: How can IWRM models be effectively applied to address water security challenges and help mitigate water scarcity?

For this reason, it is essential to strengthen collaboration between academia, government, and the private sector. The synergy among these actors should be directed toward implementing clear and effective regulatory measures for water governance, promoting the development of strong policies, establishing monitoring and evaluation mechanisms, generating knowledge, and developing concrete solutions.

The analysis showed that more than 50% of the studies employed tool-based models, followed by water policies and specific practices. Scientific production varied significantly across continents, with Asia leading in the number of publications, although most of these countries face water scarcity according to the Falkenmark indicator. Europe and North America also contributed a substantial number of studies, although with varying degrees of water stress. However, the databases consulted contained relatively few publications from Latin America, highlighting comparisons with other regions worldwide. Consequently, this region was underrepresented, despite facing significant challenges in water management. Despite the significant challenges facing water management, Latin America remains underrepresented in scientific studies on the topic. The region faces multiple water-related problems, mainly linked to pollution, deforestation, and limited technological advances. Water pollution, driven by industrial and agricultural discharges and inadequate treatment of domestic wastewater, affects water quality and quantity, posing risks to both human populations and ecosystems. Furthermore, the loss of natural vegetation, particularly in watersheds, reduces water production by altering the hydrological cycle, decreasing infiltration rates, and increasing surface runoff, which favors erosion and sedimentation in water bodies.

These factors hinder sustainable water resources management, further highlighting the need for increased scientific production and policy-driven strategies tailored to the region’s specific challenges. Scientific production is linked to the availability of optimal conditions, such as funding for infrastructure and education focused on research. These factors, in turn, depend on a country's initiatives and economic conditions, such as its GDP.

A viable approach to strengthening research on water management in Latin America is fostering collaboration between local, national, and international academic institutions. Expanding these partnerships could facilitate access to global expertise and international funding sources, not only enhancing scientific research in the region but also promoting the exchange of knowledge and best practices. This would contribute to a broader understanding of local water-related challenges and support the development of solutions.

In terms of methodological approaches, a significant evolution toward an economic-social focus was observed, especially after 2015. This shift may be related to the increasing importance of industry, municipal water supply and agriculture, the primary stakeholders in blue water resources. However, the concept of water footprint, which represents the total volume of freshwater used to produce goods and services [23], introduces uncertainty in the evaluation of IWRM and supply models. This is because it primarily focuses on human consumption needs without adequately considering the water requirements of environmental systems.

In summary, this review underscores the need for more integrated and specific approaches to water management, addressing both socio-economic and environmental needs.

The evolution of models and including studies in multiple languages and regions, can provide a stronger foundation for decision-making and implementing effective water resource management policies.

ACKNOWLEDGMENT

This research is part of the doctoral thesis of student Juan Francsico Mercado Arias, supported by a national scholarship from the Secretariat of Science, Humanities, Technology and Innovation (Secihti) and PhD in Biosystematics, Ecology, and Management of Natural and Agricultural Resources (BEMARENA).

REFERENCES

[1] Ríos, J.G., Amasifuen, B.P., del Pilar Palomino Alvarado, G., Gonzales, T.V.P. (2023). Water governance: A systematic analysis of challenges, issues and proposals for sustainable water management. Producción + Limpia, 18(2): 116-138. https://doi.org/10.22507/pml.v18n2a7

[2] Wicaksono, A.A., Suprapti, A., Sunarti, S., Ariyanti, V. (2024). Implementing IWRM approaches with climate-change adaptation on riverside slum upgrading, Indonesia. Journal of Water and Climate Change, 15(7): 3056-3073. https://doi.org/10.2166/wcc.2024.676

[3] Hasan, N., Pushpalatha, R., Manivasagam, V.S., Arlikatti, S., Cibin, R. (2023). Global sustainable water management: A systematic qualitative review. Water Resources Management, 37(13): 5255-5272. https://doi.org/10.1007/s11269-023-03604-y

[4] e Costa, M.M., Neto, S. (2023). Exploratory analysis of the water governance frameworks regarding the OECD principles in two river basins in Brazil and Portugal. Utilities Policy, 82: 101556. https://doi.org/10.1016/j.jup.2023.101556

[5] Ahmad, S., Jia, H., Ashraf, A., Yin, D., Chen, Z., Xu, C., Chenyang, W., Jia, Q., Xiaoyue, Z., Israr, M., Ahmed, R. (2023). Water resources and their management in Pakistan: A critical analysis on challenges and implications. Water-Energy Nexus, 6: 137-150. https://doi.org/10.1016/j.wen.2023.10.001

[6] Santos, C.A. (2019). Paradigms of integrated water management(I): An evolutionary critique to integrated water resources management (IWRM). Revista Científica Ecociencia, 6(2): 1-21. https://doi.org/10.21855/ecociencia.62.164

[7] Singh, A. (2014). Irrigation planning and management through optimization modelling. Water Resources Management, 28(1): 1-14. https://doi.org/10.1007/s11269-013-0469-y

[8] Azadi, Y., Yaghoubi, J., Gholamrezai, S., Rahimi-Feyzabad, F. (2024). Farmers' adaptation behavior to water scarcity in Western Iran: Application of the values-identity-personal norms model. Agricultural Water Management, 306: 109210. https://doi.org/10.1016/j.agwat.2024.109210

[9] Rodríguez-Flores, J.M., Medellín-Azuara, J., Valdivia-Alcalá, R., Arana-Coronado, O.A., García-Sánchez, R.C. (2019). Insights from a calibrated optimization model for irrigated agriculture under drought in an irrigation district on the central Mexican high plains. Water, 11(4): 858. https://doi.org/10.3390/w11040858

[10] García-Tejero, I., Durán-Zuazo, V., Muriel-Fernández, J. (2014). Towards sustainable irrigated Mediterranean agriculture: Implications for water conservation in semi-arid environments. Water International, 39(5): 635-648. https://doi.org/10.1080/02508060.2014.931753

[11] Walczykiewicz, T., Bryła, M., Kraj, K. (2024). Expectations and reality of IWRM implementation across 30 years of water management in Poland. Water International, 49(3-4): 358–368. https://doi.org/10.1080/02508060.2024.2321781

[12] Hatamkhani, A., KhazaiePoul, A., Moridi, A. (2022). Sustainable water resource planning at the basin scale with simultaneous goals of agricultural development and wetland conservation. AQUA-Water Infrastructure, Ecosystems and Society, 71(6): 768-781. https://doi.org/10.2166/aqua.2022.025

[13] Aquino, J., Sanchez, P.A., Roa, U.F., Dayo, M.H., Gigantone, C. (2023). Experiences, challenges, and initiatives on water resource management of a small island community: The case of Basco, Batanes, Philippines. SciEnggJ, 16(Supplement): 49-57. https://doi.org/10.54645/202316SupESZ-63

[14] Gallagher Ford, L., Melnyk, B.M. (2019). The underappreciated and misunderstood PICOT question: A critical step in the EBP process. Worldviews on Evidence-Based Nursing, 16(6): 422-423. https://doi.org/10.1111/wvn.12408

[15] Benitez Hurtado, S.R., Tenesaca-Martínez, K., Torres-Diaz, V., Quito, B., Ojeda, C., Ochoa-Moreno, S. (2024). Assessing the influence of GDP, globalization, civil liberties, and foreign direct investment on researchers in R&D per country: Dynamic Panel Cointegration Analysis for Latin American countries. Social Sciences & Humanities Open, 10: 100929. https://doi.org/10.1016/j.ssaho.2024.100929

[16] Galina, C.S., Martínez, J.F., Murphy, B.D. (2023). Constraints on research in biological and agricultural science in developing countries: The example of Latin America. Publications, 11(2): 22. https://doi.org/10.3390/publications11020022

[17] Fuentes, A. (2022). Review of website: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Revista De Estudios E Investigación En Psicología Educación, 9(2): 323-327. https://doi.org/10.17979/reipe.2022.9.2.9368

[18] Zisopoulou, K., Panagoulia, D. (2021). An in-depth analysis of physical blue and green water scarcity in agriculture in terms of causes and events and perceived amenability to economic interpretation. Water, 13(12): 1693. https://doi.org/10.3390/w13121693

[19] Falkenmark, M., Rockström, J. (2006). The new blue and green water paradigm: Breaking new ground for water resources planning and management. Journal of Water Resources Planning and Management, 132(3): 129-132. https://doi.org/10.1061/(ASCE)0733-9496(2006)132:3(129)

[20] Zhang, Y., Yu, F.Y., Schoenebeck, G., Kempe, D. (2022). A system-level analysis of conference peer review. In the 23rd ACM Conference on Economics and Computation, Boulder, Colorado, USA, pp. 1041-1080. https://doi.org/10.1145/3490486.3538235

[21] Pedraja-Rejas, L., Rodríguez-Ponce, E., Muñoz-Fritis, C., Laroze, D. (2023). Sustainable Development Goals and

education: A bibliometric review—The case of Latin America. Sustainability, 15(12): 9833. https://doi.org/10.3390/su15129833

[22] Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., et al. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. Systematic Reviews, 10(1): 89. https://doi.org/10.1186/s13643-021-01626-4

[23] Nkiaka, E., Bryant, R.G., Kom, Z. (2024). Understanding links between water scarcity and violent conflicts in the Sahel and Lake Chad Basin using the water footprint concept. Earth's Future, 12(2): e2023EF004013. https://doi.org/10.1029/2023EF004013

[24] van Eck, N.J., Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics, 84(2): 523-538. https://doi.org/10.1007/s11192-009-0146-3

[25] Simons, G., Bastiaanssen, W., Immerzeel, W. (2015). Water reuse in river basins with multiple users: A literature review. Journal of Hydrology, 522: 558-571. https://doi.org/10.1016/j.jhydrol.2015.01.016

[26] Muratoglu, A., Iraz, E., Ercin, E. (2022). Water resources management of large hydrological basins in semi-arid regions: Spatial and temporal variability of water footprint of the Upper Euphrates River basin. Science of The Total Environment, 846: 157396. https://doi.org/10.1016/j.scitotenv.2022.157396

[27] López Báez, W. (2014). Watershed management analysis as a tool for sustainable use of natural resources. Revista Chapingo Serie Zonas Áridas, 13(2): 39-46. https://www.redalyc.org/articulo.oa?id=455545055001.

[28] Ruess, P. (2015). Mapping of water stress indicators. CE 394K Term Paper, 1-17.

[29] Henao, C., Gutiérrez, J.P.L. (2023). Impact of the economic, political and social environment on per capita scientific production: A comparison of Asia-Pacific and Latin America and the Caribbean. Salud, Ciencia y Tecnología - Serie de Conferencias, 2: 385. https://doi.org/10.56294/sctconf2023385

[30] Palomo-Hierro, S., Gómez-Limón, J.A., Riesgo, L. (2015). Water markets in Spain: Performance and challenges. Water, 7(2): 652-678. https://doi.org/10.3390/w7020652

[31] Galli, N., Chiarelli, D., Ricciardi, L., Rulli, M. (2023). A Blue water scarcity-based method for hydrologically sustainable agricultural expansion design. Water Resources Research, 59(10): e2023WR034473. https://doi.org/10.1029/2023WR034473

[32] Hoekstra, A.Y. (2014). Sustainable, efficient, and equitable water use: The three pillars under wise freshwater allocation. WIREs Water, 1(1): 31-40. https://doi.org/10.1002/wat2.1000

[33] Robledo-Buitrago, D.A., Bayona-Penagos, L.V. (2023). Perception of climate change and adaptation strategies in agro-food systems of Facatativá, Cundinamarca. Luna Azul, 57: 88-99. https://doi.org/10.17151/luaz.2023.57.6

[34] Gao, F., Luo, Y., Zhao, C. (2023). Effects of climate and land-use change on the supply and demand relationship of water provision services in the Yellow River Basin. Land, 12(12): 2089. https://doi.org/10.3390/land12122089

[35] Rodríguez-Ferrero, N., Salas-Velasco, M., Sanchez-Martínez, M.T. (2010). Assessment of productive efficiency in irrigated areas of Andalusia. International Journal Water Resources Development, 26(3): 365-379. https://doi.org/10.1080/07900627.2010.489288

[36] Canals, L., Chapagain, A., Orr, S., Chenoweth, J., Anton, A., Clift, R. (2010). Assessing freshwater use impacts in LCA, part 2: Case study of broccoli production in the UK and Spain. The International Journal of Life Cycle Assessment, 15(6): 598-607. https://doi.org/10.1007/s11367-010-0187-0

[37] Pfister, S., Bayer, P., Koehler, A., Hellweg, S. (2011). Environmental impacts of water use in global crop production: Hotspots and trade-offs with land use. Environmental Science & Technology, 45(13): 5761-5768. https://doi.org/10.1021/es1041755

[38] Davies, E.G.R., Simonovic, S.P. (2011). Global water resources modeling with an integrated model of the social-economic-environmental system. Advances in Water Resources, 34(6): 684-700. https://doi.org/10.1016/j.advwatres.2011.02.010

[39] Schmitz, C., Lotze-Campen, H., Gerten, D., Dietrich, J.P., Bodirsky, B., Biewald, A., Popp, A. (2013). Blue water scarcity and the economic impacts of future agricultural trade and demand. Water Resources Research, 49(6): 3601-3617. https://doi.org/10.1002/wrcr.20188

[40] Wang, X., Li, X., Fischer, G., Sun, L., Tan, M., Xin, L., Liang, Z. (2015). Impact of the changing area sown to winter wheat on crop water footprint in the North China Plain. Ecological Indicators, 57: 100-109. https://doi.org/10.1016/j.ecolind.2015.04.023

[41] Liu, J., Hertel, T., Lammers, R., Prusevich, A., Baldos, U., Grogan, D., Frolking, S. (2017). Achieving sustainable irrigation water withdrawals: Global impacts on food security and land use. Environmental Research Letters, 12(10): 104009. https://doi.org/10.1088/1748-9326/aa88db

[42] Salmoral, G., Willaarts, B.A., Garrido, A., Guse, B. (2017). Fostering integrated land and water management approaches: Evaluating the water footprint of a Mediterranean basin under different agricultural land use scenarios. Land Use Policy, 61: 24-39. https://doi.org/10.1016/j.landusepol.2016.09.027

[43] Lathuillière, M.J., Coe, M.T., Castanho, A., Graesser, J., Johnson, M.S. (2018). Evaluating water use for agricultural intensification in Southern Amazonia using the Water Footprint Sustainability Assessment. Water, 10(4): 349. https://doi.org/10.3390/w10040349

[44] Jodar-Abellan, A., Fernández-Aracil, P., Melgarejo-Moreno, J. (2019). Assessing water shortage through a balance model among transfers, groundwater, desalination, wastewater reuse, and water demands (SE Spain). Water, 11(5): 1009. https://doi.org/10.3390/w11051009

[45] Paul, M., Negahban-Azar, M., Shirmohammadi, A., Montas, H. (2020). Assessment of agricultural land suitability for irrigation with reclaimed water using geospatial multi-criteria decision analysis. Agricultural Water Management, 231: 105987. https://doi.org/10.1016/j.agwat.2019.105987

[46] Amarasinghe, U., Sikka, A., Mandave, V., Panda, R., Gorantiwar, S., Chandrasekharan, K., Ambast, S. (2021). A re-look at canal irrigation system performance: A pilot study of the Sina irrigation system in Maharashtra, India. Water Policy, 23(1): 114-129. https://doi.org/10.2166/wp.2020.291

[47] Zhou, Q., Zhang, Y., Wu, F. (2021). Evaluation of the most proper management scale on water use efficiency and water productivity: A case study of the Heihe River Basin, China. Agricultural Water Management, 246: 106671. https://doi.org/10.1016/j.agwat.2020.106671

[48] Zhang, C., Li, J., Zhou, Z., Sun, Y. (2021). Application of ecosystem service flows model in water security assessment: A case study in Weihe River Basin, China. Ecological Indicators, 120: 106974. https://doi.org/10.1016/j.ecolind.2020.106974

[49] Zhang, F., Cai, Y., Tan, Q., Wang, X. (2021). Spatial water footprint optimization of crop planting: A fuzzy multiobjective optimal approach based on MOD16 evapotranspiration products. Agricultural Water Management, 256: 107096. https://doi.org/10.1016/j.agwat.2021.107096

[50] Deepa, R., Anandhi, A., Bailey, N., Grace, J., Betiku, O., Muchovej, J. (2022). Potential environmental impacts of peanut using Water Footprint Assessment: A case study in Georgia. Agronomy, 12(4): 930. https://doi.org/10.3390/agronomy12040930

[51] Arefinia, A., Bozorg-Haddad, O., Ahmadaali, K., Zolghadr-Asli, B., Loáiciga, H. (2022). Cropping patterns based on virtual water content considering water and food security under climate change conditions. Natural Hazards, 114(2): 1709-1721. https://doi.org/10.1007/s11069-022-05443-3