BILINGUAL PUBLISHING GROUP

Research in Ecology

https://journals.bilpubgroup.com/index.php/re

REVIEW

Women and Water Management in Central Asia: Exploring Participation and Regional Differences

Zulfiya Kannazarova [1,2*] , ***Meruyert Seidumanova*** [3], ***Madina Mussayeva*** [4], ***Eldiiar Duulatov*** [5], ***Kuanysh Uzbekov*** [6], ***Odinakhon Pulatova*** [2], ***Rukhsora Khudayberganova*** [7], ***Malika Kushbokova*** [7], ***Kundiz Nisanbayeva*** [7]

[1] *Department of Agricultural Machinery Technologies, Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, National Research University, Tashkent 100000, Uzbekistan*

[2] *Department of Environmental Sciences and Sustainable Development, Central Asian University of Environmental and Climate Change Studies, Green University, Darkhan 111104, Uzbekistan*

[3] *School of Social Sciences and Transformative, Almaty Management University, Almaty 050060, Kazakhstan*

[4] *Office of Knowledge Dissemination, Seifullin Kazakh Agrotechnical Research University, Astana 010000, Kazakhstan*

[5] *Institute of Geology, National Academy of Sciences of the Kyrgyz Republic, Bishkek 720040, Kyrgyzstan*

[6] *Graduate School of Business Sciences, University of Tsukuba, National University Corporation, Tsukuba 305-8577, Japan*

[7] *Research Institute of Environment and Nature Conservation Technologies, Tashkent 100043, Uzbekistan*

ABSTRACT

Women across Central Asia play essential roles in agriculture, water management, and climate adaptation; however, gendered vulnerabilities and institutional constraints continue to shape unequal access to land, water, training, and decision-making processes. This study examines the role of women in water management across Central Asia, focusing on the intersection of gender inequality, water governance, and climate change. The study employs a systematic literature review, combined with thematic analysis of 20 peer-reviewed articles published between 2011 and 2025 in the Scopus database. The findings identify key recurring themes, including the feminization of agriculture, institutional

*CORRESPONDING AUTHOR:
Zulfiya Kannazarova, Department of Agricultural Machinery Technologies, Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, National Research University, Tashkent 100000, Uzbekistan; Department of Environmental Sciences and Sustainable Development, Central Asian University of Environmental and Climate Change Studies, Green University, Darkhan 111104, Uzbekistan; Email: kannazarovazulfiya@tiiame.uz

ARTICLE INFO
Received: 3 March 2026 | Revised: 25 April 2026 | Accepted: 29 April 2026 | Published Online: 22 July 2026
DOI: https://doi.org/10.30564/re.v8i4.13238

CITATION
Kannazarova, Z., Seidumanova, M., Mussayeva, M., et al., 2026. Women and Water Management in Central Asia: Exploring Participation and Regional Differences. Research in Ecology. 8(4): 107–125. DOI: https://doi.org/10.30564/re.v8i4.13238

barriers to women's participation, and increased climate vulnerability in water-scarce regions such as the Aral Sea Basin. The analysis reveals that despite policy recognition of gender equality, structural constraints-such as limited access to resources, decision-making power, and institutional support-continue to hinder women's effective participation in water governance. The study contributes by providing a structured synthesis of fragmented regional literature and highlighting context-specific challenges in Central Asia. However, the study is limited by the relatively small dataset and reliance on published literature, suggesting the need for further empirical research.

Keywords: Women; Water Management; Climate; Livelihood; Central Asia

1. Introduction

Central Asia is one of the world's most water-stressed regions, shaped by climate change, demographic shifts, and legacy systems from the Soviet era [1]. Water governance lies at the heart of sustainable development in Central Asia, a region where resource scarcity, environmental degradation, and geopolitical interdependence shape both policy and everyday life [2]. The desiccation of the Aral Sea-one of the world's most devastating environmental crises-remains a stark reminder of how unsustainable management practices and fragmented governance can lead to long-term social and ecological harm [3]. Today, climate change further intensifies these challenges, altering hydrological regimes, reducing glacial reserves, and straining water-sharing arrangements among Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan [4]. Effective water governance in this context is not merely a technical or economic issue, but a deeply political and social process that requires inclusive and participatory decision-making. In Central Asia, gender disparities in decision-making remain especially visible within institutions that manage water resources, irrigation systems, and environmental policy [5]. Historical legacies of Soviet technocratic governance, combined with entrenched gender norms and limited institutional support, have constrained women's advancement in these fields [6]. Even as women play crucial roles at the household and community levels-collecting, using, and managing water-they remain underrepresented in formal leadership positions, basin councils, and ministerial departments responsible for resource management [7]. Addressing this imbalance is essential not only for gender justice but also for improving governance quality and ensuring that diverse knowledge systems and priorities are reflected in policy outcomes. However, despite growing global attention to gender and water governance, there is a lack of systematic and region-specific synthesis focusing on Central Asia. Existing studies are often fragmented, country-specific, and lack comparative perspectives across the region. Furthermore, limited attention has been given to how gender dynamics interact with post-Soviet institutional structures and transboundary water governance systems. This distinction is particularly important in the Aral Sea basin, where climate stressors, upstream and downstream dependencies, and evolving governance structures are increasing pressure on water systems and communities.

This study addresses this gap by examining women's participation in water resources management in several Central Asian countries, situating gender dynamics in transboundary hydrological and institutional contexts. At the same time, the article contributes to advancing the global policy agenda reflected in the Sustainable Development Goals (SDGs), in particular SDG 5 (Gender Equality), SDG 6 (Clean Water and Sanitation), and SDG 13 (Climate Action). By linking local participation models to regional governance issues, the study provides an integrated perspective that is both empirically grounded and policy-relevant.

2. Literature Review

2.1. Global Gender and Water Governance

Gender has emerged as a fundamental component of contemporary water governance. Global research shows that women and men interact with water resources in very different ways and face different levels of vulnerability. Women around the world are disproportionately responsible for domestic water collection, food production, and household water management. In many parts of Africa

and Asia, women and girls collectively spend 250 million hours a day collecting water, three times more than men and boys [8]. Despite their important role in water access and use, women are significantly underrepresented in formal water sector institutions. According to a recent global study, women make up less than 20–25% of the water workforce, and their representation is particularly low in technical and management positions. On average, 23% of licensed engineers and managers in water utilities are women. This underrepresentation limits women's influence in policymaking, resource allocation, and infrastructure development-all essential components of effective water management [9]. Advocates argue that empowering women in water management leads to more inclusive, sustainable, and equitable water management outcomes. When women participate in decision-making, water services are more focused on household and community needs, and water user committees or utilities are more responsive and transparent [10]. Until these challenges are addressed by closing gender data gaps, promoting gender-responsive policies, and developing women's leadership, the full potential of gender-inclusive water governance will remain unfulfilled.

2.2. Country-Specific Insights

2.2.1. Kazakhstan

Kazakhstan presents a compelling case for examining women's leadership in water governance within a post-Soviet, climate-vulnerable, and resource-intensive setting [11]. As the largest Central Asian republic, its institutional frameworks, policy reforms, and environmental priorities shape both the challenges and opportunities for gender-inclusive governance in the water sector [12].

Kazakhstan has made notable progress in formalizing commitments to gender equality. It ranks highest in Central Asia on the Global Gender Gap Index and is recognized by the Organization for Economic Co-operation and Development (OECD, 2025) for its efforts to promote gender parity in governance. The country's National Action Plan on Gender Equality (2022–2025) includes specific provisions related to gender-responsive environmental policy and climate governance [13]. Despite these advances, gender gaps persist in water-related decision-making. According to the 2024 Gender Analysis Report, in Kazakhstan, women constitute over 60% of university graduates, including in fields such as environmental science and engineering. However, this educational advantage does not translate into proportional representation in leadership roles across water and environmental institutions [14]. Recent administrative data show that only 14% of leadership positions in the Ministry of Water Resources and other central environmental agencies are held by women. Representation in local Water User Associations (WUAs) and basin councils remains below 20%, despite active female involvement in irrigation and household-level water management. In rural areas, women are often "consulted" in planning but lack actual influence, reinforcing patterns of tokenism and exclusion. Nevertheless, promising practices are emerging. Pilot initiatives in the Aral Sea region have encouraged women's participation in irrigation committees and ecosystem restoration, providing localized models for more inclusive environmental governance. These efforts align with national gender policies and regional climate adaptation strategies.

2.2.2. Kyrgyzstan

Recent data from state employment records indicate that at the beginning of 2015, women held 26.4% of political and specialist positions in public service, while they occupied 40.7% of administrative posts [15]. Despite this level of workforce participation, women remain significantly underrepresented in elected office and governance. After the 2016 elections to local councils, only 10% of deputies were women, and in several councils there were no female members at all. In municipal city councils, women's representation also remained low. At the national level, in the legislature elected in 2015, women held just 19.2% of seats [16]. Preliminary evidence from the water-management sector suggests a similar gender imbalance. Among the total workforce of water-sector specialists, only a fraction are women; managerial and leadership roles are predominantly male, while women are more often employed in lower- or mid-level specialist positions. Although comprehensive, publicly available data for the water sector remains limited, this pattern aligns with the broader national trend of underrepresentation of women in decision-making posts. Such disparities in representation and access to leadership and governance roles limit women's ability to influence water policies and control natural resource management.

Given the important role of women in social well-being and in caring for future generations, their marginalization from leadership undermines the inclusiveness and sustainability of water governance.

2.2.3. Tajikistan

Tajikistan's water resources play a key role in the country's socioeconomic development, with 93% of Central Asia's hydropower originating there. However, they are under significant pressure from climate change. According to scientists, more than 30% of the country's glaciers have already been lost in recent decades, threatening long-term water security and food sustainability. Despite the country's natural potential, access to water remains a challenge. In rural areas, approximately half the population lacks reliable access to safe drinking water, and much of the infrastructure dates back to the Soviet era and requires modernization [17]. Women traditionally play a central role in providing for household needs and agriculture. Due to the massive labor migration of men, women are increasingly managing irrigation and farming. However, their formal participation in Water User Associations (WUAs) remains low. Key barriers include limited access to finance and educational programs, traditional gender roles, the high burden of family care, and a lack of gender-disaggregated statistics and incentives for their inclusion in governance. The consequences of women's underrepresentation are clear: water supply and irrigation projects often fail to address issues such as safety during water collection, proximity to sources, or the sanitation needs of women and girls. Nevertheless, positive examples are emerging. In 2024, a pilot project to improve women farmers' access to irrigation water was launched in Tajikistan [18]. This project includes training, Non-Governmental Organizations (NGO) support, and women's involvement in WUA activities. Initial results show that such initiatives lead to increased crop yields and greater participation of women in decision-making. International organizations emphasize the need to integrate gender aspects into water and climate projects. For example, the Green Climate Fund recommends incorporating gender indicators into all water and climate projects, and regional forums in Dushanbe (2024–2025) link glacier conservation to women's expanded roles in resource management.

2.2.4. Turkmenistan

Turkmenistan presents a unique case in examining gender dynamics within water governance. While it shares regional challenges such as aridity, dependence on transboundary water sources, and the enduring influence of Soviet-era irrigation infrastructure, the country's institutional and socio-cultural context distinctly shapes women's participation. Since independence, water management in Turkmenistan has remained highly centralized, with decision-making concentrated within state agencies and dominated by male technocrats. The legacy of Soviet governance has had a lasting impact, resulting in low levels of female representation in technical, hydrological, and administrative roles across the sector. However, since the mid-2000s, gender considerations in water policy have gradually gained visibility through international and national programs aiming to integrate women's participation into capacity-building and educational initiatives. This institutional context reflects a blend of centralized decision-making alongside emerging recognition of social dimensions such as gender, community engagement, and sustainable water use [19]. Quantitative data illustrate persistent patterns in women's participation within the water sector. In 2006, women held approximately 17% of administrative and managerial positions in water-related organizations, indicating a measurable yet limited representation in leadership roles [20]. Similarly, female students comprised only about 3% of those enrolled in hydrology and irrigation programs at Turkmen Agricultural University in 2008, highlighting continued gender imbalances in technical education relevant to water management [21]. Although updated official statistics are scarce, project reports and workshop documentation suggest that these participation levels have remained relatively steady, with some diversification in women's professional roles, particularly in technical and advisory capacities. Access to water resources also reveals important gender-related dynamics. National estimates indicate that 95% of the population had access to safely managed drinking water in 2021; however, disparities exist between urban (approximately 85%) and rural areas (around 42%) as of 2016 [22]. In rural communities, women frequently bear responsibility for water collection and domestic management, roles that influence local gen-

der relations and resource use practices. These conditions underpin development initiatives that emphasize training and awareness programs targeted at women to enhance water governance and sustainability.

2.2.5. Uzbekistan

Recent gender assessments show that women in Uzbekistan remain significantly underrepresented in water-sector governance. According to the United Nations Development Programme (UNDP) and the World Bank (2020), women constitute only 12–15% of employees in water-related governmental institutions, while less than 5% hold leadership positions, indicating a persistent gender imbalance in decision-making structures [13]. Studies of Water User Associations (WUAs) provide further insight into the local context. The International Water Management Institute (IWMI), using the Gender Performance Indicator for Irrigation (GPII), found that women's participation in WUA governing bodies is below 10%, and many WUAs include no women at all in decision-making committees [23]. This is despite women's central role in household agriculture and daily water-use management. Institutional norms, rather than lack of involvement, limit their participation [24]. Media and sociological research further highlight cultural influences. A gender analysis of Uzbek press narratives shows that engineering and water-management roles are consistently portrayed as "male professions," reinforcing stereotypes that discourage women from entering technical water-sector roles [25]. Regional gender assessments for Central Asia indicate that Uzbekistan faces similar structural barriers as neighboring states, including limited access to technical education, low representation in public administration, and reduced involvement in natural-resource governance [26]. These systemic constraints collectively contribute to women's continued underrepresentation in the sector.

3. Materials and Methods

This study applies a systematic literature review combined with thematic analysis to examine the role of women in water management in Central Asia. The review was carried out using the Scopus database, one of the most widely used bibliographic online sources, covering the period from 2011 to 2025. The review of the literature employed the following keywords related to women, gender, female, and water management, water governance, water resources, irrigation, Central Asia, Uzbekistan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and the Aral Sea. The review was carried out in October 2025. A total of 20 publications from Central Asian countries were selected for further analysis on women in water management. Only studies that addressed a clearly defined research focus within the Central Asian region, fell within the specified time frame, and were indexed as peer-reviewed articles in the selected database were included. Publications were excluded if they were not directly relevant to the research topic, lacked sufficient methodological detail, or focused on other geographical contexts. In addition, the limited availability of region- and topic-specific studies-particularly in internationally indexed journals-further restricted the pool of eligible publications. Constraints related to Scopus database coverage and language selection also contributed to the reduction of the final sample. As a result, the screening process yielded a smaller but more focused and analytically robust body of literature.

In addition to identifying thematic patterns, the analysis explicitly codes recurring empirical findings according to three analytical dimensions derived from Gender and Development (GAD) and political ecology frameworks:

- Access to and control over resources (e.g., land, water, infrastructure).
- Participation in and influence over governance institutions (e.g., WUAs, basin organizations).
- Distribution of environmental and livelihood burdens under conditions of water stress and climate variability.

This coding structure enables a systematic interpretation of how gendered inequalities are reproduced across different institutional and environmental contexts.

The analysis of the publications was performed using a CSV file, Microsoft Excel 2021, RIS format and ArcGIS 10.8.

3.1. Article Review and Study Eligibility Criteria

For the search process, relevant keywords such as women OR gender OR female AND "water management"

OR "water governance" OR "water resources" OR "irrigation" AND "Central Asia" OR Uzbekistan OR Kazakhstan OR Kyrgyzstan OR Tajikistan OR Turkmenistan OR "Aral Sea" were used, and all articles in English and Russian were added to a spreadsheet. The following filters were applied: document type = "article," timespan = "2011–2025," subject area = Environmental Science, Earth and Planetary Sciences, Agricultural and Biological Sciences, Engineering, and deadline = September 2025. **Figure 1** shows the flow of the selected methodology for the research.

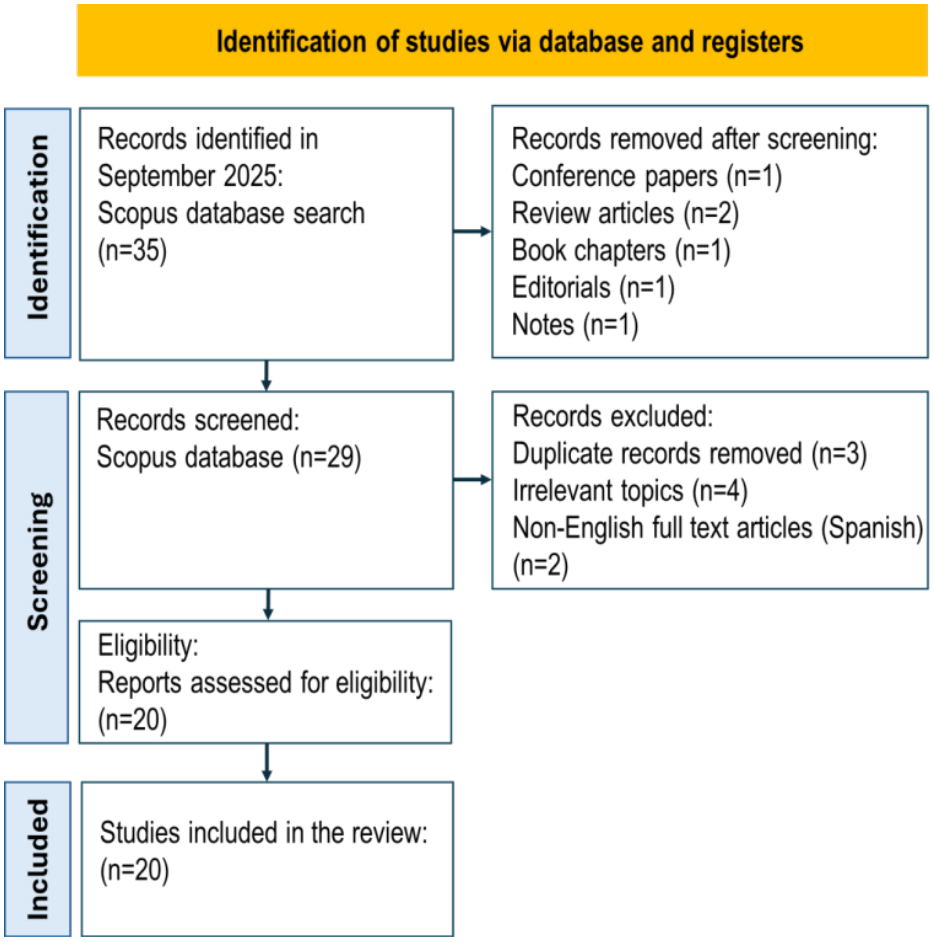

Figure 1. Methodology flowchart of the research.

Inclusion Criteria: Focus on Central Asia; addresses women, gender, or female participation; discusses water management, irrigation, water governance, climate impacts, or rural livelihoods; peer-reviewed journal articles or book chapters.

Inclusion Criteria: Peer-reviewed journal articles; Published between 2011 and 2025; English and Russian languages. Subject areas: Environmental Science, Earth Sciences, Agriculture, Engineering.

3.2. Data Extraction and Synthesis

From the 20 articles, information was categorized under the following themes: climate change and environmental stressors; women's roles in agriculture and irrigation; institutional structures (WUAs, basin organizations); migration, labor division, and feminization; health, rights, and socio-economic well-being.

3.3. Thematic Analysis

The thematic synthesis followed a structured process of identifying recurring patterns, grouping them into broader analytical categories, and interpreting these patterns across studies. This approach enables a systematic comparison of findings while acknowledging variation in the depth and scope of available literature across countries.

This approach enabled the systematic identification

of cross-cutting patterns in the literature, particularly those related to women's participation in water governance, access to resources, and institutional constraints.

To strengthen analytical rigor, the study explicitly distinguishes between empirical findings derived from the reviewed literature and their subsequent theoretical interpretation. Recurring patterns identified through thematic analysis-such as constraints related to land ownership, limited participation in Water User Associations (WUAs), and unequal access to training and resources-are first presented as empirical observations based on multiple studies.

These empirically identified patterns are then interpreted using Gender and Development (GAD) and political ecology frameworks. Rather than being applied deductively, these frameworks serve as analytical lenses to interpret consistent patterns across the dataset. This approach ensures that theoretical insights are grounded in the reviewed literature and reflect observed regularities, rather than being introduced independently.

4. Results and Discussion

4.1. Geographical Scope of the Women and Water Management Issue in Central Asia

Figure 2 illustrates the hydrological structure of the Aral Sea Basin and its major river systems across Central Asia. The map delineates the overall Aral Sea drainage basin (outlined in red), showing the transboundary area in which surface water flows toward the Aral Sea. Major rivers, including the Syr Darya and the Amu Darya, are highlighted, demonstrating the interconnected river network that links upstream mountainous regions with downstream irrigation zones. Particular attention is given to the Naryn River Basin in Kyrgyzstan and the Pamir Mountains in Tajikistan, which represent key upstream water source regions. These mountainous areas function as critical water towers for Central Asia, supplying meltwater and river flows that sustain agriculture, livelihoods, and domestic water use downstream in Uzbekistan, Kazakhstan, and Turkmenistan.

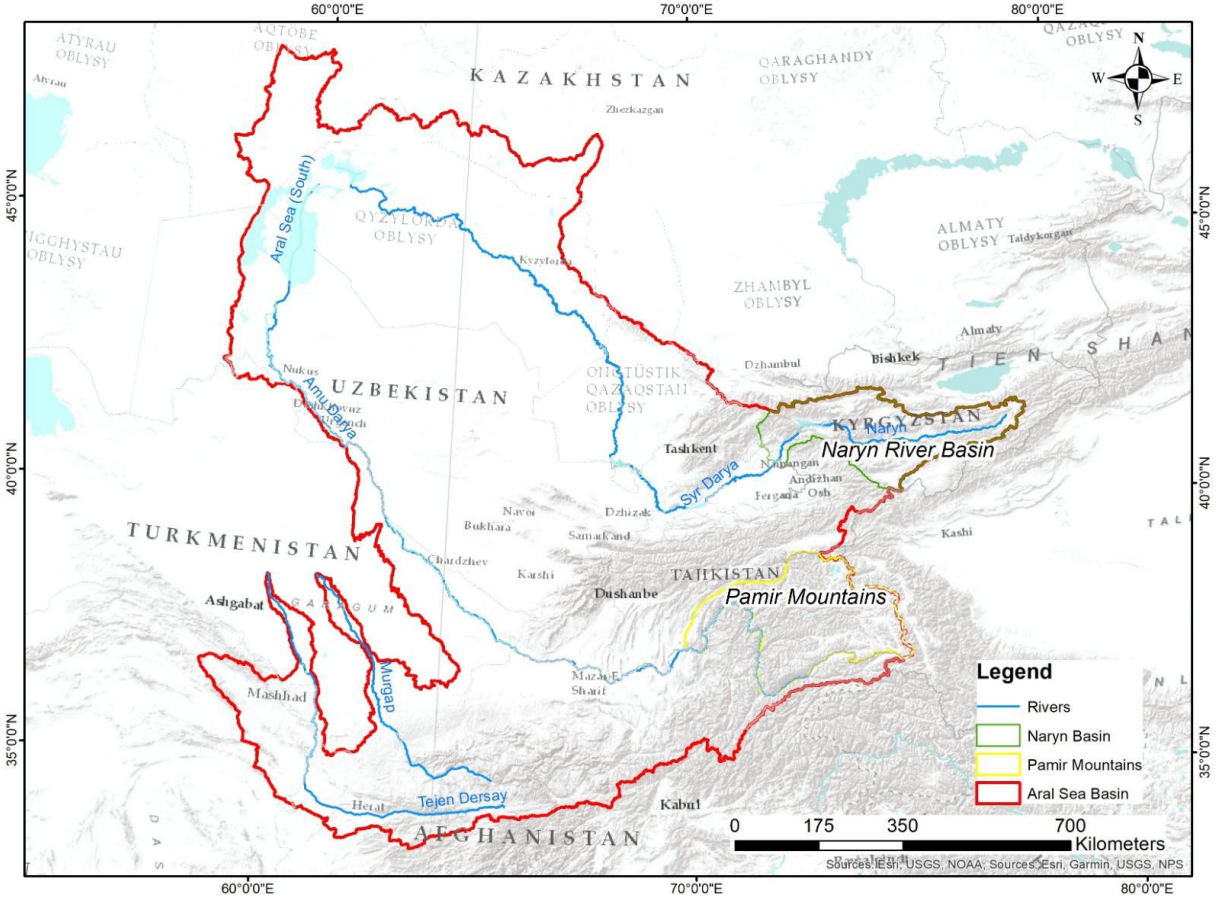

Figure 2. Geographic distribution of women in water management issues in Central Asia.

The geographic scope depicted in the map underscores the transboundary character of water governance in the region. Water resources originating in Kyrgyzstan and Tajikistan flow across national borders into Kazakhstan, Uzbekistan, and Turkmenistan, illustrating the structural interdependence of these states within a shared hydrological system. From a gender perspective, the map highlights that research on women and water management is embedded within environmentally vulnerable and irrigation-dependent regions, particularly in the Aral Sea Basin and mountainous upstream areas. These zones are characterized by water scarcity, environmental degradation, and intensive agricultural use, all of which shape gendered divisions of labor, access to resources, and participation in water governance institutions.

Overall, the map emphasizes that gender issues in water management cannot be understood within national boundaries alone. Instead, they must be situated within the broader transboundary river basin context, where ecological vulnerability, upstream–downstream dependencies, and institutional arrangements intersect. This reinforces the need for regionally coordinated and gender-sensitive approaches to water governance across Central Asia.

4.2. Thematic Structure

The systematic analysis identifies seven thematic areas that characterise the existing research on gender, water governance, and climate-related challenges in Central Asia. The identified thematic clusters are not only descriptive but correspond to recurring structural dimensions of gender inequality. Specifically, the themes reflect patterns related to resource access, institutional participation, and environmental vulnerability, which are used as analytical categories in the subsequent interpretation.

These themes, summarised in **Table 1**, reflect the main clusters of topics addressed in the literature and demonstrate how environmental change, resource governance arrangements, and rural socio-economic conditions intersect with gender across diverse settings in the region. While the number of studies remains limited, the available evidence provides consistent insights into these interrelated dynamics.

Table 1. Thematic Clusters Identified in the Literature on Gender, Water Governance, and Climate in Central Asia.

Theme	Description	Representative Findings	Key Sources
Climate Change and Environmental Stressors	Increasing water scarcity, temperature rise, changing precipitation, land degradation	Women face a higher workload; more time spent collecting water; climate shocks reduce crop productivity	Azarov et al., 2025 [27], Panella, 2021 [28], Stucker and Lopez-Gunn, 2014 [29], Sidle et al., 2025 [30]
Feminization of Agriculture	Male migration increases women's share of agricultural work	Women manage farms but lack land rights, access to technology, and training	Ghimire et al., 2023 [18], Kim, 2014 [31], Balasubramanya, 2019 [32], Nixon and Owusu, 2017 [33], Mukhamedova and Wegerich, 2018 [34], Sidle et al., 2025 [30]
Gendered Barriers in Water Governance	Limited female representation in WUAs and basin institutions	Leadership norms are masculinized; women are excluded from decision-making	Azarov et al., 2025 [27], Gunchinmaa et al., 2011 [35], Sehring, 2022 [36], Seitalieva, 2024 [37],
Livelihood Vulnerabilities and Rural Poverty	Water scarcity, declining soil fertility, and poor infrastructure deepen gender inequality	Rural women have fewer assets and lower adaptive capacity	Azarov et al., 2025 [27], Omarova et al., 2019 [38]
Health and Environmental Impacts	Toxic exposure, dust storms, and poor Water, Sanitation and Hygiene (WASH) access	Higher reproductive health risks; water quality issues in schools and rural areas	Zhurabekova, 2018 [39], Toleubekov et al., 2022 [40]
Irrigation Practices and Institutional Performance	Outdated infrastructure, weak governance, and mismanagement	Women farmers receive less training; irrigation systems are unreliable	Ghimire et al., 2023 [18], Mukhamedova and Wegerich, 2014 [41], Toleubekov et al., 2022 [40], Bossenbroek and Zwarteveen, 2014 [42]
Adaptation and Resilience Pathways	Ecosystem-based adaptation, livelihood diversification, and community engagement	Education, gender-responsive water governance, and co-management	Uysal Oğuz et al., 2024 [3], Sen Roy, 2018 [43]

4.2.1. Climate Change and Environmental Stressors

Studies document a range of climate- and environment-related changes in rural areas of Central Asia, including reduced water availability, rising temperatures, altered precipitation patterns, glacier retreat, and land degradation [27]. Evidence from the Naryn region of Kyrgyzstan and the Pamir Mountains of Tajikistan shows that these shifts affect the reliability of water sources and the performance of agricultural and pastoral systems [44]. Across these settings, women's responsibilities in water collection [28], household provisioning, and subsistence agriculture are reported to be influenced by changes in water access and seasonal conditions, particularly in high-altitude and water-scarce communities [29].

4.2.2. Feminization of Agriculture

Research conducted in Tajikistan, Uzbekistan, and Kyrgyzstan reports an increased role of women in agricultural production, often associated with male labour migration or changes in rural labour structures [31,32,41]. Women are noted to take on substantial responsibilities in crop cultivation, livestock management, and daily farm operations. At the same time, studies highlight limited access to land ownership, credit, agricultural inputs, and extension services [33,35]. As a result, women's expanded agricultural roles are not accompanied by equivalent gains in access to productive resources or decision-making processes.

4.2.3. Gendered Barriers in Water Governance

Evidence from Uzbekistan, Kyrgyzstan, and Kazakhstan indicates that women remain underrepresented in irrigation and water governance structures [36–38]. Irrigation is frequently characterised as a male domain, and Water User Associations often reflect these gendered norms. Documented barriers include land-ownership requirements for membership, limited participation in meetings and leadership roles, and organisational practices that prioritise male engagement. These institutional and socio-cultural factors restrict women's opportunities to influence water allocation and governance processes.

4.2.4. Livelihood Vulnerabilities and Rural Poverty

Studies from rural Kazakhstan and Kyrgyzstan examine how water scarcity, limited infrastructure, and environmental pressures shape livelihood security [39,40]. Reported impacts include constraints on agricultural productivity, access to grazing resources, and the stability of household income. Women are noted to face specific limitations in access to assets, credit, and agricultural inputs, which can affect their ability to manage household livelihoods under conditions of environmental stress. These findings highlight the intertwined environmental and socio-economic constraints in rural communities.

4.2.5. Health and Environmental Impacts

Research from environmentally affected regions of Central Asia, including areas impacted by the Aral Sea crisis, documents health risks linked to dust storms, chemical pollutants, and inadequate water and sanitation infrastructure [34,42]. These conditions are associated with respiratory and reproductive health challenges and shape daily household routines. Women and girls are reported to be particularly affected due to their roles in domestic water management and caregiving, highlighting gender-differentiated implications of environmental degradation.

4.2.6. Irrigation Practices and Institutional Performance

Analyses of irrigation management in Central Asia point to persistent challenges related to ageing infrastructure, inconsistent water delivery, and overlapping institutional mandates [30]. These factors influence the predictability and equity of water distribution. In many contexts, women have limited access to irrigation-related information, technical training, or governance forums, constraining their capacity to adapt to fluctuating water availability. Existing governance arrangements often prioritise male landholders, reinforcing patterns of exclusion from water management roles.

4.2.7. Adaptation and Resilience Pathways

A smaller body of literature examines adaptation strategies aimed at addressing water variability and en-

vironmental change, including community-based initiatives, ecosystem-based approaches, and livelihood diversification [45]. Women's participation in these initiatives is noted in several cases, though shaped by access to information, institutional support, and socio-economic constraints. The studies provide examples of emerging practices to strengthen resilience while also identifying factors that influence women's ability to engage in adaptation processes.

4.3. Gender-Specific Barriers in Water and Irrigation Governance

The reviewed literature highlights several categories of barriers that influence women's access to water resources and participation in irrigation governance in Central Asia. Although the empirical base remains limited, the reviewed studies consistently identify barriers related to socio-cultural norms, land ownership, institutional practices, and access to resources. These barriers are reported across multiple country contexts and are associated with limited participation of women in formal water governance structures, particularly in Water User Associations (WUAs) and leadership roles.

First, socio-cultural expectations regarding gender roles shape who is regarded as an appropriate participant in irrigation management. In many rural areas, irrigation work and decision-making are viewed as male responsibilities, resulting in low levels of women's attendance at Water User Association (WUA) meetings and other governance forums [43]. These norms limit women's opportunities to contribute to discussions on water allocation or to engage in collective decision-making processes.

Second, resource-based inequalities, particularly in relation to land ownership, function as a key structural barrier. WUA membership and voting rights are frequently tied to formal land ownership, yet women in Central Asia tend to hold land at lower rates due to inheritance practices and household bargaining arrangements. As a consequence, women may be excluded from formal governance structures, even when they are responsible for aspects of agricultural production.

Third, capacity-related constraints, including unequal access to training, extension services, and technical knowledge, further limit women's engagement. Several assessments indicate that extension services and irrigation-related training courses often prioritise male farmers, resulting in fewer opportunities for women to obtain technical information or skills relevant to water management and agricultural productivity [46]. Limited access to such services can reinforce dependency on informal networks and reduce women's ability to adopt improved practices.

Fourth, institutional factors such as male-dominated leadership structures and the absence of gender-sensitive policy frameworks also contribute to women's limited influence within irrigation governance. In these contexts, women's participation, when present, is often nominal rather than substantive, with limited impact on governance outcomes.

Additionally, economic constraints intersect with these barriers. Lower average incomes and reduced access to credit can hinder women's ability to invest in irrigation equipment, improved seeds, or other technologies that enhance resilience to water variability [47]. These financial limitations shape the extent to which women can benefit from irrigation systems or respond to environmental stress.

Finally, environmental conditions in certain regions, including those affected by land degradation or poor water quality, have implications for household labour demands and health. Studies from environmentally stressed areas of Central Asia, including the Aral Sea region, document that women's responsibilities in domestic water management expose them more frequently to issues such as unreliable water quality or sanitation challenges. These conditions can increase workloads and health risks, particularly where infrastructure is limited.

Importantly, the intensity and configuration of these barriers vary across countries. The classification of barrier intensity across countries (e.g., high, moderate) is based on a qualitative comparative synthesis rather than quantitative measurement. Specifically, this categorization reflects:

(1) The frequency with which particular barriers are reported in the literature for each country;
(2) The convergence of evidence across multiple studies;
(3) The consistency of patterns across different thematic dimensions, including institutional, socio-cultural, and resource-based constraints. This approach provides an interpretive, evidence-informed comparison

and should be understood as indicative rather than statistically representative. The reviewed studies more frequently report institutional and socio-cultural barriers in Uzbekistan and Tajikistan, suggesting a relatively higher concentration of these constraints compared to other cases (**Table 2**). In these contexts, restrictive gender norms and institutional arrangements converge to reinforce exclusion. By contrast, the literature on Kazakhstan more often highlights the presence of formal gender policy frameworks, alongside reported gaps in implementation. However, a persistent implementation gap limits women's actual influence in decision-making processes. Kyrgyzstan represents an intermediate case, where women's participation in the workforce does not translate into proportional representation in governance, while in Turkmenistan, highly centralized governance structures and limited access to technical education further constrain women's engagement in the water sector.

Overall, the barriers summarised in **Table 3** illustrate how socio-cultural norms, institutional arrangements, and resource access patterns combine to shape women's participation in water and irrigation governance across the region.

Table 2. Indicative cross-country variation in reported gender barriers in water governance in Central Asia.

Country	Indicative Intensity of Reported Barriers	Dominant Barrier Types	Underlying Structural Drivers
Uzbekistan	High	Institutional, socio-cultural	Strong linkage between land ownership and WUA membership; entrenched gender norms limiting women's participation in technical and leadership roles
Tajikistan	High	Resource-based, socio-cultural	Feminization of agriculture driven by male migration without corresponding access to land, finance, or decision-making authority
Kazakhstan	Moderate	Institutional (implementation gap)	Advanced gender policy frameworks with persistent gaps in enforcement and representation in water governance institutions
Kyrgyzstan	Moderate	Institutional, political	Relatively higher female workforce participation, but limited translation into governance influence and leadership roles
Turkmenistan	High	Structural, institutional	Highly centralized governance systems and limited access to technical education constrain women's entry into water sector decision-making

Note: The classification of intensity is based on qualitative synthesis of the literature and reflects the relative frequency and consistency of reported barriers across studies. It does not represent a quantitative or statistically derived measure.

Table 3. Gender-specific barriers in water and irrigation governance in Central Asia.

Barrier Category	Specific Barriers Identified	Impacts on Women
Socio-Cultural Norms	Patriarchal decision-making; irrigation seen as "men's work"	Limited participation in governance; exclusion from WUA meetings
Land and Resource Rights	Few female landowners; unclear inheritance rights	Cannot become formal WUA members; lack of control over water allocation
Access to Training and Technology	Extension services target men; low access to farm machinery	Reduced productivity; dependency on informal networks
Institutional Barriers	Male-dominated leadership; limited gender-sensitive policies	Token participation; weaker adaptive capacity
Economic Constraints	Lower income; limited access to credit	Difficulty investing in climate-resilient technologies
Environmental Exposure	Toxic dust storms, water contamination	Higher health risks; increased workloads

These patterns indicate that gender-specific barriers in water governance are sustained by deeper structural factors rather than isolated constraints. Three key drivers explain their persistence. First, post-Soviet institutional legacies continue to shape water governance systems as technocratic and male-dominated, limiting women's access to leadership and decision-making roles despite formal reforms. Second, gendered land tenure systems act as a gatekeeping mechanism. Because participation in Water User Associations (WUAs) is often tied to land ownership, and women are less likely to own land, they are systematically excluded from formal governance structures. Third, the

feminization of agriculture has increased women's responsibilities due to male labor migration, without corresponding gains in access to resources or decision-making power. This creates a persistent gap between women's practical involvement and their institutional authority. Together, these factors demonstrate that gender inequalities in water governance are structurally embedded and require institutional, rather than purely policy-based, responses.

4.4. Entry Points for Strengthening Gender-Responsive Water Governance

Although the evidence base on gender-responsive water governance in Central Asia remains limited, existing studies and regional policy assessments highlight several areas where targeted interventions have the potential to enhance women's participation and improve equity in water management. These entry points, summarised in **Table 3**, relate to capacity development, institutional reform, technological improvements, livelihood diversification, environmental health measures, and community-based adaptation. Capacity-building initiatives are frequently identified as a practical mechanism for expanding women's engagement in irrigation and agricultural decision-making. Programmes that provide gender-inclusive training-such as technical workshops on irrigation scheduling, water-saving methods, or basic agricultural engineering-can broaden access to information and support women's contributions to farm-level water management. Regional assessments indicate that training opportunities designed to accommodate women's schedules and roles tend to improve participation rates and skill acquisition. Institutional reform constitutes another area of potential impact. Studies on water governance structures in Central Asia show that representation in Water User Associations (WUAs) remains uneven, with women often occupying few leadership positions. Measures such as gender-sensitive governance guidelines, participatory procedures, or voluntary targets for women's inclusion have been proposed in policy frameworks to address these disparities. While empirical evaluations of such reforms remain limited, evidence from comparable contexts suggests that more inclusive decision-making processes can enhance responsiveness to diverse user needs. Technological and infrastructure improvements also represent meaningful entry points, particularly in areas experiencing water scarcity or variable supply. Access to efficient irrigation technologies, reliable water delivery systems, and basic household water infrastructure has been associated with reduced labour burdens and improvements in agricultural productivity. These benefits can be especially relevant for women whose daily responsibilities involve water collection, household management, or small-scale farming. Livelihood diversification is highlighted in several regional studies as a strategy for reducing vulnerability to environmental variability. Introducing or supporting climate-resilient crops, expanding non-farm income opportunities, or enhancing market access can increase household economic stability. Such diversification may benefit women in particular when it supports their existing livelihood activities or reduces dependency on climate-sensitive income sources. Environmental health and WASH-related interventions are another area where gendered impacts are evident. Research from environmentally stressed areas, including the Aral Sea region, indicates that improvements in water quality, sanitation, and exposure mitigation can reduce health risks and lessen the domestic workload associated with managing limited or contaminated water suppliesSanitation and Hygiene (WASH. These interventions can indirectly support women's wellbeing and productivity.

Moving beyond general recommendations, the analysis identifies specific measures that can enhance women's meaningful participation. These include the introduction or strengthening of gender quotas within Water User Associations (WUAs) and other local governance bodies to ensure representation in decision-making processes. In parallel, targeted and inclusive training programs are essential to build women's technical, managerial, and leadership capacities, particularly in contexts where socio-cultural norms have historically limited their public roles.

Finally, community-based adaptation approaches-such as participatory planning, local water committees, or collaborative resource-management initiatives-are identified as pathways that can enhance social cohesion and empower diverse stakeholder participation. Although empirical studies documenting such initiatives in Central Asia remain limited, global evidence suggests that participatory governance structures can facilitate more inclusive decision-making and improve adaptation outcomes when designed to incorporate women's perspectives.

Taken together, the entry points outlined in **Table 4** demonstrate areas where targeted interventions may support more gender-responsive water governance in Central Asia. While further empirical research is needed to assess their effectiveness in practice, these approaches align with regional development priorities and offer a foundation for strengthening equity and resilience in water management systems.

Table 4. Positive Entry Points for Strengthening Gender-Responsive Water Governance.

Intervention Area	Example Actions	Expected Benefits
Capacity Building	Gender-inclusive irrigation training	Improves women's technical skills
Institutional Reform	Women's quotas in WUAs; gender mainstreaming	Increases representation and decision-making power
Technology and Infrastructure	Drip irrigation, clean water systems	Reduces labor burden; increases agricultural efficiency
Livelihood Diversification	Climate-resilient crops (quinoa, licorice)	Enhances income security
Health and Environmental Protection	Reducing toxic exposure, improving WASH	Reduces health disparities
Community-Based Adaptation	Participatory water governance	Strengthens social cohesion and resilience

4.5. Gender and Development (GAD) Perspective

The thematic analysis reveals several recurring empirical patterns across the reviewed literature that help explain the persistence of gender inequalities in water governance in Central Asia. These patterns are interpreted through the lenses of Gender and Development (GAD) and political ecology, which are used here as analytical frameworks to interpret consistent findings across studies rather than as externally imposed concepts. The application of GAD and political ecology frameworks in this study is operationalized through the systematic interpretation of empirically identified patterns across the reviewed literature, rather than as abstract theoretical references.

Across multiple studies, a consistent pattern emerges in which women increasingly assume responsibility for agricultural production, irrigation practices, and household water management, particularly in contexts of male labour migration. At the same time, their participation in formal governance structures-such as Water User Associations (WUAs)-remains limited due to land-based membership criteria, institutional practices, and socio-cultural norms.

This recurring mismatch between women's expanding roles and their limited decision-making authority can be interpreted through a GAD perspective as a "responsibility–authority gap," where increased productive and resource-management responsibilities are not accompanied by proportional access to institutional power, resource control, or formal recognition. Importantly, this interpretation is grounded in repeated empirical observations across the literature rather than introduced as a purely normative claim.

The literature further identifies several structural mechanisms underlying this gap. First, unequal access to productive resources-particularly land-functions as a key mechanism of exclusion. Since WUA membership and decision-making rights are often tied to land ownership, and land remains disproportionately concentrated among men, women are structurally underrepresented in governance spaces.

Second, evidence from multiple studies points to the persistence of institutional practices and organizational cultures that reproduce gendered inequalities. Even in contexts where gender equality policies exist, such as Kazakhstan, implementation gaps are frequently observed, with women's participation remaining limited or largely symbolic. This reflects the institutional reproduction of gender norms within governance structures.

Third, the literature consistently highlights the undervaluation of women's contributions to water management. Women's roles at the household and farm levels are often informal and insufficiently recognized within formal systems of governance, which reduces their influence in decision-making processes.

Taken together, these findings suggest that gender inequality in water governance cannot be explained solely by levels of participation, but is more closely linked to the persistence of unequal power relations and institutional rules that shape access, recognition, and authority.

A second recurring pattern concerns the persistence of exclusionary institutional arrangements across coun-

tries. Evidence indicates that water governance systems continue to operate through established rules and organizational structures that reproduce historical patterns of exclusion, including land-based access criteria, hierarchical decision-making processes, and the continued dominance of technocratic approaches.

These findings can be interpreted as evidence of institutional lock-in effects, whereby governance systems exhibit path dependency and limited adaptability to more inclusive practices. In the Central Asian context, this is closely linked to the persistence of post-Soviet institutional legacies, including centralized governance structures, male-dominated technical sectors, and limited participatory decision-making. These structural characteristics continue to shape who has access to decision-making power within water governance systems.

A third pattern relates to unequal access to knowledge, training, and technical expertise. Several studies report that irrigation training, extension services, and technical education opportunities are more accessible to men, while women rely more heavily on informal or experiential knowledge. In parallel, irrigation and water management continue to be framed as male-dominated domains within both education systems and professional environments.

From a political ecology perspective, these dynamics can be understood through three interrelated mechanisms identified across the literature:

(1) Control over resources, where access to water is mediated by institutions that prioritize landowners and technical actors;
(2) Environmental burden distribution, where women disproportionately experience the impacts of water scarcity, pollution, and inadequate infrastructure, particularly in vulnerable regions such as the Aral Sea Basin;
(3) Knowledge and authority asymmetry, where formal technical knowledge systems-historically associated with male-dominated institutions are prioritized over local and experiential knowledge, which is often associated with women's roles.

Together, these mechanisms illustrate how gender inequalities are embedded within broader socio-environmental systems shaped by power, historical legacies, and control over resources. The findings consistently indicate that gendered inequalities in water governance are structured across three interconnected domains:

- Resource allocation systems (e.g., irrigation access, land ownership, infrastructure);
- Institutional hierarchies (e.g., state agencies, WUAs);
- Environmental stressors (e.g., climate change, water scarcity).

These patterns are further reinforced by post-Soviet institutional legacies. Under the Soviet system, water governance was highly centralized, technocratic, and male-dominated, with limited community participation. Evidence from the reviewed literature suggests that these characteristics persist in contemporary governance systems through hierarchical institutional designs, limited inclusivity in decision-making, and the continued association of technical expertise with male-dominated professions. At the same time, post-Soviet transformations-including market reforms and labour migration-have contributed to the feminization of agriculture without corresponding gains in institutional authority, reinforcing existing inequalities.

Across the reviewed cases, three interrelated structural drivers emerge consistently:

(1) Institutional lock-in effects, reflected in persistent governance rules that limit inclusivity;
(2) Socio-cultural reinforcement mechanisms, where norms defining irrigation and water management as male domains continue to shape participation;
(3) A mismatch between roles and rights, where women's increasing responsibilities are not matched by equivalent access to decision-making power or resources.

Importantly, the cross-country variation identified in this study reflects differences in how these structural factors interact. For example, Kazakhstan demonstrates relatively advanced gender policy frameworks, yet persistent implementation gaps limit women's representation in decision-making. Kyrgyzstan shows relatively higher female labour participation but limited translation into governance influence. In Uzbekistan and Tajikistan, stronger convergence of institutional and socio-cultural barriers reinforces exclusion, while in Turkmenistan, highly centralized governance structures further constrain participatory inclusion.

These differences suggest that gender outcomes are shaped not only by policy presence, but also by governance structures, institutional openness, and enforcement capacity.

Importantly, these theoretical interpretations are grounded in recurring empirical patterns identified across the reviewed studies, particularly those related to institutional exclusion, unequal resource access, and gendered divisions of labour. In this way, the integration of GAD and political ecology frameworks provides a systematic and empirically grounded explanation of how gender inequalities in water governance are reproduced across different national contexts. Taken together, this analytical approach allows the study to move beyond a descriptive synthesis toward identifying generalizable structural mechanisms shaping gender inequality in water governance across Central Asia.

These national differences are further shaped by transboundary hydrological conditions. The study integrates upstream–downstream dynamics into the gender analysis, showing how water availability, seasonal variability, and interstate dependencies influence local governance arrangements and participation opportunities. For example, upstream countries face distinct management pressures related to water storage and energy production, while downstream countries are more affected by irrigation demands and allocation uncertainties. These dynamics intersect with gendered roles and institutional constraints, reinforcing the need for context-specific and regionally coordinated approaches to promoting inclusive water governance.

The findings of this study have direct implications for policy frameworks and regional cooperation efforts in the Aral Sea Basin. By revealing how gendered participation is shaped by both socio-cultural constraints and transboundary governance dynamics, the results underscore the need to move beyond formal commitments to gender inclusion toward more context-sensitive and operational strategies. In particular, the identified "responsibility–authority gap" highlights a persistent disconnect between women's roles in water management at the local level and their limited influence in decision-making processes.

Aligning with the priorities of SDG 5, SDG 6, and SDG 13, our findings suggest that gender-responsive water governance must be embedded within broader climate adaptation and transboundary cooperation policies. This includes not only increasing women's representation in Water User Associations and local institutions, but also ensuring that institutional reforms address structural barriers such as access to resources, capacity-building opportunities, and inclusive infrastructure. At the regional level, integrating gender considerations into transboundary water agreements and basin-level strategies could enhance both equity and sustainability outcomes. In this way, the study contributes to ongoing policy discussions by providing evidence-based entry points for more inclusive and resilient water governance in Central Asia.

A key contribution of this analysis is the conceptualization of the "responsibility–authority gap" as a unifying explanatory framework. Across all cases, women are found to play substantial roles in day-to-day water management, particularly at the household and community levels, yet remain underrepresented in formal decision-making structures. This disconnect highlights a systemic imbalance in which responsibility for water use and management does not translate into corresponding authority or influence. By framing the findings through this lens, the study moves beyond descriptive accounts of participation to provide a more integrated explanation of persistent gender inequalities in water governance, while also offering a basis for cross-country comparison and policy intervention.

4.6. Limitation

This study has several limitations that should be acknowledged when interpreting the findings. First, the analysis is based on a relatively small sample of studies (n = 20) drawn exclusively from the Scopus database. While Scopus provides access to high-quality, peer-reviewed literature, this restriction may have led to the exclusion of relevant studies published in other databases or in grey literature, particularly regional reports and locally produced research.

Second, the review was limited to publications in English and Russian. This language selection may have constrained the representation of local knowledge and perspectives, especially in contexts where research is published in national languages. As a result, certain country-specific dynamics and locally grounded insights may be underrepresented.

Third, the distribution of studies across countries is

uneven. While Kazakhstan and Uzbekistan are relatively well represented in the dataset, evidence from countries such as Turkmenistan and Tajikistan remains limited. This imbalance affects the depth of analysis and means that cross-country comparisons should be interpreted with caution, as they reflect variations in available literature rather than comprehensive national-level assessments.

Fourth, the study relies on a qualitative thematic synthesis of existing literature. While this approach enables the identification of recurring patterns across studies, it does not allow for statistical generalization or precise measurement of the relative intensity of barriers across countries. The comparative analysis presented in this study should therefore be understood as indicative and evidence-informed rather than definitive.

Finally, as with any systematic review, the study is subject to potential selection and screening bias. Although clear inclusion criteria were applied, the process of identifying and interpreting relevant studies may have influenced the composition of the final dataset and the patterns identified.

5. Conclusions

This study provides a structured synthesis of the role of women in water management across Central Asia, highlighting persistent gender inequalities despite increasing recognition in policy frameworks. Importantly, the contribution of this study lies not only in synthesizing existing knowledge, but in offering a theory-informed explanation of why gender inequalities persist across different national contexts. By integrating GAD and political ecology perspectives with the reviewed academic evidence, the analysis identifies recurring structural mechanisms including institutional path dependency, unequal access to productive resources, and an authority gap that shape women's participation in water governance. This shifts the discussion beyond descriptive accounts toward a more analytical understanding of how gendered power relations are reproduced within water governance systems in Central Asia. The findings emphasize that structural barriers, including limited access to resources and decision-making power, continue to constrain women's participation. The Central Asian context-characterized by transboundary water systems and post-Soviet institutional legacies-adds complexity to gender and water governance dynamics. Future research should focus on empirical, field-based studies to better understand local-level dynamics and develop context-specific policy interventions. Overall, the central message is that improving water governance in Central Asia requires moving women's roles from informal responsibility to formal, measurable decision-making power. A gender-transformative approach is essential to meet SDGs 5, 6, and 13 and to support sustainable development in the Aral Sea Basin and broader Central Asia. Future research should build on this analytical framework through empirical, field-based studies, while policy efforts should move beyond formal inclusion toward transforming the institutional rules and resource access mechanisms that underpin gender inequality in water governance.

Author Contributions

Conceptualization, Z.K.; methodology, E.D.; formal analysis, M.M., E.D., K.U., R.K., M.K. and K.N.; investigation, M.S. and O.P.; data curation, M.S. and O.P.; writing—original draft preparation, Z.K.; writing—review and editing, Z.K., M.S., M.M. and K.U.; visualization, M.M., E.D., O.P., R.K., M.K. and K.N.; supervision, Z.K.; project administration, Z.K. All authors have read and agreed to the published version of the manuscript.

Funding

This work received no external funding.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

All the data is presented in the article.

Acknowledgements

The authors express their sincere gratitude to the organizers of the 7th Aral Sea Summer School, hosted in Kazakhstan by the Kazakh-German University (DKU) and the International Fund for Saving the Aral Sea (IFAS). Participation in this program significantly contributed to the development of the research presented in this article. It provided valuable academic exchange, field experience, and networking opportunities with experts in water management, climate change adaptation, and sustainable development in Central Asia. We also thank the lecturers, invited speakers, and field specialists whose insights and guidance enriched our understanding of regional environmental challenges and innovative approaches to water governance. Appreciation is extended to the fellow participants for their constructive discussions, collaboration, and shared professional support throughout the program. Finally, we acknowledge the institutional and logistical support provided by the Kazakh-German University and the partner organizations that facilitated the summer school activities. Their commitment to capacity building and knowledge sharing in the Aral Sea Basin has played an essential role in advancing research and education on water sustainability in the region.

Conflicts of Interest

The authors declare no conflict of interest.

AI Use Statement

The authors declare that no artificial intelligence (AI) tools were used in the preparation of this manuscript.

References

[1] Tynchtyk, M., Akylbek, U., Mambetkulova, A., et al., 2024. Water resources in Commonwealth of Independent States Countries: A literature review. Advanced Logistic Systems: Theory and Practice. 18, 87–96.

[2] Durán-Sánchez, A., Álvarez-García, J., González-Vázquez, E., et al., 2020. Wastewater Management: Bibliometric Analysis of Scientific Literature. Water. 12, 2963.

[3] Uysal Oğuz, C., Özkan, A., Özer, S., 2024. Socio-economic and Environmental Dimensions of the Aral Sea Disaster from the Sustainable Development Perspective. Bilig. 116, 29–58.

[4] Khasanov, S., Li, F., Kulmatov, R., et al., 2022. Evaluation of the perennial spatio-temporal changes in the groundwater level and mineralization, and soil salinity in irrigated lands of arid zone: As an example of Syrdarya Province, Uzbekistan. Agricultural Water Management. 263, 107444.

[5] Kannazarova, Z., Juliev, M., Muratov, A., et al., 2025. Bibliometric analysis of publications about soil salinity in Central Asia during 2000–2022 with a special look at the importance of drainage. Dokuchaev Soil Bulletin. 123, 273–299.

[6] Sehring, J., Sharipova, B., Assubayeva, A., 2024. The politics of water governance in Central Asia: Institutionalizing river basin management. In: Fritsch, O. (Ed.). Handbook on the Governance and Politics of Water Resources. Edward Elgar Publishing: Cheltenham, UK. pp. 205–217.

[7] Bowen, D.S., Miller, A.L., 2018. Education, leadership, and conservation: Empowering young Q'eqchi' women in Guatemala. International Journal of Educational Development. 59, 28–34.

[8] UN, 2023. Water and Gender. UN: New York, NY, USA. Available from: https://www.unwater.org/water-facts/water-and-gender

[9] World Bank, 2019. Women in Water Utilities: Breaking Barriers. World Bank: Washington DC, USA. Available from: https://www.worldbank.org/en/news/feature/2019/08/27/breaking-barriers

[10] Trivedi, A., 2018. Women Are the Secret Weapon for Better Water Management. Available from: https://www.wri.org/insights/women-are-secret-weapon-better-water-management (cited 3 March 2026).

[11] Baisakalova, A., Tankibayeva, A., 2025. Current Status of Women in Public Administration Leadership in Kazakhstan. In: Tankibayeva, A., McLean, G.N., Seitova, D. (Eds.). Central Asian Women in Leadership: Challenges and Opportunities. Springer Nature Switzerland: Cham, Switzerland. pp. 33–60.

[12] McLean, G.N., 2025. Empowered Voices: Celebrating Women's Leadership across Central Asia's Five Republics. In: Tankibayeva, A., McLean, G.N., Seitova, D. (Eds.). Central Asian Women in Leadership: Challenges and Opportunities. Springer Nature Switzerland: Cham, Switzerland. pp. 1–8.

[13] United Nations Uzbekistan, 2021. Uzbekistan United Nations Country Results Report 2020: United Nations Development Assistance Framework (UNDAF) 2016–2020. UN: Tashkent, Uzbekistan. Available

from: https://uzbekistan.un.org/en/123773-uzbekistan-united-nations-country-results-report-2020

[14] Atakhanova, Z., Howie, P., 2022. Women in Kazakhstan's Energy Industries: Implications for Energy Transition. Energies. 15(13), 4540.

[15] Begishbek Kyzy, M., 2023. Women in water resources management: Case study of water user associations in Karasuu district, Kyrgyzstan. Hydrometeorology and ecology. 2(109), 34–51.

[16] National Statistics of the Kyrgyz Republic. 2018. Employment population by sex and age: Women. Available from: https://stat.gov.kg/en/opendata/category/2260/?utm_source

[17] The World Bank, 2022. Tajikistan: Strengthening Water and Irrigation Management Project. The World Bank: Washington, DC, USA. Available from: https://documents.worldbank.org/en/publication/documents-reports/documentdetail/191641663678738939

[18] Ghimire, T., Harou, A.P., Balasubramanya, S., 2023. Migration, gender labor division and food insecurity in Tajikistan. Food Policy. 116(2), 102438.

[19] Sharipova, B., Chemayeva, N., 2022. Adaptive water governance in Central Asia: Un-puzzling the concept. Central Asian Journal of Water Research. 8(2). 1–18

[20] FAO. 2024. Innovative Ecosystem Restoration and Capacity Building in the Aral Sea Region. FAO: Rome, Italy. Available from: https://www.fao.org/countryprofiles/news-archive/detail-news/en/c/1730753/?utm_source

[21] Rahaman, M.M., Varis, O. (Eds.), 2008. Central Asian Waters: Social, Economic, Environmental and Governance Puzzle. Helsinki University of Technology: Espoo, Finland. (in Finnish)

[22] O'Hara, S.L., Hannan, T., 2016. Irrigation and Water Management in Turkmenistan: Past Systems, Present Problems and Future Scenarios. Europe-Asia Studies. 51(2), 21–41.

[23] Lefore, N., Weight, E., Mukhamedova, N., 2017. Improving Gender Equity in Irrigation: Application of a Tool to Promote Learning and Performance in Malawi and Uzbekistan. International Water Management Institute (IWMI): Colombo, Sri Lanka. DOI: https://doi.org/10.5337/2017.217

[24] Kannazarova, Z., Muqumova, D., Norkobilov, M., et al., 2025. Women's Leadership in Science in Uzbekistan. In: Tankibayeva, A., McLean, G.N., Seitova, D. (Eds.). Central Asian Women in Leadership: Challenges and Opportunities. Springer Nature Switzerland: Cham, Switzerland. pp. 87–109.

[25] Bozorova, M.A., 2020. Press coverage of gendered labour division in the water sector of Uzbekistan. Journal of Central Asian Social Studies. 6(2), 42–65.

[26] Asian Development Bank (ADB), 2020. Gender Equality and the Sustainable Management of Natural Resources in Central Asia. Asian Development Bank: Metro Manila, Philippines.

[27] Azarov, A., Kulikov, M., Sidle, R.C., et al., 2025. Climate Change and Its Impact on Natural Resources and Rural Livelihoods: Gendered Perspectives from Naryn, Kyrgyzstan. Climate. 13(3), 57.

[28] Panella, T., 2021. Development for water, food, and nutrition security in a competitive environment—An Asian perspective. Irrigation and Drainage. 70(3), 380–387.

[29] Stucker, D., Lopez-Gunn, E. (Eds.), 2014. Adaptation to Climate Change through Water Resources Management: Capacity, Equity and Sustainability. Routledge: London, UK.

[30] Sidle, R.C., Caiserman, A., Azarov, A., et al., 2025. Multifaceted effects of climate dynamics and other environmental stressors on women farmers in the Pamir Mountains. Regional Environmental Change. 25, 41.

[31] Kim, E., 2014. Conceptual practice of 'rural wellbeing' in Uzbekistan: Contradictions and implications for gender equality. Rural Society. 23(3), 243–256.

[32] Balasubramanya, S., 2019. Effects of training duration and the role of gender on farm participation in water user associations in Southern Tajikistan: Implications for irrigation management. Agricultural Water Management. 216, 1–11.

[33] Nixon, R., Owusu, F., 2017. Choice, Inclusion, and Access to Information: Understanding Female Farmers' Participation in Kyrgyzstan's Water-User Associations. Sustainability. 9(12), 2346.

[34] Mukhamedova, N., Wegerich, K., 2018. The feminization of agriculture in post-Soviet Tajikistan. Journal of Rural Studies. 57, 128–139.

[35] Gunchinmaa, T., Hamdamova, D., Koppen, B.V., 2011. Gender in Irrigated Farming: A Case Study in the Zerafshan River Basin, Uzbekistan. Gender, Technology and Development. 15(2), 201–222.

[36] Sehring, J., 2022. Gendered River Basin Institutions: The Chu–Talas Commission in Central Asia. In: Sehring, J., ter Horst, R., Zwarteveen, M. (Eds.). Gender Dynamics in Transboundary Water Governance: Feminist Perspectives on Water Conflict and Cooperation. Routledge: London, UK. pp. 129–145.

[37] Seitalieva, G.A., 2024. Conflicts over water and energy resources in Central Asia and their impact on women's rights. BIO Web of Conferences. 107, 04004.

[38] Omarova, A., Tussupova, K., Hjorth, P., et al., 2019. Water Supply Challenges in Rural Areas: A Case Study from Central Kazakhstan. International Journal of Environmental Research and Public Health. 16(5), 688.

[39] Zhurabekova, G., 2018. The Toxicity of Lindane in the Female Reproductive System: A Review on the Aral Sea. Euromediterranean Biomedical Journal. 13(24), 104–108.

[40] Toleubekov, B., Bolatova, Z., Stafström, M., 2022. Assessing Access to WASH in Urban Schools during COVID-19 in Kazakhstan: Case Study of Central Kazakhstan. International Journal of Environmental Research and Public Health. 19(11), 6438.

[41] Mukhamedova, N., Wegerich, K., 2014. Integration of Villages into WUAs: The Rising Challenge for Local Water Management in Uzbekistan. International Journal of Water Governance. 2(2–3), 153–170.

[42] Bossenbroek, L., Zwarteveen, M., 2014. Irrigation management in the Pamirs in Tajikistan: A man's domain? Mountain Research and Development. 34(3), 266–275.

[43] Sen Roy, S., 2018. Water. In Linking Gender to Climate Change Impacts in the Global South. Springer International Publishing: Cham, Switzerland. pp. 75–91.

[44] Sidle, R.C., 2020. Dark Clouds over the Silk Road: Challenges Facing Mountain Environments in Central Asia. Sustainability. 12(2), 9467.

[45] Stulina, G.V., 2015. Role of Women in the Irrigated Agriculture Sector in the Fergana Valley: Findings of Field Surveys Irrigation and Drainage. 64(4), 491–500.

[46] Srivastava, S., Dewi, M.B.K., Suman, R.K., et al., 2022. Managing in-Land Water Disasters in the Aral Sea: Sub-Regional Pathways for Adaptation and Resilience: An Analysis of Climate Change Impact on the Aral Sea Transboundary Hazard. United Nations ESCAP, IDD: Bangkok, Thailand.

[47] OECD, 2025. OECD Economic Outlook, Interim Report September 2025: Finding the Right Balance in Uncertain Times. OECD: Paris, France. Available from: https://www.oecd.org/en/publications/oecd-economic-outlook-interim-report-september-2025_67b10c01-en.html