

Article

Water Security Under Climate Change: Challenges and Solutions Across 43 Countries

Maridelly Amparo-Salcedo ¹, Ana Pérez-Gimeno ² and Jose Navarro-Pedreño ^{2,*}

¹ Faculty of Science, School of Biology, Autonomous University of Santo Domingo, Santo Domingo 10105, Dominican Republic; mamparosalcedo@gmail.com

² Department of Agrochemistry and Environment, University Miguel Hernández of Elche, Avda. de la Universidad, s/n, 03202 Elche, Alicante, Spain; aperez@umh.es

* Correspondence: jonavar@umh.es

Abstract: Different countries face significant challenges in managing water-related natural hazards, such as floods and shortages, while ensuring adequate water quality and quantity to satisfy human needs and preserve ecosystems. Climate change projections exacerbate this situation by intensifying the hydrological cycle, resulting in substantial changes in precipitation patterns, evapotranspiration, and groundwater storage. This study reviews water security challenges across 43 countries, drawing on 128 articles obtained from databases including EBSCOHOST, Scopus and ResearchGate, as well as specific journals. Key search terms included “water security”, “water security and climate change”, “water scarcity”, “water risk index”, “water balance”, “water assessment”, and “land use and land cover change”. The analysis reveals the main water security issues present in 43 countries (flash floods, drought and water quality), and the response measures identified these challenges to water security. All the countries studied face one or more critical water-related effects. Afghanistan, Bangladesh, India, and Mexico were identified as the most severely affected, dealing with a combination of water scarcity, flooding, and water pollution. The most suggested strategies for improving water security include sustainable urban planning, improving consumption efficiency, strategic land-use planning, applying technologies to predict availability of water resources and planning according to variations in resource availability over time. In addition, other general actions include enhancing water storage infrastructure, improving consumption efficiency and adopting sustainable urban planning.



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Keywords: water security; water scarcity; floods; shortages; climate change; water strategies

1. Introduction

Water resources are an essential strategic asset for sustainable development and a determinant of human life and socioeconomic progress. Water resource security is seriously threatened in many areas due to the limited supply, unequal distribution, and declining environmental quality of water resources, which have become major barriers to human sustainable development and societal advancement [1]. A growing number of places are facing water security problems, including droughts, flood disasters, and water environmental degradation, because of population development, economic expansion, and climate change [2]. Considering the growth of the population and the increasing water demand over the last century, achieving water security—having enough water to provide constant and reliable food, energy, health, and livelihoods—is becoming more and more difficult [3].

Water security includes the quantity, quality, and availability of water required to satisfy human needs, support development, protect ecosystems, and manage extreme water-related events such as floods [4]. It is influenced by both human and natural factors, including land use, economic development, and management strategies [5]. As a critical component of sustainable development, water security directly affects human health, livelihoods, and the stability of social, economic, and ecological systems [6].

Some of the main ways in which water insecurity manifests are drought and/or water scarcity, water pollution, and floods. Risks associated with water security vary significantly depending on geographic context, even within the same watershed [7]. For instance, in China's West River basin, the upper region faces a high risk of extreme droughts, while the lower region is primarily threatened by floods caused by heavy rainfall. These floods damage crops, agricultural infrastructure, and critical systems such as roads, housing, and sanitation networks, exacerbating economic and food security challenges in the area [8]. In contrast, in countries like Brazil, while the Jaguari basin currently experiences a low risk of water scarcity, projections indicate a significant increase in risk due to declining rainfall in the future [9].

Understanding the impact of climate change on water security is essential to address water-related vulnerabilities [9,10] and effectively plan for future changes [10], especially in the face of the increasing frequency and intensity of extreme weather events [11].

Water security has been widely studied in recent years, but no article has been found that consolidates the current state of this issue based on scientific publications from different countries on a global scale. This information gap could be crucial in recognizing the importance and magnitude of the challenges we face regarding current and future water security. This review identifies the main water security issues and suggests strategies to face them in the 43 countries under climate change. The information compiled in this article can serve as a starting point for further exploration of temporal variations in knowledge on this topic, providing a baseline for future research, in order to identify emerging challenges and develop more effective strategies for addressing water security concerns.

2. Materials and Methods

A preliminary bibliographic search was conducted using multiple databases, and articles were collected from EBSCOHOST, ResearchGate and Scopus, using keywords such as "water security" "water security and climate change" "water scarcity", "water risk index", "water balance", "water assessment", "water evaluation and planning" and "land use and land cover change" (combine or separately).

As illustrated in Figure 1, the distribution of studies across countries was uneven, influenced by the selection criteria: (i) open-access scientific publications and available research for academic institutional use; (ii) provide clear information on the researched topic; (iii) published in the period 2014–2024 as focusing on the last decade allows for a more detailed and relevant analysis of the most recent effects of climate change; (iv) studies with a territorial approach, either by political demarcation, river basin, or at the country level. Two key factors were considered for selecting the study period: the impact of climate change on the study of the issue and the influence of climate variability on changes in the problem within a given territory.

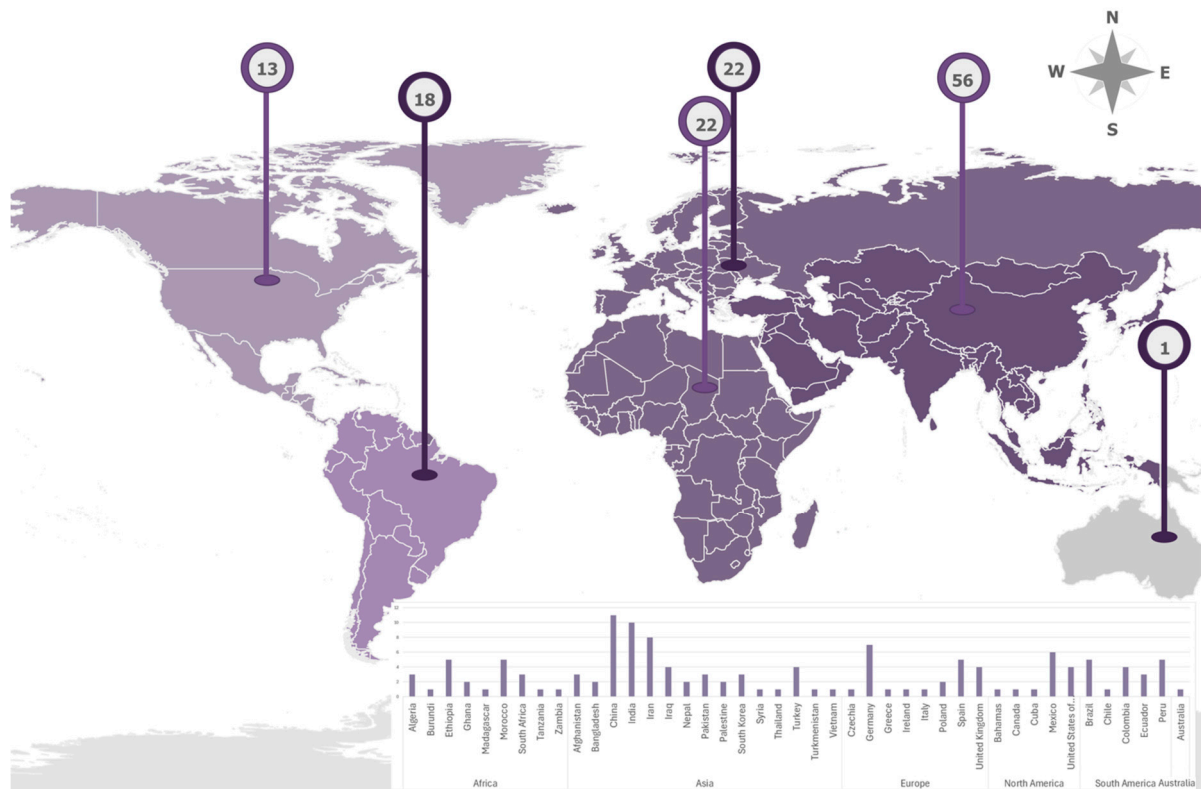


Figure 1. Geographic distribution of number of articles published in each continent.

1. Climate change is one of the main catalyzers compromising water security. In this regard, the changes observed over the last decade, including rising temperatures and alterations throughout the hydrological cycle, have intensified the study of water-related issues such as scarcity, floods, and pollution.
2. Due to climate variability, spatial and temporal changes in water security issues can occur rapidly, making previously gathered information obsolete in a short period. This can be due to the implementation of solutions to address the problem or because the situation has worsened.

The articles received a preliminary classification to identify those that focused on the effects of climate change in each country so, 132 articles were selected from the 150 reviewed initially. To ensure better data homogeneity, the inclusion was limited to a maximum of eleven articles per country. These exclusion criteria were implemented to ensure a balanced representation of water security issues across diverse geographical regions. This approach aimed to avoid an overrepresentation of countries with a higher number of accessible publications while still capturing relevant and diverse perspectives.

The following main criteria guided the article selection process:

1. Territorial Specificity: Only articles that address water security issues within defined national or watershed boundaries were included.
2. Data Homogeneity: To prevent bias from regions with extensive publication records, a maximum of eleven articles per country was established. This ensured a more equitable geographical representation.
3. Currency and Relevance: When more than eleven relevant articles were identified per country, priority was given to the most recent publications and those articles covering different watersheds to provide a more comprehensive understanding of the water security challenges.

This methodology allowed for a broad yet balanced global analysis while maintaining data consistency and relevance.

The water security issues identified in each country were classified into water scarcity, flooding, and water quality attending to direct mentions that highlight the problem and its current and future trends. The water security challenges identified for the 43 countries analyzed in the present study are shown on a map (Figure 2), created using the QGIS tool, with an accessible shapefile of the global country distribution. The recommended measures from different studies were categorized, separating those from articles with a global perspective and those addressing the effects of climate change. These measures were organized into 3 and 5 thematic axes, respectively, highlighting those with the greatest convergence.

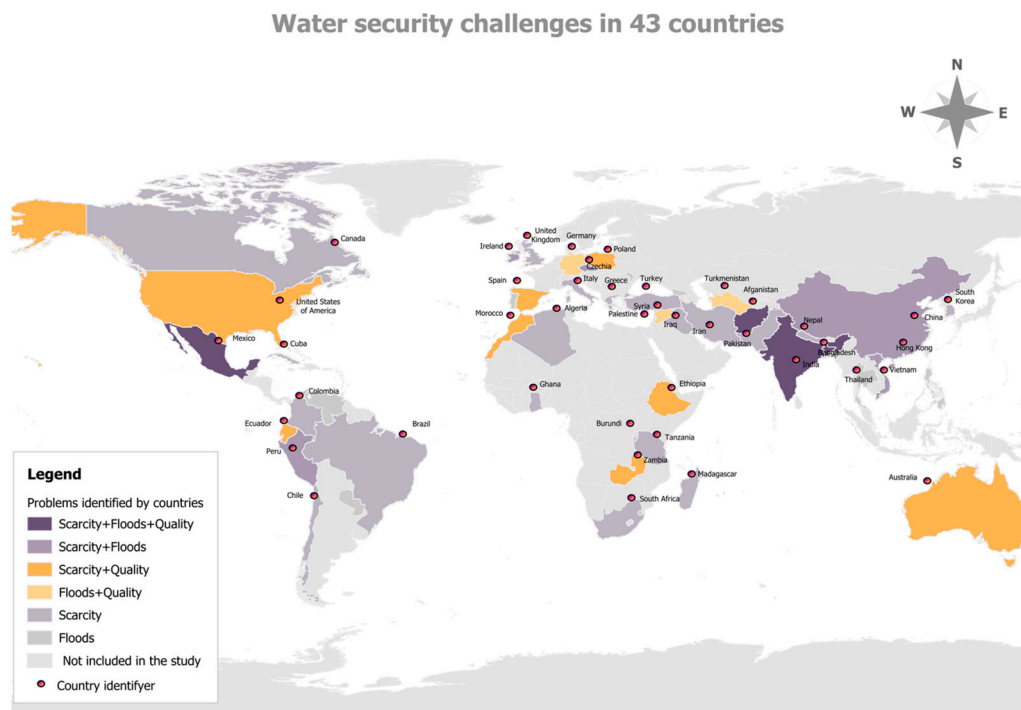


Figure 2. Water security challenges in 43 studied countries.

3. Results and Discussion

3.1. Water Security and Climate Change

The global use of water resources has risen significantly due to rapid population growth, industrial development, and agricultural expansion. Concurrently, climate change variability poses a substantial challenge to water security by intensifying the hydrological cycle [11,12]. Projections of climate change scenarios indicate significant alterations in precipitation and evapotranspiration patterns [13] across many regions worldwide [14]. These changes exacerbate variability in water availability [9,15] by increasing the frequency and severity of droughts and periods of water surplus [16,17].

Precipitation levels directly affect production, human livelihoods, and water service performance. Excessive precipitation can lead to flood disasters, while insufficient rainfall can result in water resource shortages [18]. Increased rainfall intensity reduces soil water retention, storage, water yield, and baseflow in upper watershed areas, exacerbating water scarcity. Intensified rainfall patterns associated with climate change heighten the vulnerability of water systems, compromising water availability during dry seasons and increasing flood risks during wet seasons [8].

Rising temperatures have also led to higher rates of evapotranspiration, further affecting water availability [19]. Climate change is expected to cause significant reductions

in runoff in regions such as Southern Europe, the Middle East, and Southern Africa, presenting severe challenges for water security [20]. As climate patterns become increasingly unpredictable, water supply and quality are rendered more fragile [21]. Additionally, rising global temperatures accelerate glacier melting. While this initially increases water availability in certain regions, the long-term effect is a reduction in glacier mass, posing a severe threat to future water supply [12]. This phenomenon also heightens the risk of seasonal flooding, food security and water sustainability [17].

3.2. Challenges in Water Security by Regions and Countries

The challenges were classified according to the three principal issues identified in the research papers and their combinations: floods (3); water scarcity (21); quality (not found as an isolated impact); flood and quality (3); scarcity and quality (8); scarcity and floods (5); scarcity, floods and quality (4). The primary water security challenge identified was water scarcity, reported in 38 of the 43 countries analyzed (88%), either as an isolated problem or in conjunction with other challenges. Water quality and flood issues followed as the second and third most prevalent concerns, each affecting 15 countries. Afghanistan, Bangladesh, India, and Mexico faced the most severe water security challenges, grappling with a combination of flooding during intense rainy seasons, water scarcity during dry periods, and widespread water quality issues, as summarized in Figure 2. Additionally, other countries that were not included in this research as Uzbekistan, Tajikistan, Myanmar, Guatemala and Belize, should prioritize water security due to their proximity with the regions, experiencing a severe water security risk.

The distribution of countries across the six classifications is as follows:

- Scarcity + Floods + Quality: Afghanistan [15,16,22]; Bangladesh [17,23]; India [24–32]; Mexico [33–38].
- Scarcity + Floods: Czechia [39]; China [1,2,5,12,40–45]; Ireland [46]; Peru [47–51]; Vietnam [52].
- Scarcity + Quality: Australia [53]; Ecuador [13,54,55]; Ethiopia [21,56–59]; Morocco [35,60–63]; Poland [64,65]; Spain [66–70]; United States of America [71–74]; Zambia [75].
- Floods + Quality: Germany [4]; Syria [76]; Turkmenistan [77].
- Scarcity: Algeria [78,79]; Bahamas [10]; Brazil [9,80–83]; Canada [84]; Chile [85]; Colombia [86–88]; Cuba [89]; Ghana [90,91]; Greece [14]; Iran [92–97]; Iraq [98–101]; Italy [102]; Madagascar [103]; Nepal [21,104]; Pakistan [105–107]; Palestine [108,109]; South Africa [110–112]; South Korea [113–115]; Tanzania [116]; Turkey [11,117,118]; United Kingdom [119].
- Floods: Burundi [120]; China [121]; Thailand [122].

The detailed supporting descriptions for this classification can be found in Table A1 in Appendix A: Description of water problems by country.

3.3. Response Measures to Guarantee Water Security

The most prioritized strategies to address water security were grouped into two branches: general responses to guarantee water security and strategies to address climate change effects with three and five subclassifications, respectively. As shown in Figure 3, the most mentioned strategies to face climate change effects were sustainable urban planning, improving consumption efficiency, strategic land-use planning, and applying technologies to predict availability and planning based on temporal resource variations, as suggested in 25, 23, 14, 8 and 6 references, respectively. The overall prioritized adaptation strategies focused on developing disaster resilience infrastructure, creating storage facilities and improving groundwater use, as recommended in five and four articles, respectively.

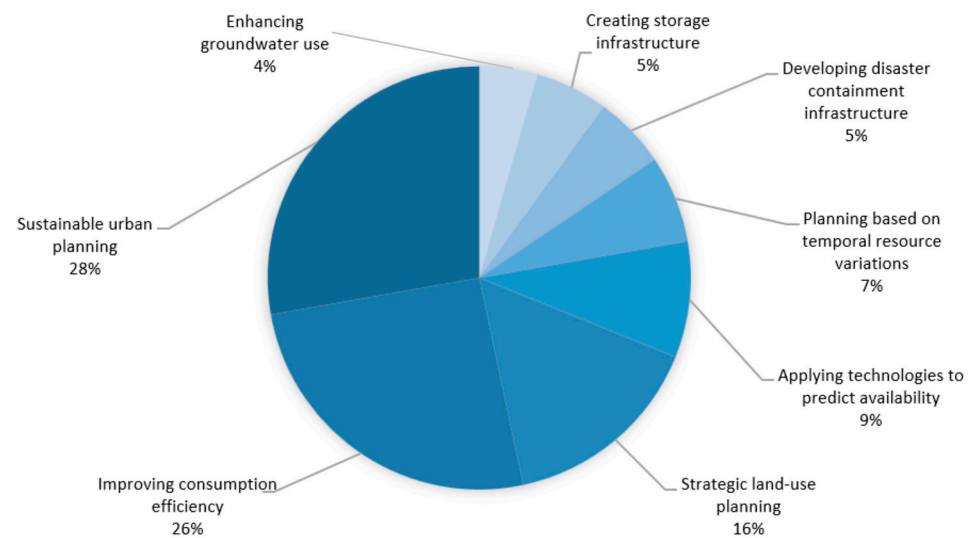


Figure 3. Principle measures to guarantee water security.

Table 1 shows the classification of the proposed measures in the reviewed articles and the water security issues they address. Of the eight classifications used, five measures target water scarcity issues, one addresses floods, one focuses on both water scarcity and quality, and one tackles all three issues together.

Table 1. Description and water security issues addressed by the principle measures identified.

Principle Measures	Description	Water Security Issues Addressed
Sustainable urban planning	Participatory planning based on human needs, environmental impacts, and governmental visions, including the coordinated use of surface and groundwater.	flash floods water scarcity and quality
Improving consumption efficiency	Water management based on supply: allocation and use of water in key sectors, adapting to the specific needs of each productive sector and implementing efficiency improvements in consumption.	water scarcity
Strategic land-use planning	Water resource planning based on the specific characteristics of each sub-basin (soil type, coverage, and agricultural practices), ensuring a balanced use of resources.	water scarcity; quality
Applying technologies to predict availability	The integration of technologies such as remote monitoring, geographic information systems (GIS), and predictive models in water management and planning.	water scarcity
Planning based on temporal resource variations	Plan the use and distribution of water resources according to the spatiotemporal patterns of precipitation changes and hydrological responses.	water scarcity
Developing disaster resilience infrastructure	Water retention infrastructure to address disasters such as floods, reducing the impact on communities and water resources.	flash floods
Creating storage facilities	Planning and construction of water storage facilities, such as reservoirs and dams, to promote aquifer recharge and increase water availability during dry periods.	water scarcity
Improving groundwater use	Combine use of Surface runoff and groundwater to maintain ecological flows in river sections that would otherwise be overexploited.	water scarcity

3.3.1. Sustainable Urban Planning

The planning of water resources requires a multidisciplinary strategy that addresses the system's complexities through robust water governance [6,84,98,108,123]. It is essential to develop adaptive water management policies that prioritize both human consumption and environmental water needs, particularly in the context of climate change [20], using an integrated water resources management approach [28,77,103,124]. Future planning must consider human needs, environmental impacts, and governmental visions [15]. To achieve this, the coordinated use of surface and groundwater is vital [92] and participatory land use planning [86].

Integrated management should include public policies and regulations, such as trans-boundary water management, regional cooperation among different government levels, and active involvement from local communities [5,7,21,23,125], prioritizing long-term sustainability [56,76]. This management model, especially during periods of scarcity, enables the prioritization of human water supply over other uses, ensuring access to water for basic needs, a cornerstone of water security [9,83] and especially guarantee minimum abstraction thresholds with our neighboring countries [91].

Creating a collaborative, open, and mutually advantageous water resource community offers a feasible solution to the global water crisis. Employing a benefit distribution mechanism based on cooperative game theory can enhance the sharing of water resources among stakeholders in a basin [126].

Adaptive management needs to consider both climate and human risks. This includes continuous monitoring of freshwater aquifers, regulation of water extraction and land use, and preparation for extreme events like hurricanes and storm surges [10,17,81].

3.3.2. Improving Consumption Efficiency

The expected growth in population and the ongoing agricultural demand highlight the critical requirement for efficient water use strategies in these areas. Among the main strategies proposed in the reviewed articles, the following stand out:

- Adapt water distribution policies to address future demands, guaranteeing adequate water supply for both human consumption and agricultural production, which are essential for food security and economic development [15].
- Introducing improvements in water use efficiency is essential to reduce the vulnerability of communities severely affected by extreme weather events [118,127]. Implementing adjustments in the allocation and use of water across key sectors, such as agriculture and urban consumption, promotes more efficient resource management. This approach helps mitigate the impact of supply shortages [11] and encourages the adoption of measures aimed at ensuring the long-term sustainability of available resources [16], tailored to the specific needs of each productive sector, including agriculture [104,116]. Agricultural water demand can be reduced by applying new irrigation technologies to minimize water losses [101]. The complementarity between rain and irrigation can be a strategy to optimize water use in agriculture [57].
- Transitioning water management from a demand-driven to a supply-driven approach is essential in regions facing water scarcity. Effective water resource management must align with the actual availability of water [128]. Optimizing water use based on both needs and availability is crucial for ensuring long-term water security, particularly during periods of reduced supply [89].
- Implement water-saving policies [40] and promote sustainable agricultural practices, such as planned irrigation and watershed management, to optimize water use in agriculture [26]. Furthermore, it is crucial to invest in water management technologies,

such as desalination and artificial recharge, to ensure the future availability of drinking water [10], while promoting the use of deficit irrigation techniques [92].

- Water leakage control involves identifying the main sources of water loss, such as high evapotranspiration, and developing resource management strategies to optimize water use and minimize losses [15,56], for example, a sprinkler irrigation system can improve the annual volume required [49]. Key measures include maintaining infrastructure and adopting more efficient technologies [14,30,47,69,89]. These initiatives can be supported by public and private funding for infrastructure and technology advances aimed at enhancing irrigation efficiency [62,106], for example, improving network performance and the use of desalination [78].
- Reuse of water in irrigation areas as a strategy to maximize the use of available resources. This practice not only helps preserve water but also supports the supply for agricultural activities during periods of low availability [89].

3.3.3. Strategic Land-Use Planning

Soil management practices and changes in vegetation cover affect water availability and quality [87]. Forests play a fundamental role in regulating the hydrological cycle by controlling surface runoff, promoting water infiltration into soils, minimizing soil erosion, and maximizing water retention [25,35,85]. Changes in land use, such as the conversion of natural areas to agricultural or urban lands, can negatively impact the water regulation capacity of the watershed [4,54]. The shift towards intensive land use, such as urbanization, reduces ecosystems' capacity to provide good-quality water, increases the demand for water purification, and simultaneously weakens their supply capacity [129]. This highlights the need for integrated water and land resource management to ensure that both agricultural production and water security remain balanced [36,67], enabling more effective and resilient water resource planning according to the specific characteristics of each sub-watershed, such as soil type, vegetation cover, and agricultural practices [43].

Nature-based solutions, such as reforestation and ecosystem restoration, can be effective strategies to mitigate the impacts of land use on water resources and address the effects of climate change [32,87]. These solutions improve soil quality and reduce vulnerability to erosion. By maintaining forest cover, the watershed's hydrological response is enhanced, contributing to water flow regulation and water quality preservation [87]. An example of such solutions is the implementation of payment for ecosystem services programs, a watershed management strategy that promotes water resource conservation through financial incentives for local farmers [9].

3.3.4. Applying Technologies to Predict and Monitor Variations in Resource Availability

The integration of technologies such as remote monitoring, geographic information systems (GIS), and predictive models can significantly enhance water management and planning capabilities [5]. Predicting when and where the most severe droughts are expected to happen allows the forecast of severe drought periods, identifying which areas will face the greatest water scarcity, providing early warnings about the severity and length of droughts, and conducting planning based on needs. It also influences the creation of more sustainable policies aimed at mitigating the effects of climate change and ensuring the long-term sustainability of water resources [16,84,118,130]. Likewise, early analysis of areas with high runoff and low aquifer recharge can help implement specific management strategies [25]. Modeling studies provide scientific support for analyzing water resource issues and developing strategies to address current and potential problems for the sustainable management of water resources [11]. Integrating this type of research into water resource

planning and management will enhance water security through the adoption of measures based on scientific data [16].

3.3.5. Planning Based on Temporal Resource Variations

There is a variation in the influence of geographical and climatic factors regarding the water security of a territory, which suggests the need for customized regional approaches to improve water security in specific areas [45]. This implies the need for water management policies that consider not only the current water supply but also future projections under different socioeconomic and climatic scenarios [70]. Understanding the spatial-temporal patterns of precipitation changes and their related hydrological responses is crucial for improving water resource management strategies in large river basins under changing climatic conditions [8].

Early warning systems based on real-time monitoring of ecological flow can help mitigate the impacts of extreme hydrological events, such as floods and droughts [131]. There is significant spatial variation in water security risks, highlighting the need for region-specific strategies to mitigate water-related hazards and vulnerabilities [5]. This integrated approach should combine water conservation, sustainable resource use, and watershed planning, prioritizing management practices based on simulated water balance component data to optimize water use [25].

3.3.6. Developing Disaster Containment Infrastructure

Disaster planning is an integral part of water security management [118]. Risk management instruments are essential for water supply companies to guarantee water security, especially when facing natural hazards, technical failures, and deliberate sabotage [132]. Improving water retention infrastructure is a mitigation and planning strategy for addressing water-related disasters, such as floods, aimed at minimizing the effects of these events on communities and water resources [104,120]. Flood mitigation strategies must respond to different contexts and scales, ensuring that infrastructure construction reduces risks for all involved. Investments in infrastructure, such as levee construction, pumping stations, and drainage systems, have been essential for managing extreme rainfall events, enhancing the resilience of cities to climate challenges [121].

3.3.7. Creating Storage Infrastructure

An alternative when projections indicate changes in flow rates or variations in rainy and dry season patterns is investment in storage and distribution infrastructure [122]. A key measure to recharge aquifers and ensure water availability during periods of scarcity involves creating structures for water storage, such as reservoirs, percolation tanks, ponds, and dams [116]. These structures help retain rainwater, promote groundwater recharge, and reduce dependency on surface water sources [30], while increasing water availability during dry periods [25]. The planning and construction of these facilities are tailored to specific scales, such as large reservoirs and dams designed to meet the needs of entire communities [106].

3.3.8. Enhancing Groundwater Use

Groundwater level and spatial-temporal fluctuations under variable basin conditions are very important for water resource management [4]. The depletion of groundwater resources and changes in rainfall patterns reduce the availability of water for irrigation, directly impacting crop production [74]. Groundwater can be a key resource for mitigating periods of water scarcity, especially in emergency situations. However, there is also a warning about the need to avoid the overexploitation of aquifers [40]. The most recommended approach is the combined use of surface and groundwater so that environmental flows can

be maintained in river stretches that would otherwise be overexploited [133]. It is crucial to integrate surface and groundwater resources through optimization models [94].

4. Conclusions

The impacts of climate change on water security vary significantly across different geographical contexts, with key challenges including water scarcity, flooding, and changes in the quality of surface and groundwater. While polar ice melt has increased water availability in certain regions, water scarcity is affecting an increasing number of nations, underscoring a growing water resource crisis that projections suggest will continue to escalate.

The study examined 43 countries, although more research is needed in most of the countries to generalize by nation, all of them face one or more water-related issues: scarcity, flooding, and poor water quality, presenting a map that categorizes the situation in each territory (this being the new and relevant information). This visualization allows for a territorial approach to understanding the issue.

Some nations are particularly vulnerable, facing increased water security challenges due to a combination of severe flooding during heavy rainy seasons, water scarcity during long dry periods, and widespread degradation of water quality. This is especially evident in countries such as Afghanistan, Bangladesh, India, and Mexico. Additionally, although Uzbekistan, Tajikistan, Myanmar, Guatemala, and Belize were not included in the study, these nations should prioritize water security due to their proximity to regions experiencing the three main challenges identified.

To address the impacts of climate change on water security, the study suggests several key adaptation strategies. These include sustainable urban planning, improving consumption efficiency, strategic land-use planning, applying technologies to predict water availability, and developing plans based on temporal resource variations. Nevertheless, these strategies must be adopted in each context, considering environmental factors and climate projections as decisive factors when planning water management and use.

One of the limitations of this article is that it is based on a review of open-access publications, which may disadvantage or exclude countries that have fewer publications available in this format. This limitation is evident in the number of articles found for Asia and Africa compared to other regions, as these continents have a higher number of accessible publications on the topic. This situation could introduce bias into the study, with results being more influenced by findings from Asia and Africa than from other analyzed regions. To mitigate this issue and avoid compromising the results, the number of publications included per country was limited to 11 articles.

Grouping the identified issues into scarcity, floods, and pollution problems helped reduce potential bias or influences from countries with a higher volume of studies. The findings on each country's situation were enriched when multiple studies provided evidence of the issue. However, even a single publication was sufficient to highlight water security challenges, allowing for an evaluation of the situation in all 43 countries. In cases where there was an excess of studies, priority was given to the most recent publications and those focusing on different watersheds.

Nevertheless, given the complexity of this topic, it is important to note that the findings presented in this article are strictly based on the reviewed publications. However, in future research, the literature search will be expanded without the limitation of having to be articles in open-access journals, which will allow us to have a more accurate global view of the problem of water security worldwide.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Description of water problems by country.

Regions	Countries	Water Problems	References
Africa	Algeria	Water scarcity is intensifying due to population growth, climate change, and urbanization. Reduced rainfall, inefficient irrigation, and over-reliance on groundwater resources exacerbate deficits, threatening agricultural productivity and aquifer recharge rates.	Bessedik et al. [78]; Boudjebieure et al. [79]
	Burundi	Water insecurity is driven by flood risks stemming from changes in runoff patterns and extreme flow events. These changes impact water availability, seasonal distribution, and agricultural production.	Kim et al. [120]
	Ethiopia	Agricultural expansion and climate change intensify water scarcity, impacting agro-food systems, water balance, and sustainability of irrigation. In Ethiopia, the Awash River Basin faces severe water quality issues due to untreated wastewater and agricultural runoff.	Flint et al. [21]; Abera and Ayenew [56]; Kidanewold et al. [57]; Gedefaw and Denghua [58]; Abate et al. [59]
	Ghana	The average rainfall over the entire basin is projected to increase in the wet season [July to December] and will be not enough in the dry season [January to June]. Population growth, climate change, and land-use changes, coupled with rising temperatures, are expected to induce water scarcity by 2050, threatening food production and key crops.	Amisigo et al. [90]; Abungba et al. [91]
	Madagascar	Despite its high potential for freshwater availability, Madagascar remains vulnerable to water scarcity. Factors such as climate change, land use and cover changes, population growth, and existing policies significantly affect water resources and the livelihoods of communities residing near major river basins.	Zy et al. [103]

Table A1. Cont.

Regions	Countries	Water Problems	References
Africa	Morocco	Land-use changes, including the expansion of agricultural and urban areas, are impacting negatively on water quality and availability of both surface and groundwater. Additional challenges include erosion, biodiversity loss and deficiencies in irrigation technology, all of which place greater pressure on the situation by adding the effects of climate variability.	Gallardo-Cruz et al. [35]; Ben et al. [60]; Nevárez-Favela and Fernández-Reynosó [61]; Andrade et al. [62]; Alitane et al. [63]
	South Africa	Current and future limited water supply capacity and availability have the greatest impact on regions such as the Eastern Cape and parts of Mpumalanga, with predictions to exacerbate with climate pattern variability. Additionally, dams and reservoirs are unable to effectively capture and manage projected rainfall increases due to inadequate water storage infrastructure.	Cullis [110]; Vernon et al. [111]; Dlamini et al. [112]
	Tanzania	The combined effects of climate change and rising water demand are expected to create a critical water security challenge, especially in the Pangani basin. While projected increases in precipitation may enhance water availability during certain seasons, they are unlikely to be sufficient to meet the growing demands of the agricultural, hydroelectric, and domestic sectors.	Kishiwa et al. [116]
	Zambia	The high demand for irrigation water, particularly in the upper and middle sections of the basin, combined with a historical decline in precipitation and elevated evapotranspiration levels, results in severe water shortages, especially during dry seasons. Furthermore, the reduction in aquifer recharge and surface flow, along with the discharge of wastewater from treatment plants, affects water quality and the long-term sustainability of the resource.	Tena et al. [75]
Asia	Afghanistan	The country is facing high vulnerability, low reliability, and limited resilience, especially in the Kabul River basin. Projections suggest that climate change will increase runoff variability, altering precipitation patterns, and amplifying surface runoff, raising the frequency and severity of droughts and floods. As a consequence, water production is projected to fall short of meeting demand.	Saka and Mohammady [15]; Sediqi and Komori [16]; Akhtar et al. [22]
	Bangladesh	Water insecurity affects parts of the country, with projections indicating a worsening trend, especially in the north-west region with the highest demand increase. This raises concerns regarding unsustainable groundwater use if appropriate management strategies are not implemented. While irrigation water demand is expected to rise in the coming decades, it may subsequently decline due to improved crop yields and population decreases. Vulnerability to both floods and groundwater contamination is projected to increase across both dry seasons and the monsoon climate system, characterized by heavy rainfall.	Raihan et al. [17]; Kirby and Mainuddin [23]

Table A1. Cont.

Regions	Countries	Water Problems	References
Asia	China	Water security risks exhibit significant regional variations, with challenges related to water availability, quality, and climate risks like droughts and floods. While some areas manage resources effectively, others face severe water security deficits. Rising water scarcity, driven by increased demand from urban, economic, agricultural, and industrial sectors, and intensive mining activities have depleted groundwater storage. In densely populated regions, water quality fluctuates significantly, with agricultural runoff and wastewater as primary contaminants. Despite these challenges, positive trends have been observed, such as the Yangtze River Basin's water security index improving from "unsafe" in 2011 to "relatively safe" by 2019, and similar positive trends in Inner Mongolia and Gansu.	Zhou et al. [1]; Li et al. [2]; Chunxia and Yiqiu [5]; Tang et al. [12]; Deng et al. [40]; Sun et al. [41]; Zhang et al. [42]; Gu et al. [43]; Zhang et al. [44]; Wang et al. [45]
	Hong Kong (China)	The region has experienced significant flood events, largely attributable to its natural topography, which limits flood management to a five-year recurrence interval. Historical floods have had a severe impact on Shenzhen and Hong Kong, disrupting local economies and the daily lives of residents. Recurrent flooding of the Shenzhen River has further adversely affected infrastructure, local economies, and communities in both cities.	Yang and Huang [121]
	India	Key challenges to water security include low rainfall, high temperatures, and consistently high evaporation rates, exacerbated by inadequate water storage infrastructure. Urbanisation has further reduced pond areas and groundwater recharge volumes. Sub-basins are particularly vulnerable to soil erosion and sedimentation. Projections indicate increased flood vulnerability due to elevated river flow and runoff, influenced by variations in precipitation amount, frequency, and intensity. Additionally, water demand is expected to far exceed supply, posing significant risks to water security. Increased runoff and reduced aquifer recharge exacerbate these issues, impacting water availability for both human consumption and agricultural use.	Ishita and Kamal [24]; Pandi et al. [25]; Sabale et al. [26]; Kumar et al. [27]; Dubey et al. [29]; Nivesh et al. [30]; Jayanthi et al. [31]; Loukika et al. [32]
	Iran	Current scenarios reveal that water demand exceeds the available capacity, posing significant risks to agricultural production and urban water supply and the projections are not favourable due to reduction in precipitation and water reservoir, presenting more frequent periods of water scarcity. Groundwater availability is in play due to overexploitation from the three main aquifers and intensive land use. Additionally, climate change is accelerating snowmelt, which, combined with increased evaporation, is contributing to long-term reductions in water availability for storage and use.	Shaabani et al. [92]; Najimi et al. [93]; Moghadam et al. [94]; Sheikha-Bagem et al. [95]; Zare et al. [96]; Salmani et al. [97]

Table A1. *Cont.*

Regions	Countries	Water Problems	References
Asia	Iraq	Water shortages have been identified due to transboundary retention caused by the Upstream dam construction and water loss of surface irrigation systems. Additionally, population growth, along with industrial and agricultural expansion, has made it increasingly difficult to meet the rising demand for water. Also, the evapotranspiration in a specific period exceeds the system's capacity to deliver water to meet demands and water availability has been affected with the reduction of flow of the Euphrates River from Turkey, combined with the limited storage capacity.	Hamdi et al. [98]; Saeed et al. [99]; Najm et al. [100]; Abdulhameed et al. [101]
	Nepal	Flood risks in the Karnali River basin are significant. Projections indicate a considerable increase in river flow, which, while potentially enhancing water availability, also presents significant risks, notably an elevated potential for flooding and challenges in managing increased water volumes during rainy seasons. Rising minimum and maximum temperatures are expected to accelerate glaciers and snow melt, further altering the basin's hydrological cycle. Additionally, reliable water sources in Nepal are diminishing due to reduced precipitation and accelerated glacier melt.	Flint et al. [21]; Lamichhane et al. [104]
	Pakistan	Water distribution within the basin is unequal, with significant challenges in agricultural areas that are heavily dependent on irrigation. Urban and industrial areas also face persistent water shortages. High unmet water demand is projected, driven by factors such as population growth, agricultural expansion, climate change, and a substantial reduction in water availability. Rising temperatures, reductions in precipitation and increased evaporation rates are expected to further reduce the flow of the Indus and the Kabul basins.	Waqas et al. [105]; Amin et al. [106]; Khalid and Saleem [107]
	Palestine	Limited water resource availability and overexploitation, combined with geopolitical challenges, significantly restrict access to additional water supplies. The region exhibits a high degree of vulnerability to both natural and anthropogenic risks, which are further intensified by increasing climate pressures, urbanisation, ongoing conflicts, and a deficit of investment in modern water management infrastructure.	Jabari et al. [108]; Jabari et al. [109]
	South Korea	Surface runoff increases, induced by changes in urban area extent and agricultural practices within the catchment, coupled with reduced groundwater recharge and evapotranspiration, suggest a shift in the water balance dynamics. Projections suggest an increase in the frequency and intensity of both meteorological and hydrological droughts, driven by declining precipitation during key seasons and rising temperatures.	Ware et al. [113]; Kim et al. [114]; Lee et al. [115]

Table A1. Cont.

Regions	Countries	Water Problems	References
Asia	Syria	Water availability challenges are driven by rapid population growth, leading to a significant decline in per capita water resources. This situation is expected to worsen under the impacts of climate change, with decreased precipitation, reduced runoff, and diminished flow in the Euphrates River, the region's main water supply.	Mourad and Alshihabi [76]
	Thailand	Water security varies unevenly across different regions. Some areas are expected to see increased water levels, while others may experience reductions. During dry season, rainfall is projected to rise by up to 84%, while increases of up to 11% are anticipated during the wet season. While these precipitation changes could enhance water availability at certain times, they also elevate the risk of extreme events, such as flooding. Such flooding is expected to impact rice paddies, intercropped plantations, and urbanised areas, posing significant challenges for both water management and land use planning.	Satriagasa et al. [122]
	Turkey	Projected climate change and population growth impacts on future water availability suggest that the basin is likely to face water shortages driven by both climatic factors and rising demand, particularly from agriculture, the region's largest water consumer. This includes the prospect of water shortages during dry periods and excessive flows in the wet season. Furthermore, groundwater has been compromised due to overexploitation and changes in recharge capacity.	Yaykiran [11]; Keleş [117]; Taylan [118]
	Turkmenistan	Climate change is expected to introduce greater seasonal variability, resulting in severe floods during wet seasons and reduced flow in the Harirud River throughout most seasons. These changes are likely to decrease water quality due to increased nutrient loads, such as nitrogen and phosphorus, and diffuse pollution from untreated agricultural wastewater. The construction of the Salma Dam in Afghanistan has further reduced downstream water flow, significantly impacting water availability in Iran and Turkmenistan. Moreover, the Doosti Reservoir, which supplies water to Mashhad in Iran, is projected to fail in meeting water demand beyond 2036, leading to critical water security challenges for the region.	Nazari [77]
	Vietnam	Base flow reduction during the dry season with significant challenge for water availability and Increased runoff during the rainy season with flood risks in downstream urban areas.	Ha and Bastiaanssen [52]

Table A1. *Cont.*

Regions	Countries	Water Problems	References
Europe	Czechia	Alterations in land use and agricultural practices have significantly altered the small water cycle, increasing surface runoff and diminishing infiltration, resulting in sedimentation, water scarcity, and localised flooding. These effects are expected to intensify with anticipated increases in temperature and variability in precipitation patterns.	Noreika et al. [39]
	Germany	Water security risks are primarily focused on the management of extreme events, such as flooding. Deforestation and land use change contribute to water quality degradation, as increased runoff transports higher levels of sediments, nutrients, and pollutants into rivers. This negatively impacts water quality for human consumption, agriculture, and other uses. Furthermore, annual river flows have risen by more than 80%, further compounding water management challenges.	Shukla et al. [4]
	Greece	Under the baseline scenario, the Ali Efenti basin faces a significant unmet annual water demand, principally driven by the agricultural sector, its largest water consumer. Simulations of deficit irrigation practices suggest significant potential for annual water savings. Within the urban, tourism, and industrial sectors, one scenario projects further water savings through enhanced distribution network efficiency and a reduction in water losses.	Psomas et al. [14]
	Ireland	Climate variability in combination with land cover change amplifies the hydrological response, resulting in more pronounced extremes in both dry and wet conditions. The increasing rate of urbanisation and its alterations in land cover have contributed to the rising frequency of extreme floods and their associated devastations.	Basu et al. [46]
	Italy	Significant droughts in the last few years, rising water stress for crops and the ecosystem in general, increase in the number of rain but reduction in overall precipitation.	Bernini et al. [102]
	Poland	The economy is heavily reliant on agriculture, where intensive farming practices and climate change are exacerbating water stress, resulting in years with low average precipitation average, classified as “dry” according to the Relative Precipitation Index [RPI]. Furthermore, reservoir water quality is severely compromised by pollution from agricultural activities.	Zlati et al. [64]; Szewczyk et al. [65]

Table A1. Cont.

Regions	Countries	Water Problems	References
Europe	Spain	Water security challenges include water shortages and groundwater overexploitation. Heavily reliant on groundwater for drinking water, agriculture, and drought mitigation in major cities such as Madrid, Barcelona, and Valencia, the country faces significant challenges. Hotspots of pronounced groundwater overexploitation include the Upper Guadiana Basin and several basins in Andalusia, where inadequate groundwater management and structural issues exacerbate the problem. In south-eastern Spain, a region experiencing chronic water scarcity, the environmental impacts of blue water consumption for energy crops are particularly severe. Climate change and environmental flow requirements are expected to significantly reduce hydroelectric power production. Under low-adaptation scenarios, the most severe impacts on water security include increased plant water stress, higher flood discharge, hillside erosion, and increased sediment yield. The implementation of more efficient irrigation techniques and adopting Nature-based Solutions [NbS] could reduce water demand.	Gunn and Amelin [66]; Núñez et al. [67]; Garcia et al. [68]; Eekhout et al. [69]; Cheng et al. [70]
	United Kingdom	The area is currently facing water security deficits, with demand exceeding supply. This situation is expected to worsen, particularly during the summer months, due to annual increases in demand. These challenges are most acute downstream of the River Dee, notably in cities such as Chester.	Abbas et al. [119]
North America	Bahamas	Water security is unevenly distributed across the island, with some areas facing greater risks than others. The study predicts that risks in Andros will intensify by the end of the century, driven by the combined effects of climate change and population growth.	Holding and Allen [10]
	Canada	This region is susceptible to severe droughts due to low annual precipitation and the geographic influence of barriers such as the Rocky Mountains. Over recent decades, a 1.7 °C increase in average annual temperature has exacerbated water stress. With 58% of the land dedicated to agriculture, fluctuations in soil moisture and recurrent droughts present significant challenges to regional food security. Projections suggest a future increase in both frequency and severity of agriculture problems.	Zare et al. [84]
	Cuba	Extreme drought events during 2011–2012 and 2015–2016 severely reduced water availability. Future decreases in precipitation, driven by climate variability and change, are expected to further compromise water availability, posing significant challenges to agricultural sustainability. Agricultural activities, particularly rice cultivation, remain the primary consumers of water resources. Projections indicate increasing pressures on water resources due to declining precipitation and increasing demand.	Puebla et al. [89]

Table A1. Cont.

Regions	Countries	Water Problems	References
North America	Mexico	There is a high vulnerability to contamination, water scarcity, and flooding. Insufficient wastewater treatment capacity, inadequate flood protection infrastructure, and inefficient water distribution systems exacerbate issues of water access and quality, negatively affecting overall water security. The conversion of natural areas into agricultural lands has further increased water demand, putting additional strain on water availability. Furthermore, projections indicate an increase in mean annual temperature and a decrease in precipitation due to climate change, leading to more frequent extreme events. These changes are expected to exacerbate water scarcity in certain regions seasonally and elevate the risk of seasonal flooding.	Cortez-Mejía et al. [33]; De La Rosa et al. [34]; Gallardo-Cruz et al. [35]; Leija et al. [36]; Colín-García et al. [37]; Molina-Sánchez and Chávez-Morales [38]
	United States of America	Mountain regions experience recurring drought conditions, notably during dry seasons (e.g., East-Taylor in Colorado). Increases in temperature and shifting precipitation, patterns snowmelt leading to increases in stational soil dryness and increases in overall surface runoff from the topographical smoothening. In the Upper Colorado River Basin, there are issues related to water quality and limited availability due to specific disturbances such as wildfires, extreme rainfall, and debris flows. Increased food production is also uncertain as the irrigated area in water-stressed regions is increasing, especially in Southwest United States.	Mital et al. [71]; Edvard [72]; Ridgway et al. [73]; Kompas et al. [74]
South America	Brazil	Water insecurity is exacerbated by groundwater contamination stemming from inadequate sanitation infrastructure. Under global warming scenarios exceeding 1.5 °C, increased evapotranspiration and decreased precipitation are projected to reduce water availability, intensifying water scarcity and vulnerability during dry months. A decline in water availability for human consumption, agriculture, and other uses is anticipated.	Sone et al. [9]; Vieira et al. [80]; Ballarin et al. [81]; Gesualdo et al. [82]; Thomaz et al. [83];
	Chile	Changes in land use and land cover are projected to reduce native and mixed forests, agricultural lands, and both young and mature non-native forest plantations. This will reduce soil water storage, diminish water availability, and decrease aquifer recharge due to lower percolation and groundwater flow. Consequently, water security within the region is expected to be negatively affected.	Pereira et al. [85]
	Colombia	Projected increases in rainfall variability and intensity exacerbate water security issues. Soil management practices and changes in vegetation cover influence water availability and quality. Agricultural practices are identified as primary contributors to sedimentation and nutrient pollution in groundwater. Also, the decline in forested areas increases surface runoff during peak rainfall periods affecting agricultural productivity and sediment transport.	Valencia et al. [86]; Ortégón et al. [87]; Ruíz et al. [88]

Table A1. Cont.

Regions	Countries	Water Problems	References
South America	Ecuador	Water availability is under threat due to climate change and land use changes driven by urbanization and agricultural activities. Future scenarios predict increased water deficits caused by rising temperatures, higher evaporation rates, and reduced precipitation. Growing water scarcity is expected, alongside increased agricultural demand, irrigation expansion, and higher energy requirements for water pumping and transport, particularly in the Machángara Basin. Additionally, anthropogenic activities, such as sedimentation and agricultural wastewater discharge, may lead to water eutrophication.	Chengot et al. [13]; Avilés et al. [54]; Ayala et al. [55]
	Peru	Current water availability exceeds demand in the Vilcanota-Urubamba, Ambato and Coata basin, and climate change scenarios predict a further increase in availability particularly during the dry season. Population growth and agricultural expansion are the primary drivers of rising demand, jeopardizing water supplies for both human and agricultural use. While some models forecast increased annual precipitation, reductions in critical-month flows intensify the challenge. Additionally, forest cover loss has diminished the basin's capacity for hydrological regulation, heightening flood risks during the rainy season and reducing base flow during the dry season.	Goyburo et al. [47]; Salomón et al. [48]; Laveriano et al. [49]; Olsson et al. [50]; Paiva et al. [51]
Australia	Australia	Changes in land use and land cover reduce infiltration and exacerbate surface runoff alternating flow patterns also combine with the increases in rainfall intensity. Also, periods of prolonged drought combined with increased water demands and overloading of nutrients from agricultural activities, urban wastewater discharge, soil erosion and sediment transport exacerbate water quality issues.	Das et al. [53]

References

- Zhou, J.R.; Li, X.Q.; Yu, X.; Zhao, T.C.; Ruan, W.X. Exploring the ecological security evaluation of water resources in the Yangtze River Basin under the background of ecological sustainable development. *Sci. Rep.* **2024**, *14*, 15475. [[CrossRef](#)] [[PubMed](#)]
- Li, J.; He, W.; Jiang, E.; Yuan, L.; Qu, B.; Degefu, D.M.; Ramsey, T.S. Evaluation and prediction of water security levels in Northwest China based on the DPSIR model. *Ecol. Indic.* **2024**, *163*, 112045. [[CrossRef](#)]
- Wolkeba, F.T.; Mekonnen, M.M.; Brauman, K.A.; Kumar, M. Indicator metrics and temporal aggregations introduce ambiguities in water scarcity estimates. *Sci. Rep.* **2024**, *14*, 15182. [[CrossRef](#)]
- Shukla, S.; Meshesha, T.W.; Sen, I.S.; Bol, R.; Bogen, H.; Wang, J. Assessing impacts of land use and land cover [LULC] Change on stream flow and runoff in Rur Basin, Germany. *Sustainability* **2023**, *15*, 9811. [[CrossRef](#)]
- Lu, C.; Ou, D.; Li, Y. A study on spatial variation of water security risks for the Zhangjiakou Region. *J. Resour. Ecol.* **2021**, *12*, 91–98. [[CrossRef](#)]
- Gain, A.K.; Giupponi, C.; Wada, Y. Measuring global water security towards sustainable development goals. *Environ. Res. Lett.* **2016**, *11*, 124015. [[CrossRef](#)]
- Da Silva Tavares, P.; Acosta, R.; Nobre, P.; Resende, N.C.; Chou, S.C.; de Arruda Lyra, A. Water balance components and climate extremes over Brazil under 1.5 °C and 2.0 °C of global warming scenarios. *Reg. Environ. Change* **2023**, *23*, 40. [[CrossRef](#)] [[PubMed](#)]
- Wu, Y.; Yin, X.; Zhou, G.; Bruijnzeel, L.A.; Dai, A.; Wang, F.; Gentile, P.; Zhang, G.; Song, Y.; Zhou, D. Rising rainfall intensity induces spatially divergent hydrological changes within a large river basin. *Nat. Commun.* **2024**, *15*, 823. [[CrossRef](#)]
- Sone, J.S.; Araujo, T.F.; Gesualdo, G.C.; Ballarin, A.S.; Carvalho, G.A.; Oliveira, P.T.S.; Wendland, E.C. Water security in an uncertain future: Contrasting realities from an availability-demand perspective. *Water Resour. Manag.* **2022**, *36*, 2571–2587. [[CrossRef](#)]

10. Holding, S.; Allen, D.M. Risk to water security for small islands: An assessment framework and application. *Reg. Environ. Change* **2016**, *16*, 827–839. [\[CrossRef\]](#)
11. Yaykiran, S.; Cuceloglu, G.; Ekdal, A. Estimation of water budget components of the Sakarya River Basin by using the WEAP-PGM model. *Water* **2019**, *11*, 271. [\[CrossRef\]](#)
12. Tang, Q.; Liu, X.; Zhou, Y.; Wang, P.; Li, Z.; Hao, Z.; Liu, S.; Zhao, G.; Zhu, B.; He, X.; et al. Climate change and water security in the northern slope of the Tianshan Mountains. *Geogr. Sustain.* **2022**, *3*, 246–257. [\[CrossRef\]](#)
13. Chengot, R.; Zylberman, R.; Momblanch, A.; Salazar, O.V.; Hess, T.; Knox, J.W.; Rey, D. Evaluating the impacts of agricultural development and climate change on the water-energy nexus in Santa Elena [Ecuador]. *Environ. Sci. Policy* **2024**, *152*, 103656. [\[CrossRef\]](#)
14. Psomas, A.; Panagopulos, Y.; Konsta, D.; Mimikou, M. Designing water efficiency measures in a catchment in Greece using WEAP and SWAT models. *Procedia Eng.* **2016**, *162*, 269–276. [\[CrossRef\]](#)
15. Saka, F.; Mohammady, A.J. Future perspective of water budget in the event of three scenarios in Afghanistan using the WEAP program. *Eng. Sci. Technol. Int. J.* **2024**, *49*, 101602. [\[CrossRef\]](#)
16. Sediqi, M.N.; Komori, D. Assessing water resource sustainability in the Kabul River Basin: A standardized runoff index and reliability, resilience, and vulnerability framework approach. *Sustainability* **2024**, *16*, 246. [\[CrossRef\]](#)
17. Raihan, F.; Ondrasek, G.; Islam, M.S.; Maina, J.M.; Beaumont, L.J. Combined impacts of climate and land use changes on long-term streamflow in the Upper Halda Basin, Bangladesh. *Sustainability* **2021**, *13*, 12067. [\[CrossRef\]](#)
18. Liu, Y.; Zhang, Y.; Yu, M.; Dai, C. Impacts of climate and land use/land cover change on water yield services in Heilongjiang Province. *Water* **2024**, *16*, 2113. [\[CrossRef\]](#)
19. Bai, M.; Shen, B.; Song, X.; Mo, S.; Huang, L.; Quan, Q. Multi-temporal variabilities of evapotranspiration rates and their associations with climate change and vegetation greening in the Gan River Basin, China. *Water* **2019**, *11*, 2568. [\[CrossRef\]](#)
20. Hagemann, S.; Chen, C.; Clark, D.B.; Folwell, S.; Gosling, S.N.; Haddeland, I.; Hanasaki, N.; Heinke, J.; Ludwig, F.; Voß, F.; et al. Climate change impact on available water resources obtained using multiple global climate and hydrology models. *Earth Syst. Dyn.* **2012**, *3*, 1321–1345. [\[CrossRef\]](#)
21. Flint, A.; Howard, G.; Nijhawan, A.; Poudel, M.; Geremew, A.; Mulugeta, Y.; Lo, E.; Ghimire, A.; Baidya, M.; Sharma, S. Managing climate change challenges to water security: Community water governance in Ethiopia and Nepal. *Geo Geogr. Environ.* **2024**, *11*, e00135. [\[CrossRef\]](#)
22. Akhtar, F.; Awan, U.K.; Borgemeister, C.; Tischbein, B. Coupling remote sensing and hydrological model for evaluating the impacts of climate change on streamflow in data-scarce environment. *Sustainability* **2021**, *13*, 14025. [\[CrossRef\]](#)
23. Kirby, M.; Mainuddin, M. The impact of climate change, population growth and development on sustainable water security in Bangladesh to 2100. *Sci. Rep.* **2022**, *12*, 22344. [\[CrossRef\]](#) [\[PubMed\]](#)
24. Bhatnagar, I.; Jain, K. Simple methodology for estimating the groundwater recharge potential of rural ponds and lakes using remote sensing and GIS techniques: A spatiotemporal case study of Roorkee Tehsil, India. *Water Resour.* **2020**, *47*, 200–210. [\[CrossRef\]](#)
25. Pandi, D.; Kothandaraman, S.; Kuppusamy, M. Simulation of water balance components using SWAT model at sub catchment level. *Sustainability* **2023**, *15*, 1438. [\[CrossRef\]](#)
26. Sabale, R.S.; Bobade, S.S.; Venkatesh, B.; Jose, M.K. Application of Arc-SWAT model for water budgeting and water resource planning at the Yeralwadi Catchment of Khatav, India. *Nat. Environ. Pollut. Technol.* **2024**, *23*, 203–213. [\[CrossRef\]](#)
27. Kumar, S.; Mishra, A.; Singh, U.K. Assessment of land cover changes and climate variability effects on catchment hydrology using a physically distributed model. *Sustainability* **2023**, *15*, 10304. [\[CrossRef\]](#)
28. Sadhwani, K.; Eldho, T.I. Assessing the vulnerability of water balance to climate change at river basin scale in humid tropics: Implications for a sustainable water future. *Sustainability* **2023**, *15*, 9135. [\[CrossRef\]](#)
29. Dubey, S.K.; Kim, J.; Her, Y.; Sharma, D.; Jeong, H. Hydroclimatic impact assessment using the SWAT model in India—State of the art review. *Sustainability* **2023**, *15*, 15779. [\[CrossRef\]](#)
30. Nivesh, S.; Patil, J.P.; Goyal, V.C.; Saran, B.; Singh, A.K.; Raizada, A.; Malik, A.; Kuriqi, A. Assessment of future water demand and supply using WEAP model in Dhasan River Basin, Madhya Pradesh, India. *Environ. Sci. Pollut. Res.* **2022**, *30*, 27289–27302. [\[CrossRef\]](#)
31. Jayanthi, S.L.; Keesara, V.R.; Sridhar, V. Prediction of future lake water availability using SWAT and support vector regression (SVR). *Sustainability* **2022**, *14*, 6974. [\[CrossRef\]](#)
32. Loukika, K.N.; Keesara, V.R.; Buri, E.S.; Sridhar, V. Predicting the effects of land use land cover and climate change on Munneru River Basin using CA-Markov and soil and water assessment tool. *Sustainability* **2022**, *14*, 5000. [\[CrossRef\]](#)
33. Cortez-Mejía, P.; Tzatchkov, V.; Rodríguez-Varela, J.M.; Llaguno-Guilberto, O.J. Calidad del agua y seguridad ante inundaciones en la gestión sostenible del recurso hídrico. *Ing. Agua* **2021**, *25*, 15–36. [\[CrossRef\]](#)
34. De La Rosa, A.; Valdés-Rodríguez, O.A.; Villada-Canela, M.; Manson, R.; Murrieta-Galindo, R. Caracterizando la seguridad hídrica con enfoque de cuenca hidrológica: Caso de estudio Veracruz, México. *Ing. Agua* **2021**, *25*, 187–203. [\[CrossRef\]](#)

35. Gallardo-Cruz, J.A.; Fernández-Montes De Oca, A.; Rives, C. Detección de amenazas y oportunidades para la conservación en la cuenca baja del Usumacinta a partir de técnicas de percepción remota. *Ecosistemas* **2019**, *28*, 82–99. [CrossRef]
36. Leija, E.G.; Valenzuela, S.I.; Valencia, M.; Jiménez, G.; Castañeda, G.; Reyes, H.; Mendoza, M.E. Análisis de cambio en la cobertura vegetal y uso del suelo en la región centro-norte de México. El caso de la cuenca baja del río Nazas. *Ecosistemas* **2020**, *29*, 1826. [CrossRef]
37. Colín-García, G.; Palacios-Vélez, E.; López-Pérez, A.; Bolaños-González, M.A.; Flores-Magdaleno, H.; Ascencio-Hernández, R.; Canales-Islas, E.I. Evaluation of the impact of climate change on the water balance of the Mixteco River Basin with the SWAT model. *Hydrology* **2024**, *11*, 45. [CrossRef]
38. Molina-Sánchez, C.; Chávez-Morales, J.; Palacios-Vélez, L.O.; Ibáñez-Castillo, L.A. Simulación hidrológica de la cuenca del río Laja con el modelo WEAP. *Tecnol. Cienc. Agua* **2022**, *13*, 136–174. [CrossRef]
39. Noreika, N.; Winterová, J.; Li, T.; Krása, J.; Dostál, T. The small water cycle in the czech landscape: How has it been affected by land management changes over time? *Sustainability* **2021**, *13*, 13757. [CrossRef]
40. Deng, Z.; Ma, Q.; Zhang, J.; Feng, Q.; Niu, Z.; Zhu, G.; Jin, X.; Chen, M.; Chen, H. A new socio-hydrology system based on system dynamics and a SWAT-MODFLOW coupling model for solving water resource management in Nanchang City, China. *Sustainability* **2023**, *15*, 16079. [CrossRef]
41. Sun, Y.; Jiang, J.; Yang, F.; Chen, X.; Yu, Z.; Guo, Q.; Zhao, Y. Spatial-temporal variation analysis of water storage and its impacts on ecology and environment in high-intensity coal mining areas. *Land. Degrad. Dev.* **2023**, *34*, 338–352. [CrossRef]
42. Zhang, X.; Ma, L.; Zhu, Y.; Lou, W.; Xie, B.; Sheng, L.; Hu, H.; Zheng, K.; Gu, Q. Temporal stability analysis for the evaluation of spatial and temporal patterns of surface water quality. *Water Resour. Manag.* **2022**, *36*, 1413–1429. [CrossRef]
43. Gu, J.; Cao, Y.; Wu, M.; Song, M.; Wang, L. A novel method for watershed best management practices spatial optimal layout under uncertainty. *Sustainability* **2022**, *14*, 13088. [CrossRef]
44. Zhang, Q.; Yu, R.; Jin, Y.; Zhang, Z.; Liu, X.; Xue, H.; Hao, Y.; Wang, L. Temporal and spatial variation trends in water quality based on the WPI index in the shallow lake of an arid area: A case study of Lake Ulansuhai, China. *Water* **2019**, *11*, 1410. [CrossRef]
45. Wang, Z.; Liu, X.; Liu, T.; Wang, W.; Liu, J. Towards the sustainable development of water security: A new copula-based risk assessment system. *Ecol. Indic.* **2024**, *166*, 112489. [CrossRef]
46. Basu, A.S.; Gill, L.W.; Pilla, F.; Basu, B. Assessment of variations in runoff due to landcover changes using the SWAT model in an Urban River in Dublin, Ireland. *Sustainability* **2022**, *14*, 534. [CrossRef]
47. Goyburo, A.; Rau, P.; Lavado-Casimiro, W.; Buytaert, W.; Cuadros-Adriazola, J.; Horna, D. Assessment of present and future water security under anthropogenic and climate changes using WEAP model in the Vilcanota-Urubamba Catchment, Cusco, Perú. *Water* **2023**, *15*, 1439. [CrossRef]
48. Salomón, M.; Guaman Ríos, C.; Rubio, C.; Galárraga, R.; Abraham, E. Indicadores de uso del agua en una zona de los Andes centrales de Ecuador. Estudio de la cuenca del Río Ambato. *Ecosistemas* **2008**, *17*, 72–85. Available online: <https://www.revistaecosistemas.net/index.php/ecosistemas/article/view/114> (accessed on 8 January 2025).
49. Laveriano, E.B.; Huamaní, J.R.; Rosas, M.A. Optimization of water resources to counteract the effects of water deficit using the WEAP Model. In Proceedings of the 9th International Conference on Civil, Structural and Transportation Engineering, Chestnut Conference Centre-University of Toronto, Toronto, ON, Canada, 13–15 June 2024. [CrossRef]
50. Olsson, T.; Kämäräinen, M.; Santos, D.; Seitola, T.; Tuomenvirta, H.; Haavisto, R.; Lavado-Casimiro, W. Downscaling climate projections for the Peruvian coastal Chancay-Huaral Basin to support river discharge modeling with WEAP. *J. Hydrol. Reg. Stud.* **2017**, *13*, 26–42. [CrossRef]
51. Paiva, K.; Rau, P.; Montesinos, C.; Lavado-Casimiro, W.; Bourrel, L.; Frappart, F. Hydrological response assessment of land cover change in a Peruvian Amazonian Basin impacted by deforestation using the SWAT Model. *Remote Sens.* **2023**, *15*, 5774. [CrossRef]
52. Ha, L.T.; Bastiaanssen, W.G.M. Determination of spatially-distributed hydrological ecosystem services (HESS) in the Red River Delta using a calibrated SWAT model. *Sustainability* **2023**, *15*, 6247. [CrossRef]
53. Das, S.K.; Ahsan, A.; Khan, M.H.R.B.; Yilmaz, A.G.; Ahmed, S.; Imteaz, M.A.; Tariq, M.A.U.R.; Shafiqzaman, M.; Ng, A.W.M.; Al-Ansari, N. Calibration, validation and uncertainty analysis of a SWAT water quality model. *Appl. Water Sci.* **2024**, *14*, 86. [CrossRef]
54. Avilés, A.; Palacios, K.; Pacheco, J.; Jiménez, S.; Zhiña, D.; Delgado, O. Sensitivity exploration of water balance in scenarios of future changes: A case study in an Andean regulated river basin. *Theor. Appl. Climatol.* **2020**, *141*, 921–934. [CrossRef]
55. Ayala Izurieta, J.E.; Beltrán Dávalos, A.A.; Jara Santillán, C.A.; Godoy Ponce, S.C.; Van Wittenberghe, S.; Verrelst, J.; Delegido, J. Spatial and temporal analysis of water quality in High Andean Lakes with Sentinel-2 satellite automatic water products. *Sensors* **2023**, *23*, 8774. [CrossRef]
56. Abera Abdi, D.; Ayenew, T. Evaluation of the WEAP model in simulating subbasin hydrology in the Central Rift Valley basin, Ethiopia. *Ecol. Process* **2021**, *10*, 41. [CrossRef]
57. Kidanewold, B.B.; Zeleke, E.B.; Michailovsky, C.I.; Seyoum, S. Partitioning blue and green water sources of evapotranspiration using the water evaluation and planning (WEAP) model. *Water Pract. Technol.* **2023**, *18*, 2943–2956. [CrossRef]

58. Gedefaw, M.; Denghua, Y. Simulation of stream flows and climate trend detections using WEAP model in awash river basin. *Cogent Eng.* **2023**, *10*, 2211365. [CrossRef]
59. Abate, B.Z.; Assefa, T.T.; Tigabu, T.B.; Abebe, W.B.; He, L. Hydrological modeling of the Kobo-Golina River in the data-scarce Upper Danakil Basin, Ethiopia. *Sustainability* **2023**, *15*, 3337. [CrossRef]
60. Ben Salem, S.; Ben Salem, A.; Karmaoui, A.; Yacoubi, M. Vulnerability of water resources to drought risk in southeastern Morocco: Case study of Ziz Basin. *Water* **2023**, *15*, 4085. [CrossRef]
61. Nevárez-Favela, M.M.; Fernández-Reynoso, D.S.; Sánchez-Cohen, I.; Sánchez-Galindo, M.; Macedo-Cruz, A.; Palacios-Espinosa, C. Comparación de los modelos WEAP y SWAT en una cuenca de Oaxaca. *Tecnol. Cienc. Agua* **2021**, *12*, 358–401. [CrossRef]
62. Andrade-Servín, A.G.; Guerrero-García, H.R.; Colín-Martínez, R. Análisis econométrico de la disponibilidad de agua para producción agrícola de riego en México (2003–2015). *Ecosistemas* **2020**, *29*, 1816. [CrossRef]
63. Alitane, A.; Essahlaoui, A.; Van Griensven, A.; Yimer, E.A.; Essahlaoui, N.; Mohajane, M.; Chawanda, C.J.; Van Rompaey, A. Towards a decision-making approach of sustainable water resources management based on hydrological modeling: A case study in Central Morocco. *Sustainability* **2022**, *14*, 10848. [CrossRef]
64. Zlati, M.L.; Antohi, V.M.; Ionescu, R.V.; Iticescu, C.; Georgescu, L.P. Quantifying the impact of the water security index on socio-economic development in EU27. *Socio-Econ. Plan. Sci.* **2024**, *93*, 101912. [CrossRef]
65. Szewczyk, M.; Tomczyk, P.; Wiatkowski, M. Water management on drinking water reservoirs in the aspect of climate variability: A case study of the Dobromierz Dam Reservoir, Poland. *Sustainability* **2024**, *16*, 6478. [CrossRef]
66. López Gunn, E.; Vargas Amelin, E. La gobernanza del agua subterránea y la seguridad hídrica en España. In *Book El agua en España: Economía y gobernanza*; Secretaría de Estado de Presupuestos y Gastos: Madrid, Spain, 2020; pp. 79–102. Available online: <https://www.ief.es/docs/destacados/publicaciones/revistas/pgp/101.pdf> (accessed on 8 January 2025).
67. Núñez, M.; Pfister, S.; Antón, A.; Muñoz, P.; Hellweg, S.; Koehler, A.; Rieradevall, J. Assessing the environmental impact of water consumption by energy crops grown in Spain. *J. Ind. Ecol.* **2013**, *17*, 90–102. [CrossRef]
68. Garcia, X.; Estrada, L.; Llorente, O.; Acuña, V. Assessing small hydropower viability in water-scarce regions: Environmental flow and climate change impacts using a SWAT+ based tool. *Environ. Sci. Eur.* **2024**, *36*, 126. [CrossRef]
69. Eekhout, J.P.C.; Delsman, I.; Baartman, J.E.M.; van Eupen, M.; van Haren, C.; Contreras, S.; Martinez-Lopez, J.; de Vente, J. How future changes in irrigation water supply and demand affect water security in a Mediterranean catchment. *Agric. Water Manag.* **2024**, *297*, 108818. [CrossRef]
70. Cheng, T.F.; Chen, D.; Wang, B.; Ou, T.; Lu, M. Human-induced warming accelerates local evapotranspiration and precipitation recycling over the Tibetan Plateau. *Commun. Earth Environ.* **2024**, *5*, 388. [CrossRef]
71. Mital, U.; Dwivedi, D.; Brown, J.B.; Steefel, C.I. Downscaled hyper-resolution (400 m) gridded datasets of daily precipitation and temperature (2008–2019) for the East–Taylor subbasin (western United States). *Earth Syst. Sci. Data* **2022**, *14*, 4949–4966. [CrossRef]
72. Sjøstedt, E.C.E.S. Quantifying Water Security in West Virginia and the Potomac River Basin. Master’s Thesis, West Virginia University, Morgantown, WV, USA, 2022. Available online: <https://researchrepository.wvu.edu/cgi/viewcontent.cgi?article=11389&context=etd> (accessed on 8 January 2025).
73. Ridgway, P.; Lane, B.; Canham, H.; Murphy, B.P.; Belmont, P.; Rengers, F.K. Wildfire, extreme precipitation and debris flows, oh my! Channel response to compounding disturbances in a mountain stream in the Upper Colorado Basin, USA. *Earth Surf. Process Landf.* **2024**, *49*, 3855–3872. [CrossRef]
74. Kompas, T.; Che, T.N.; Grafton, R.Q. Global impacts of heat and water stress on food production and severe food insecurity. *Sci. Rep.* **2024**, *14*, 14398. [CrossRef] [PubMed]
75. Tena, T.M.; Mwaanga, P.; Nguvulu, A. Hydrological modelling and water resources assessment of Chongwe River Catchment using WEAP model. *Water* **2019**, *11*, 839. [CrossRef]
76. Mourad, K.A.; Alshihabi, O. Assessment of future Syrian water resources supply and demand by the WEAP model. *Hydrol. Sci. J.* **2016**, *61*, 393–401. [CrossRef]
77. Nazari Mejdari, H.; Moridi, A.; Najjar-Ghabel, S. Water quantity–quality assessment in the transboundary river basin under climate change: A case study. *J. Water Clim. Change* **2023**, *14*, 4747–4762. [CrossRef]
78. Bessedik, M.; Abdelbaki, C.; Tiar, S.M.; Badraoui, A.; Megnounif, A.; Goosen, M.; Mourad, K.; Baig, M.B.; Alataway, A. Strategic decision-making in sustainable water management using demand analysis and the water evaluation and planning model. *Sustainability* **2023**, *15*, 16083. [CrossRef]
79. Boudjebie, E.; Ghrieb, L.; Maoui, A.; Chaffai, H.; Chini, Z.L. Long-term water demand assessment using WEAP 21: Case of The Guelma Region, Middle Seybouse (Northeast Algeria). *Geogr. Tech.* **2021**, *16*, 69–79. [CrossRef]
80. Vieira, I.F.B.; Rolim, F.C.; Carvalho, M.N.; Caldas, A.M.; Costa, R.C.A.; Silva, K.S.d.; Parahyba, R.d.B.V.; Pacheco, F.A.L.; Fernandes, L.F.S.; Pissarra, T.C.T. Water security assessment of groundwater quality in an anthropized rural area from the Atlantic forest biome in Brazil. *Water* **2020**, *12*, 623. [CrossRef]

81. Ballarin, A.S.; Sousa Mota Uchôa, J.G.; dos Santos, M.S.; Almagro, A.; Miranda, I.P.; da Silva, P.G.C.; da Silva, G.J.; Gomes Júnior, M.N.; Wendland, E.; Oliveira, P.T.S. Brazilian water security threatened by climate change and human behavior. *Water Resour. Res.* **2023**, *59*, e2023WR034914. [\[CrossRef\]](#)
82. Gesualdo, G.C.; Oliveira, P.T.; Rodrigues, D.B.B.; Gupta, H.V. Assessing water security in the São Paulo metropolitan region under projected climate change. *Hydrol. Earth Syst. Sci.* **2019**, *23*, 4955–4968. [\[CrossRef\]](#)
83. Thomaz, F.R.; Miguez, M.G.; De Souza, J.G.; De Moura, G.W.; Fontes, J.P. Water scarcity risk index: A tool for strategic drought risk management. *Water* **2023**, *15*, 255. [\[CrossRef\]](#)
84. Zare, M.; Azam, S.; Sauchyn, D.; Basu, S. Assessment of meteorological and agricultural drought indices under climate change scenarios in the South Saskatchewan River Basin, Canada. *Sustainability* **2023**, *15*, 5907. [\[CrossRef\]](#)
85. Pereira, C.O.; Escanilla-Minchel, R.; González, A.C.; Alcayaga, H.; Aguayo, M.; Arias, M.A.; Flores, A.N. Assessment of future land use/land cover scenarios on the hydrology of a coastal basin in South-Central Chile. *Sustainability* **2022**, *14*, 16363. [\[CrossRef\]](#)
86. Valencia, S.; Villegas, J.C.; Hoyos, N.; Duque-Villegas, M.; Salazar, J.F. Streamflow response to land use/land cover change in the tropical Andes using multiple SWAT model variants. *J. Hydrol. Reg. Stud.* **2024**, *54*, 101888. [\[CrossRef\]](#)
87. Ortégón, Y.A.C.; Acosta-Prado, J.C.; Acosta Castellanos, P.M. Impact of land cover changes on the availability of water resources in the Regional Natural Park Serranía de Las Quinchas. *Sustainability* **2022**, *14*, 3237. [\[CrossRef\]](#)
88. Ruíz-Ordoñez, D.M.; Camacho De Angulo, Y.V.; Pencué Fierro, E.L.; Figueroa Casas, A. Mapping ecosystem services in an Andean Water Supply Basin. *Sustainability* **2023**, *15*, 1793. [\[CrossRef\]](#)
89. Puebla, J.H.; Osorio, M.D.; Gonzalez, F.; Pérez, J.D. Grain sorghum (*Sorghum vulgare* L. Monech) response to irrigation time and nitrogen fertilizer during two plantation dates. In *Book. Revista Ingeniería Agrícola*; Instituto de Investigaciones de Ingeniería Agrícola: La. Habana, Cuba, 2016; Volume 6, pp. 3–10. [\[CrossRef\]](#)
90. Amisigo, B.A.; McCluskey, A.; Swanson, R. Modeling impact of climate change on water resources and agriculture demand in the Volta Basin and other basin systems in Ghana. *Sustainability* **2015**, *7*, 6957–6975. [\[CrossRef\]](#)
91. Abungba, J.A.; Adjei, K.A.; Gyamfi, C.; Odai, S.N.; Pingale, S.M.; Khare, D. Implications of land use/land cover changes and climate change on Black Volta Basin future water resources in Ghana. *Sustainability* **2022**, *14*, 12383. [\[CrossRef\]](#)
92. Shaabani, M.K.; Abedi-Koupai, J.; Eslamian, S.S.; Gohari, S.A.R. Simulation of the effects of climate change, crop pattern change, and developing irrigation systems on the groundwater resources by SWAT, WEAP and MODFLOW models: A case study of Fars province, Iran. *Environ. Dev. Sustain.* **2024**, *26*, 10485–10511. [\[CrossRef\]](#)
93. Najimi, F.; Aminnejad, B.; Nourani, V. Assessment of climate change's impact on flow quantity of the mountainous watershed of the Jajrood River in Iran using hydroclimatic models. *Sustainability* **2023**, *15*, 15875. [\[CrossRef\]](#)
94. Moghadam, S.H.; Ashofteh, P.S.; Loáiciga, H.A. Optimal water allocation of surface and ground water resources under climate change with WEAP and IWOA modeling. *Water Resour. Manag.* **2022**, *36*, 3181–3205. [\[CrossRef\]](#)
95. Sheikha-BagemGhaleh, S.; Babazadeh, H.; Rezaie, H.; Sarai-Tabrizi, M. The effect of climate change on surface and groundwater resources using WEAP-MODFLOW models. *Appl. Water Sci.* **2023**, *13*, 121. [\[CrossRef\]](#)
96. Zare, M.; Adib, A.; Bajestan, M.S.; Beigipoor, G.H. Non-priority and priority allocation policies in water resources management concerning water resources scarcity using the WEAP model in the catchment area of Fars province. *J. Hydraul. Struct.* **2022**, *8*, 21–34. [\[CrossRef\]](#)
97. Salmani, H.; Javadi, S.; Eini, M.R.; Golmohammadi, G. Compilation simulation of surface water and groundwater resources using the SWAT-MODFLOW model for a karstic basin in Iran. *Hydrogeol. J.* **2023**, *31*, 571–587. [\[CrossRef\]](#)
98. Hamdi, A.A.; Abdulhameed, I.M.; Mawlood, I.A. Application of WEAP model for managing water resources in Iraq: A Review. *IOP Conf. Ser. Earth Environ. Sci.* **2023**, *1222*, 012032. [\[CrossRef\]](#)
99. Saeed, F.; Al-Khafaji, M.S.; Al-Faraj, F.A.M.; Uzomah, V. Sustainable adaptation plan in response to climate change and population growth in the Iraqi part of Tigris River Basin. *Sustainability* **2024**, *16*, 2676. [\[CrossRef\]](#)
100. Najm, A.B.A.; Abdulhameed, I.M.; Sulaiman, S.O. Improving the cultivated area for the Ramadi Irrigation Project By Using Water Evaluation and Planning Model. *Iraqi Acad. Sci. J.* **2021**, *26*, 105–114. [\[CrossRef\]](#)
101. Abdulhameed, I.M.; Sulaiman, S.O.; Najm, A.B.A.; Al-Ansari, N. Optimising water resources management by using water evaluation and planning (WEAP) in the West of Iraq. *J. Water Land Dev.* **2022**, *53*, 176–186. [\[CrossRef\]](#)
102. Bernini, A.; Becker, R.; Adeniyi, O.D.; Pilla, G.; Sadeghi, S.H.; Maerker, M. Hydrological implications of recent droughts (2004–2022): A SWAT-based study in an ancient lowland irrigation area in Lombardy, Northern Italy. *Sustainability* **2023**, *15*, 16771. [\[CrossRef\]](#)
103. Zy Harifidy, R.; Zy Misa Harivelo, R.; Hiroshi, I.; Jun, M.; Kazuyoshi, S. A systematic review of water resources assessment at a large river basin scale: Case of the major river basins in Madagascar. *Sustainability* **2022**, *14*, 12237. [\[CrossRef\]](#)
104. Lamichhane, M.; Phuyal, S.; Mahato, R.; Shrestha, A.; Pudasaini, U.; Lama, S.D.; Chapagain, A.R.; Mehan, S.; Neupane, D. Assessing climate change impacts on streamflow and baseflow in the Karnali River Basin, Nepal: A CMIP6 multi-model ensemble approach using SWAT and web-based hydrograph analysis tool. *Sustainability* **2024**, *16*, 3262. [\[CrossRef\]](#)

105. Waqas, M.; Khalid, S.; Rasheed, H. Social implications of water scarcity in local community of district Rawalpindi. *Int. J. Soc. Sci. Arch. IJSSA* **2024**, *7*, 412–415. Available online: <https://www.ijssa.com/index.php/ijssa> (accessed on 8 January 2025).
106. Amin, A.; Iqbal, J.; Asghar, A.; Ribbe, L. Analysis of current and future water demands in the upper indus basin under IPCC climate and socio-economic scenarios using a hydro-economic WEAP model. *Water* **2018**, *10*, 537. [\[CrossRef\]](#)
107. Khalid, M.; Saleem, M.W.; Rashid, M.; Dittthakit, P.; Weesakul, U.; Kaewmoracharoen, M. Integration of the water evaluation and planning system model with the Nash bargaining theory for future water demand and allocation in the Kabul River Transboundary basin under different scenarios. *Eng. Sci.* **2024**, *30*, 1146. [\[CrossRef\]](#)
108. Jabari, S.; Shahrour, I.; El Khattabi, J. Assessment of the urban water security in a severe water stress area—application to Palestinian cities. *Water* **2020**, *12*, 2060. [\[CrossRef\]](#)
109. Jabari, S.; Shahrour, I.; Khatabi, J. Use of risk analysis for water security assessment. *MATEC Web Conf.* **2019**, *295*, 02008. [\[CrossRef\]](#)
110. Cullis, J. A Study: Water security and climate change risks for municipalities. *IMIESA* **2022**, *47*, 5–14. Available online: https://hdl.handle.net/10520/ejc-imiesa_v47_n5_a14 (accessed on 8 January 2025).
111. Nagan, V.; Seyam, M.; Abunama, T. Assessment of long-term water demand for the Mgeni system using Water Evaluation and Planning [WEAP] model considering demographics and extended dry climate periods. *Water SA* **2023**, *49*, 338–354. [\[CrossRef\]](#)
112. Dlamini, N.; Senzanje, A.; Mabhaudhi, T. Assessing climate change impacts on surface water availability using the WEAP model: A case study of the Buffalo river catchment, South Africa. *J. Hydrol. Reg. Stud.* **2023**, *46*, 101330. [\[CrossRef\]](#)
113. Ware, H.H.; Chang, S.W.; Lee, J.E.; Chung, I.M. Assessment of hydrological responses to land use and land cover changes in forest-dominated watershed using SWAT model. *Water* **2024**, *16*, 528. [\[CrossRef\]](#)
114. Kim, J.H.; Sung, J.H.; Chung, E.S.; Kim, S.U.; Son, M.; Shiru, M.S. Comparison of projection in meteorological and hydrological droughts in the Cheongmicheon Watershed for RCP4.5 and SSP2-4.5. *Sustainability* **2021**, *13*, 2066. [\[CrossRef\]](#)
115. Lee, J.; Park, M.; Min, J.H.; Na, E.H. Integrated assessment of the land use change and climate change impact on baseflow by using hydrologic model. *Sustainability* **2023**, *15*, 12465. [\[CrossRef\]](#)
116. Kishiwa, P.; Nobert, J.; Kongo, V.; Ndomba, P. Assessment of impacts of climate change on surface water availability using coupled SWAT and WEAP models: Case of upper Pangani River Basin, Tanzania. *Proc. Int. Assoc. Hydrol. Sci.* **2018**, *378*, 23–27. [\[CrossRef\]](#)
117. Keleş Özgenç, E. Evaluation using the SWAT model of the effects of land use land cover changes on hydrological processes in the Gala Lake Basin, Turkey. *Environ. Qual. Manag.* **2024**, *34*, e22238. [\[CrossRef\]](#)
118. Taylan, E.D. An Approach for future droughts in Northwest Türkiye: SPI and LSTM methods. *Sustainability* **2024**, *16*, 6905. [\[CrossRef\]](#)
119. Abbas, S.A.; Xuan, Y.; Bailey, R.T. Assessing climate change impact on water resources in water demand scenarios using SWAT-MODFLOW-WEAP. *Hydrology* **2022**, *9*, 164. [\[CrossRef\]](#)
120. Kim, J.B.; Habimana, J.d.D.; Kim, S.-H.; Bae, D.-H. Assessment of climate change impacts on the hydroclimatic response in Burundi Based on CMIP6 ESMs. *Sustainability* **2021**, *13*, 12037. [\[CrossRef\]](#)
121. Yang, J.; Huang, G. Study on the mechanism of multi-scalar transboundary water security governance in the Shenzhen River. *Sustainability* **2024**, *16*, 7138. [\[CrossRef\]](#)
122. Satriagasa, M.C.; Tongdeenok, P.; Kaewjampa, N. Assessing the implication of climate change to forecast future flood using SWAT and HEC-RAS model under CMIP5 climate projection in Upper Nan Watershed, Thailand. *Sustainability* **2023**, *15*, 5276. [\[CrossRef\]](#)
123. Sun, L.; Zhou, X.; Gu, A. Effects of climate change on hydropower generation in China based on a WEAP model. *Sustainability* **2022**, *14*, 5467. [\[CrossRef\]](#)
124. Ganoulis, J. A New Dialectical model of water security under climate change. *Water* **2023**, *15*, 2672. [\[CrossRef\]](#)
125. Zhang, K.; Lu, H.; Wang, B. Benefit distribution mechanism of a cooperative alliance for basin water resources from the perspective of cooperative game theory. *Sustainability* **2024**, *16*, 6729. [\[CrossRef\]](#)
126. Herrera-Franco, G.; Bollmann, H.A.; Pasqual Lofhagen, J.C.; Bravo-Montero, L.; Carrión-Mero, P. Approach on water-energy-food (WEF) nexus and climate change: A tool in decision-making processes. *Environ. Dev.* **2023**, *46*, 100858. [\[CrossRef\]](#)
127. Huang, M.; Mu, Z.; Zhao, S.; Yang, R. Ecological water requirement of natural vegetation in the Tarim River Basin based on multi-source data. *Sustainability* **2024**, *16*, 7034. [\[CrossRef\]](#)
128. Tian, X.; Jiang, N.; Jin, C.; Nie, T.; Gao, Y.; Meng, F. Analysis of spatial and temporal variation in sustainable water resources and their use based on improved combination weights. *Water* **2023**, *15*, 2752. [\[CrossRef\]](#)
129. Yang, Y.; Zhang, J.; Hu, Y. Land use intensity alters ecosystem service supply and demand as well as their interaction: A spatial zoning perspective. *Sustainability* **2024**, *16*, 7224. [\[CrossRef\]](#)
130. Zhang, X.; Yu, J.; Wang, L.; Zhang, R. Determination of river ecological flow thresholds and development of early warning programs based on coupled multiple hydrological methods. *Water* **2024**, *16*, 1986. [\[CrossRef\]](#)
131. Heumer, F.; Grischek, T.; Tränckner, J. Water supply security—Risk management instruments in water supply companies. *Water* **2024**, *16*, 1814. [\[CrossRef\]](#)

132. Baeza Sanz, D.; Vizcaino Martínez, P. Estimación de caudales ecológicos en dos cuencas de Andalucía: Uso conjunto de aguas superficiales y subterráneas. *Ecosistemas* **2008**, *17*, 24–36. Available online: <https://www.revistaecosistemas.net/index.php/ecosistemas/article/view/112> (accessed on 8 January 2025).
133. Campos, J.A.; Da Silva, D.D.; Pires, G.F.; Filho, E.I.F.; Amorim, R.S.S.; de Menezes, F.C.M.; de Melo, C.B.; Lorentz, J.F.; Aires, U.R.V. Modeling environmental vulnerability for 2050 considering different scenarios in the Doce River Basin, Brazil. *Water* **2024**, *16*, 1459. [[CrossRef](#)]

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