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| Research Article |

Regulating Transboundary Water Resources and Hydraulic Infrastructure in Central Asia

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Abstract: Despite the formal recognition of international water law principles, Central Asian states have not effectively incorporated these norms into enforceable domestic regulations governing the Amu Darya and Syr Darya basins. This study aims to examine the extent to which international legal standards governing transboundary water management are incorporated into domestic regulatory regimes and to evaluate the capacity of existing legal frameworks to address emerging cross border risks related to water allocation and hydrotechnical safety. The research employs a doctrinal and comparative legal approach by interpreting treaty obligations and systematically analysing national legislation and institutional arrangements in selected Central Asian jurisdictions. The findings identify three principal issues. First, states formally recognise the principle of equitable utilisation but fail to establish precise allocation rules and effective enforcement mechanisms. Second, national authorities regulate hydrotechnical safety primarily within domestic legal systems without developing binding cross border supervision mechanisms. Third, fragmented institutional mandates weaken coordinated compliance with transboundary obligations. The study concludes that institutional fragmentation rather than normative scarcity constitutes the principal regulatory challenge, and that sustainable regional water governance requires integrated basin level institutions, harmonised safety standards, and enforceable cooperative mechanisms among riparian states.

Keywords: Governance; Hydraulic; Legal Challenges; Water;

INTRODUCTION

The protection and sustainable utilization of freshwater resources in transboundary river basins constitutes a significant legal and policy challenge in the twenty first century. This challenge becomes particularly pronounced in Central Asia, where the Amu Darya and Syr Darya river systems support agricultural production, hydropower development, and the broader socio economic stability of the region.[1] Although international law establishes a normative framework governing shared watercourses through principles such as equitable and reasonable utilisation, the prevention of significant transboundary harm, prior notification of planned measures, and

[1] Alkama, R., Kedida, E.G., Arsano, Y., 2024. Transboundary water governance challenges and environmental pressures in the Upper Blue Nile Basin: Implications for conservation and integrated management. Journal of Hydrology: Regional Studies 41, 101913. https://doi.org/10.1016/j.ejrh.2024.101913

cooperation in good faith, Central Asian states have not yet implemented these principles coherently within their domestic legal systems.[2]

Legal fragmentation persists in the regulation of the Amu Darya and Syr Darya basins, particularly in relation to water allocation and the governance of hydrotechnical infrastructure safety. This study therefore examines the normative inconsistency between international transboundary water obligations and the domestic regulatory frameworks applied by regional states.[3] National legislation in Central Asian states formally affirms state sovereignty over water resources and prioritizes domestic energy production and irrigation needs, yet these legal frameworks do not establish clear statutory mechanisms that translate equitable allocation principles into operational rules.[4] This regulatory limitation is particularly evident in the governance of the Amu Darya and Syr Darya basins. Domestic regulations primarily govern dam safety, environmental risk assessment, and emergency response within national jurisdictions, while regional authorities have not developed harmonized standards or binding coordination procedures. Large scale hydraulic infrastructure projects therefore generate potential downstream impacts without an effective cross border regulatory framework.[5]

This condition produces a structural tension between doctrines of territorial sovereignty embedded in national law and cooperative obligations established by international water law. The absence of integrated basin level governance further intensifies institutional fragmentation and reduces legal predictability in shared river systems. Consequently, this regulatory disjunction constitutes the central doctrinal and policy problem examined in the present research.[6] The Amu Darya and Syr Darya basins form the structural foundation of regional water security in Central Asia. Rapid population growth, climate variability, increasing energy demand, and environmental degradation, most visibly reflected in the crisis of the Aral Sea, have significantly intensified the complexity of water governance in the region. At the same time, national water legislation across Central Asian states reflects divergent economic and strategic priorities, which produce considerable variation in regulatory scope, institutional capacity, and the effectiveness of legal enforcement mechanisms governing shared water resources. [7]

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[2] Petra Kinga Kézai, Petra Kinga Kézai and Agnieszka Skala, 'Remarks on the Location Theories of Startups: A Case Study on the Visegrad Countries', *Regional Science Policy and Practice*, 16.9 (2024), 100063 https://doi.org/10.1016/j.rspp.2024.100063

[3] Andrea Caragliu and Paolo Landoni, 'Firm Aggregations and Firm Performance: Evidence from Network Contracts', *Regional Science Policy and Practice*, 16.9 (2024), 100064 https://doi.org/10.1016/j.rspp.2024.100064

[4] Kaiyrbek Orazaliev and others, 'Current Regulation of Water Relations in Central Asia', *Regional Science Policy and Practice*, 16.9 (2024), 100038 https://doi.org/10.1016/j.rspp.2024.100038

[5] Kulyanda K. Nurasheva and others, 'Capital Inflow and Investment Attractiveness of Central Asian Countries (on the Example of Kazakhstan)', *Regional Science Policy and Practice*, 16.9 (2024), 100039 https://doi.org/10.1016/j.rspp.2024.100039

[6] Ozenbayeva, A., Yerezhepkyzy, R., Yessetova, S., Jangabulova, A., & Beissenbayeva, M. (2022). Legal regulation of transboundary water resources of the Republic of Kazakhstan. Environmental Development, 44, 100781. https://doi.org/10.1016/j.envdev.2022.100781

[7] Orr Simon, Jamie Pittock, Ashok Chapagain, and David Dumaresq. 2021. "Dams on the Transboundary Rivers of Central Asia: Legal, Institutional and Environmental Challenges." International

From a hydropolitical perspective, the interaction between geographical positioning and political authority significantly shapes patterns of cooperation and tension among states sharing transboundary water resources. Although previous scholarship has examined interstate bargaining dynamics between upstream and downstream countries, it has not sufficiently analysed the regulatory coherence between international legal obligations and their domestic implementation mechanisms.[8] This analytical gap becomes particularly important in the governance of the Amu Darya and Syr Darya basins, where upstream states increasingly frame shared river systems as strategic national resources.[9] In doing so, they often invoke interpretations of territorial sovereignty that may conflict with cooperative obligations established under international water law, thereby generating legal uncertainty and complicating the development of coordinated regional water governance. The urgency of examining this issue lies in the widening gap between formal treaty commitments and their practical operationalization within national legal systems. The post-Soviet transition from a centrally coordinated management structure to fragmented interstate governance has generated doctrinal uncertainty, regulatory inconsistencies, and overlapping institutional competences.[10]

In the absence of harmonised allocation standards, binding safety procedures, and enforceable coordination mechanisms, the expansion of large-scale hydropower infrastructure in the Amu Darya and Syr Darya basins increases the risk of downstream environmental damage, legal disputes, and heightened regional tension. International water law restricts unilateral state action by establishing reciprocal obligations rather than absolute territorial control over shared watercourses.[11] However, the practical effectiveness of principles such as equitable utilisation, the prevention of transboundary harm, prior notification of planned measures, and the exchange of information depends on their consistent incorporation into domestic legal systems.[12] This study therefore examines whether existing legal frameworks in Central Asia are capable of translating international obligations into enforceable regulatory practice. Clarifying this issue contributes to a deeper doctrinal understanding of the tension between sovereignty and cooperative duties while simultaneously supporting the

Journal of Water Resources Development 37 (1): 1–21. https://doi.org/10.1080/07900627.2019.1706823

[8] Ai Qing Feng and others, 'Will the 2022 Compound Heatwave–Drought Extreme over the Yangtze River Basin Become Grey Rhino in the Future?', *Advances in Climate Change Research*, 15.3 (2024), 547–56 https://doi.org/10.1016/j.accre.2024.05.004

[9] Gang Feng Zhang and others, 'Variability and Trends of Near-Surface Wind Speed over the Tibetan Plateau: The Role Played by the Westerly and Asian Monsoon', *Advances in Climate Change Research*, 15.3 (2024), 525–36 https://doi.org/10.1016/j.accre.2024.04.007

[10] Bin Zhou and others, 'Process-Driven Susceptibility Assessment of Glacial Lake Outburst Debris Flow in the Himalayas under Climate Change', *Advances in Climate Change Research*, 15.3 (2024), 500–514 https://doi.org/10.1016/j.accre.2023.11.002

[11] Xiang Li and others, 'Intensified Warming Suppressed the Snowmelt in the Tibetan Plateau', *Advances in Climate Change Research*, 15.3 (2024), 452–63 https://doi.org/10.1016/j.accre.2024.06.005

[12] Yao Li and others, 'Frequency and Size Change of Ice–Snow Avalanches in the Central Himalaya: A Case from the Annapurna II Glacier', *Advances in Climate Change Research*, 15.3 (2024), 464–75 https://doi.org/10.1016/j.accre.2024.03.006

development of stronger legal certainty, environmental protection, and long-term regional stability in shared river governance. [13]

The governance of transboundary river basins in Central Asia operates at the intersection of international water law, national sovereignty doctrines, energy security strategies, and infrastructure safety regulation. The Amu Darya and Syr Darya systems form the core of regional water security, supporting irrigated agriculture, hydropower production, and socio-economic stability. However, expanding hydraulic construction, demographic pressures, climate variability, and ecological degradation have intensified regulatory complexity. In this setting, water governance is no longer limited to allocation questions but increasingly encompasses infrastructure safety, environmental risk management, and cross-border liability.[14]

International legal standards establish reciprocal obligations governing shared watercourses, including equitable utilisation, prevention of significant transboundary harm, prior notification of planned measures, and cooperation in good faith. At the domestic level, however, water resource management and dam safety regulation remain primarily framed within sovereign control and national development priorities.[15] Large-scale hydropower initiatives, such as the Rogun Hydropower Plant, illustrate this dynamic, as they combine legitimate national energy objectives with potential downstream environmental and seismic risks. This situation exposes a broader structural issue: the absence of harmonised regional mechanisms linking hydraulic infrastructure oversight with transboundary water governance.[16]ν

Existing scholarship has extensively examined hydropolitical relations in Central Asia. Studies grounded in hydro-hegemony theory analyse power asymmetries between upstream and downstream states. Other research emphasises allocation principles, treaty interpretation, environmental consequences of dam construction, and the evolution of water diplomacy frameworks. Multi-level governance models have also been proposed, highlighting the role of regional institutions and non-state actors in cooperative water management. While these contributions provide valuable insights into interstate bargaining, sovereignty narratives, and institutional cooperation, they tend to treat water allocation and infrastructure safety as analytically separate domains. A significant research gap therefore remains. Limited attention has been given to the regulatory interface between transboundary water

[13] United Nations (UN-Water), *The United Nations Global Water Conventions: Fostering Sustainable Development and Peace* (Geneva: United Nations, 2020), available at: https://www.unwater.org/publications/the-united-nations-global-water-conventions. United Nations, *Convention on the Protection and Use of Transboundary Watercourses and International Lakes* (Helsinki, 1992), available at: https://treaties.un.org.

[14] Peng Cui and others, 'Disastrous Effects of Climate Change on High Mountain Asia', *Advances in Climate Change Research*, 15.3 (2024), 365–66 https://doi.org/10.1016/j.accre.2024.06.004

[15] Republic of Tajikistan. (2000). *Water Code of the Republic of Tajikistan*. Adopted on 29 November 2000. FAOLEX. Available at: https://faolex.fao.org/docs/pdf/taj34375E.pdf

[16] Hao Wang and others, 'Disaster Effects of Climate Change in High Mountain Asia: State of Art and Scientific Challenges', *Advances in Climate Change Research*, 15.3 (2024), 367–89 https://doi.org/10.1016/j.accre.2024.06.003

law and domestic hydrotechnical safety regimes [17] Comparative assessment of discrepancies in dam safety standards, environmental risk procedures, liability frameworks, and supervisory competences across national legal systems is underdeveloped. Consequently, the coherence between water allocation governance and infrastructure-related risk prevention remains insufficiently theorised and inadequately examined from a doctrinal perspective.[18]

This study addresses that gap by conceptualising transboundary water management and hydraulic safety regulation as interdependent components of a unified governance architecture. Through a comparative and doctrinal analysis of treaty obligations, national legislation, and institutional mandates, the research evaluates whether current legal arrangements ensure structural consistency and effective compliance. The scientific novelty of the study lies in integrating infrastructure safety regulation into the broader framework of transboundary water governance and identifying normative and institutional inconsistencies that undermine legal predictability. By proposing mechanisms for coordinated oversight and enhanced legal interoperability, the article contributes both to doctrinal clarification and to the development of sustainability-oriented regional regulatory design.[19]

Climate variability, ageing hydraulic infrastructure, and increasing technogenic pressures intensify not only environmental risks but also legal responsibility in the governance of shared water systems. From a regulatory perspective, these developments raise a fundamental question: whether existing national legal frameworks on dam safety, environmental impact assessment, and emergency prevention are sufficiently aligned with binding international obligations governing transboundary watercourses. [20] Under contemporary international water law, states are required not only to allocate water equitably but also to prevent significant transboundary harm and exercise due diligence in the planning and operation of infrastructure with potential cross-border effects. However, domestic legislation in several Central Asian jurisdictions continues to regulate hydraulic installations primarily within a sovereign and territorially confined framework, without embedding enforceable cross-border procedural safeguards.[21]

[17] Ting Xing Chen and others, 'Using Copula Functions to Predict Climatic Change Impacts on Floods in River Source Regions', *Advances in Climate Change Research*, 15.3 (2024), 406–18 https://doi.org/10.1016/j.accre.2024.04.006

[18] Jian Sheng Hao, Yan Wang and Lan Hai Li, 'Snowpack Variations and Their Hazardous Effects under Climate Warming in the Central Tianshan Mountains', *Advances in Climate Change Research*, 15.3 (2024), 442–51 https://doi.org/10.1016/j.accre.2024.06.001

[19] Ozenbayeva, A., Yerezhepkyzy, R., Yessetova, S., Jangabulova, A., & Beissenbayeva, M. (2022). Legal regulation of transboundary water resources of the Republic of Kazakhstan. Environmental Development, 44, 100781. https://doi.org/10.1016/j.envdev.2022.100781

[20] Yan Wang and others, 'Antecedent Snowmelt and Orographic Precipitation Contributions to Water Supply of Pakistan Disastrous Floods, 2022', *Advances in Climate Change Research*, 15.3 (2024), 419–30 https://doi.org/10.1016/j.accre.2023.12.002

[21] Hui Zhang and others, 'Variations and Future Projections of Glacial Discharge of Urumqi River Headwaters, Eastern Tien Shan (1980s–2017)', *Advances in Climate Change Research*, 15.3 (2024), 537–46 https://doi.org/10.1016/j.accre.2024.05.001

Scholarly debate on transboundary water use in Central Asia has traditionally concentrated on allocation principles, treaty interpretation, and interstate coordination between upstream and downstream countries. Core doctrinal reference points include equitable and reasonable utilisation, the obligation not to cause significant harm, prior notification, and cooperation in good faith. While this body of research has substantially clarified the normative structure of international water law, it has tended to treat infrastructure safety as a technical or environmental issue rather than as a component of binding legal compliance.[22]

A parallel strand of scholarship has examined the environmental consequences of hydropower development and the incorporation of international conventions and bilateral agreements into domestic legislation. Yet these studies rarely conduct a systematic doctrinal analysis of how dam safety regulation, liability rules, risk assessment procedures, and supervisory competences interact with transboundary obligations. In particular, insufficient attention has been paid to the normative coherence between sovereign control provisions in national water codes and the cooperative duties embedded in international law. This doctrinal gap creates uncertainty regarding the scope of due diligence, the standard of preventive conduct required, and the allocation of responsibility in cases of infrastructure-related harm. Accordingly, a legal analysis that integrates hydraulic infrastructure safety within the broader architecture of transboundary water governance is necessary to clarify regulatory inconsistencies and strengthen normative coherence. Addressing this issue is essential not only for environmental protection but also for ensuring legal predictability, compliance with international obligations, and the stability of interstate relations in the region.[23]

This study investigates the evolving regulatory models governing shared watercourses and hydraulic infrastructure across Central Asia. It evaluates the structural coherence and practical effectiveness of these legal arrangements and explores mechanisms capable of enhancing interstate coordination within a sustainability-oriented governance framework. The analysis adopts a comparative and doctrinal perspective, integrating historical developments, institutional practice, and contemporary regulatory trends. By examining the distribution of legal competences and oversight mechanisms, the study assesses how transboundary water management interacts with infrastructure safety regulation. This integrated methodological approach allows for a critical appraisal of normative gaps, inconsistencies in implementation, and opportunities for strengthening regional legal alignment.

METHOD

This study applies a qualitative doctrinal and comparative legal research method to examine the coherence between international transboundary water law and domestic regulatory frameworks governing hydraulic infrastructure safety in Central Asia. The research adopts normative legal research as its primary design because it focuses on

[22] Sunil Subba and others, 'Extreme Precipitation Detection Ability of Four High-Resolution Precipitation Product Datasets in Hilly Area: A Case Study in Nepal', *Advances in Climate Change Research*, 15.3 (2024), 390–405 https://doi.org/10.1016/j.accre.2024.05.005

[23] Olim Narzullaev, Anor Mukasheva, and Dilafruz Sadikova, 'Ensuring Legal Protection of Biological Diversity Regulations for Safeguarding Ecosystems', *Journal of Human Rights, Culture and Legal System*, 5.2 (2025), https://doi.org/10.53955/jhcls.v5i2.515

the interpretation and evaluation of legal norms, institutional arrangements, and regulatory structures rather than experimental or survey-based investigation. The study analyses legal provisions regulating shared water resources in the Amu Darya and Syr Darya basins. The research employs an integrated analytical approach that combines doctrinal interpretation, comparative legal analysis, and institutional assessment within a sustainability-oriented governance perspective. Primary data consist of national water legislation, regulatory instruments governing hydrotechnical infrastructure safety, and international legal frameworks, including the Convention on the Protection and Use of Transboundary Watercourses and International Lakes and the Convention on the Law of the Non-Navigational Uses of International Watercourses. Secondary data include academic literature, institutional reports, policy documents, and statistical information related to regional water governance.[24]

The analysis proceeds through several analytical stages. Doctrinal analysis interprets statutory provisions and treaty norms to determine the scope of legal obligations governing transboundary water management. Comparative legal analysis evaluates similarities and differences between domestic regulatory systems and international legal standards to identify inconsistencies and implementation gaps. Historical institutional analysis traces the transformation of water governance structures from the centralized management system of the Soviet Union to contemporary interstate regulatory arrangements. Structural and systemic analysis examines the distribution of regulatory authority among state institutions and evaluates the effectiveness of oversight mechanisms governing hydrotechnical safety. The integration of these analytical methods enables a comprehensive assessment of the capacity of existing legal frameworks to implement international obligations within domestic regulatory practice.[25]

RESULT AND DISCUSSION

Legal Problems of Transboundary Water Relations

The governance of shared river systems in Central Asia is influenced not only by environmental conditions and geopolitical asymmetries but also by the interaction between national regulatory instruments and international legal frameworks.[26] The analysis examines several key legal sources that shape water governance in the region, particularly within the Amu Darya and Syr Darya basins. At the national level, the study analyses the Water Code of the Republic of Uzbekistan, the Water Code of the Republic of Kazakhstan, the Law of the Republic of Uzbekistan on the Safety of Hydraulic Structures, and the Law of the Republic of Kazakhstan on Civil Protection. At the international level, the research evaluates the normative influence of the Convention on the Protection and Use of Transboundary Watercourses and International Lakes adopted in 1992 and the Convention on the Law of the non navigational Uses of International Watercourses adopted in 1997. Through the

[24] J Shroder, 'Chapter 20 - Concluding Transboundary Water Activities', in *Transboundary Water Resources in Afghanistan*, ed. by John Shroder and Sher Jan Ahmadzai (Boston: Elsevier, 2016), pp. 453–71 https://doi.org/https://doi.org/10.1016/B978-0-12-801886-6.00020-3

[25] Mehak Majeed, 'Book Review', *Regional Science Policy & Practice*, 16.9 (2024), 100071 https://doi.org/10.1016/j.rspp.2024.100071

[26] Kun Zhang and others, 'Could the EU Carbon Border Adjustment Mechanism Promote Climate Mitigation? An Economy-Wide Analysis', *Advances in Climate Change Research*, 15.3 (2024), 557–71 https://doi.org/10.1016/j.accre.2024.05.002

examination of these regulatory instruments, the study assesses the extent to which domestic legal frameworks incorporate international principles governing equitable water allocation, transboundary harm prevention, and cooperative management of shared water resources.[27]

The structural inconsistency between the formal recognition of international obligations and their effective domestic operationalization. The 2025 Water Code of Uzbekistan strengthens provisions concerning rational water use, environmental sustainability, and state supervision. However, despite references to international cooperation, the Code does not establish sufficiently detailed procedural mechanisms ensuring mandatory cross-border coordination in the planning, approval, and operation of large-scale hydraulic infrastructure with potential transboundary impact.[28] Similarly, Kazakhstan's Water Code incorporates principles of international cooperation but does not fully integrate binding preventive standards for downstream risk management within the regulatory framework governing dam safety and civil protection. As a result, notification procedures, joint environmental impact assessments, and liability allocation mechanisms remain insufficiently institutionalized. Comparative analysis further indicates that the hierarchical relationship between constitutional environmental guarantees, sectoral water legislation, and hydraulic infrastructure safety regulation lacks full normative synchronization. Institutional competences are distributed across multiple authorities, often without clearly defined coordination procedures in cases involving transboundary risk.[29]

Regional hydropolitical asymmetry, in which upstream states prioritize hydropower development while downstream states rely extensively on irrigation for agricultural production, intensifies the practical implications of regulatory gaps in the governance of the Amu Darya and Syr Darya basins.[30] Nevertheless, the principal legal problem does not arise from geographic disparity alone but from the absence of harmonized statutory mechanisms capable of translating international water law obligations into effective and enforceable domestic regulatory procedures. Thus, the study identifies a legally significant deficiency: the incomplete doctrinal coherence between transboundary water law commitments and national hydraulic infrastructure regulation in Uzbekistan and Kazakhstan. Without precise procedural alignment,

[27] Model Water Code for the Member States of the Commonwealth of Independent States." *Interparliamentary Assembly of the Member States of the Commonwealth of Independent States*, Resolution No. 27-10, adopted at the Twenty-Seventh Plenary Session, Available at: https://lawrussia.ru/

[28] Shivdas Virk, Andrew Papworth and Sarah Papworth, 'What Should We Do? An Explanatory Analysis of the Decision-Making Process in Biodiversity Conservation', *Environmental Science and Policy*, 149.August (2023), 103562 https://doi.org/10.1016/j.envsci.2023.103562

[29] Seema Arora-Jonsson and Nora Wahlström, 'Unraveling the Production of Ignorance in Climate Policymaking: The Imperative of a Decolonial Feminist Intervention for Transformation', *Environmental Science and Policy*, 149.August (2023) https://doi.org/10.1016/j.envsci.2023.103564

[30] Hussam Hussein, Meadow Poplawsky and Tanisha Mohapatra, 'The Political Context of Change in Transboundary Freshwater Agreements', *Environmental Science and Policy*, 149.May (2023), 103572 https://doi.org/10.1016/j.envsci.2023.103572

preventive obligations remain vulnerable to discretionary interpretation, weakening legal certainty, accountability, and cross-border trust.[31]

A review of legislative frameworks across Central Asian states suggests that certain regulatory provisions governing water use and hydraulic safety require modernization to address contemporary environmental and infrastructural challenges. At the same time, interstate coordination in transboundary water management has entered a more institutionally structured phase, reflecting evolving regional governance dynamics. In particular, former confrontations surrounding water and energy infrastructure have increasingly been replaced by agreement-based mechanisms that take mutual interests into account.[32] Notably, between 2018 and 2022, Uzbekistan and Tajikistan reached agreements through negotiations on the Rogun and Yavan hydropower plants. In addition, in 2022 Uzbekistan and Kyrgyzstan signed a bilateral agreement on the Kambarata hydropower project. Furthermore, during 2021–2023, the foundations for multilateral cooperation involving Uzbekistan, Kazakhstan, and Kyrgyzstan were established with regard to the Toktogul and Kambarata hydropower complexes. [33] Table 1 illustrates that water cooperation in Central Asia increasingly relies on project-based bilateral arrangements in the hydropower sector, while river basin governance remains largely dependent on broad and often weak multilateral framework agreements adopted in the early post-Soviet period.

Table 1. Major transboundary water facilities and river basins in Central Asia: users and legal characteristics

Water facility / river basin	Participating states	Status of cooperation	Dominant use	Legal form of arrangement
Rogun Hydropower Project	Tajikistan, Uzbekistan	Ongoing negotiations	Hydropower generation	Bilateral, project-based
Yavan Hydropower Facility	Tajikistan, Uzbekistan	Agreement concluded (2022)	Hydropower generation	Bilateral
Kambarata Hydropower Complex	Kazakhstan, Kyrgyzstan, Uzbekistan	Negotiations in progress	Energy and water regulation	Multilateral (emerging)
Toktogul Reservoir and HPP	Kazakhstan, Kyrgyzstan, Uzbekistan	Agreement concluded (2021)	Mixed: energy & irrigation	Multilateral
Kemripabad Hydropower Facility	Kyrgyzstan, Uzbekistan	Agreement concluded (2022)	Hydropower generation	Bilateral
Amu Darya River Basin	Tajikistan, Uzbekistan, Turkmenistan, Afghanistan	Framework agreement (1992)	Irrigation-dominated	Multilateral framework
Syr Darya River Basin	Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan	Framework agreement (1992)	Mixed water use	Multilateral framework

Source: From various sources processed by the author.

The expansion of large-scale hydraulic infrastructure in Central Asia has intensified regulatory tensions surrounding the governance of shared river systems. Infrastructure development projects have increased the strategic significance of coordinated legal

[31] Normatovich, O. A. (2023). Water resource management and irrigation efficiency reforms in Uzbekistan: Targets and challenges toward 2030. Journal of Water and Land Use Policy, 5(2), 45–58. https://kun.uz/en/53050830?utm_source.com

[32] Alice McClure and others, 'Exploring the Role of Transdisciplinary Learning for Navigating Climate Risks in African Cities: The Case of Lusaka, Zambia', *Environmental Science and Policy*, 149.September 2022 (2023), 103571 https://doi.org/10.1016/j.envsci.2023.103571

[33] Kenjayev, A. A., Madaminova, D. I., Abdullayev, K. N., & Kuralbayev, A. A. (2025). Contemporary issues of transboundary water utilisation in Central Asia: Political and legal analysis. Legality: Jurnal Ilmiah Hukum, 33(2), 493–512. https://doi.org/10.22219/ljih.v33i2

responses at the regional level, particularly in the management of the Amu Darya and Syr Darya basins. As a result, regional institutions and national governments continue to prioritize the development of updated normative and institutional instruments capable of strengthening cross border integration in water management. Academic and policy debates concerning the equitable allocation and sustainable management of shared water resources have produced a broad body of analytical perspectives.[34] Scholars, policy experts, and technical practitioners have offered diverse evaluations of appropriate governance models, legal standards, and mechanisms for interstate cooperation. A systematic review of transboundary water governance in the Amu Darya and Syr Darya basins reveals several principal observations. First, the geographical distribution of water resources remains structurally asymmetrical between upstream and downstream states. Second, legal coordination between hydropower development policies and irrigation dependent agricultural systems remains insufficient. Third, the construction and expansion of hydraulic infrastructure increase the potential for transboundary environmental and safety risks. Fourth, national legislation has not yet fully incorporated the core principles of international water law into domestic regulatory frameworks.[35]v

Hydraulic Structure Safety: The Experience of Kazakhstan

The results demonstrate that Kazakhstan's regulatory framework governing hydraulic infrastructure lacks structural coherence and fails to ensure systematic integration of sustainability-oriented and preventive legal standards. This deficiency is not merely administrative in nature but reflects a normative fragmentation across sectoral legislation. First, doctrinal analysis reveals that hydraulic infrastructure safety is regulated through dispersed provisions contained in water law, environmental law, civil protection legislation, and construction regulations, without a unified statutory framework. The absence of a dedicated Law "On the Safety of Hydraulic Structures" produces legal uncertainty regarding risk classification, preventive obligations, supervisory competences, and liability standards. [36] Existing regulatory acts primarily address dam declaration and categorization requirements, leaving other categories of hydraulic installations without comprehensive procedural safeguards. This legislative dispersion weakens hierarchical consistency and undermines enforceable compliance mechanisms. [37]

[34] Duong T. Khuu, Peter J.S. Jones and Paul Ekins, 'Development of Marine Protected Areas (MPAs) in Vietnam from a Coevolutionary Governance Perspective: Challenges of Unholy Alliances between the State, Businesses and NGOs', *Environmental Science and Policy*, 149.June (2023), 103560 https://doi.org/10.1016/j.envsci.2023.103560

[35] Silvia Olvera-Hernandez and others, 'Can Theatre Be Used in Environmental Governance? The View of Environmental Professionals in Mexico', *Environmental Science and Policy*, 149.June (2023), 103559 https://doi.org/10.1016/j.envsci.2023.103559

[36] Zonn, I. S., Glantz, M. H., Kostianoy, A. G., & Kosarev, A. N. (2020). Water resources of Central Asia: Regional challenges, water scarcity and transboundary issues. Environmental Earth Sciences, 79, 1–17. https://doi.org/10.1007/s12665-020-09170-5

[37] Koybakov, M., Abdullaev, I., Rakhmatullaev, S., & Platonov, A. (2020). Water infrastructure reforms and efficiency improvements under climate and demographic pressure in Central Asia. International Journal of Water Resources Development, 36(4), 620–637. https://doi.org/10.1080/07900627.2019.1707546

Second, empirical evidence regarding the condition of hydraulic infrastructure confirms the existence of regulatory deficiencies. Official statistical data indicate that a significant proportion of hydraulic facilities in the Amu Darya and Syr Darya basins were constructed more than three decades ago and have not undergone systematic rehabilitation. Approximately sixty percent of these structures remain in technically unsatisfactory condition, and regulatory authorities classify many of them as high-risk installations. These findings demonstrate that the existing regulatory framework does not effectively operationalize preventive maintenance obligations or establish adequate oversight mechanisms capable of ensuring continuous monitoring, technical accountability, and risk-based governance in the management of hydrotechnical infrastructure. [38] Third, comparative institutional assessment identifies overlapping competences among state authorities responsible for water management, emergency prevention, environmental control, and construction supervision. The lack of clearly delineated mandates and coordination procedures results in fragmented accountability. The legal framework thus operates reactively, focusing on post-disaster mitigation rather than ex ante risk prevention. This structural weakness became evident during major emergency events, including the Kyzylagash reservoir disaster (2010), the Kokpekty dam failure (2014), and the large-scale floods of 2024, which exposed deficiencies in early warning systems, inter-agency coordination, and supervisory enforcement.

Fourth, when assessed within the broader transboundary context, these domestic regulatory gaps acquire regional significance. Given that approximately 44 percent of Kazakhstan's freshwater inflow originates beyond its borders and that all major river basins are international in character, insufficient preventive regulation of hydraulic infrastructure poses potential cross-border risks. The absence of integrated standards linking infrastructure safety with transboundary water obligations undermines legal predictability and cooperative stability. Accordingly, the results establish a central finding: Kazakhstan's current regulatory architecture remains fragmented, reactive, and insufficiently harmonized with both sustainability principles and transboundary preventive obligations. The core deficiency lies not only in infrastructural ageing, but in the absence of a coherent statutory design capable of translating risk management requirements into enforceable legal standards.[39]

Improving the Legal Model and Sustainable Development

Effective governance of shared water systems in Central Asia is undermined not only by hydrological variability or geopolitical asymmetry, but by identifiable legal-system deficiencies. Prior to proposing institutional reform, it is necessary to articulate the specific normative and structural problems that generate regulatory instability. First, at the level of legal substance, there is a doctrinal inconsistency between international cooperation obligations and domestic regulatory frameworks. [40]

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International water law requires equitable utilization, prevention of significant transboundary harm, prior notification, and due diligence. However, domestic legislation in several Central Asian jurisdictions continues to conceptualize water primarily as a sovereign economic asset. This normative framing results in vague cross-border impact assessment standards, limited procedural guarantees for interstate consultation, and insufficient integration of climate-adaptive obligations. The gap between treaty commitments and statutory operationalization reflects a lack of doctrinal coherence.[41]

Second, at the level of legal structure, institutional fragmentation weakens enforcement capacity. Water governance responsibilities are typically dispersed among water management authorities, environmental regulators, emergency agencies, and infrastructure oversight bodies. The absence of clearly delineated competences and binding coordination procedures produces overlapping mandates and reactive regulatory responses. Cross-border cooperation mechanisms often remain declarative rather than enforceable, thereby limiting preventive oversight. Third, at the level of legal culture, patterns of implementation reveal a preference for nationally oriented development priorities over basin-oriented cooperation.[42]

Although international frameworks emphasize sustainable development and coordinated resource management, reflected, for example, in monitoring mechanisms linked to Sustainable Development Goal 6—these commitments are not consistently internalized within administrative practice. [43] Societal and institutional attitudes continue to prioritize sectoral economic benefits over shared ecological responsibility, weakening compliance incentives. Hydrological instability exposes the insufficiency of reactive governance models and underscores the need for anticipatory legal mechanisms capable of addressing uncertainty. [44] The transformation of formerly unified Soviet-era water administration into interstate governance further complicates regulatory coherence, elevating water. [45] Accordingly, modernization of transboundary water governance requires not merely normative adjustment but systemic legal reconstruction. While the formation and regulation of water resources in upstream states are closely connected to hydropower generation, water use in

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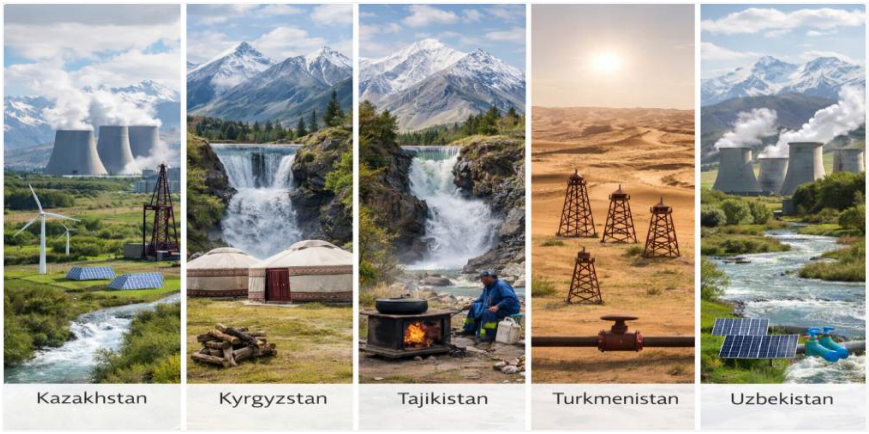
downstream states is directed mainly toward irrigation and agricultural needs (Figure 1).



Source: Author's elaboration

The analysis aligns with broader international research indicating that shared water governance in Central Asia is increasingly affected by accelerating climatic shifts and hydrological instability. Intensifying temperature trends and glacier retreat are reshaping the region's water balance, amplifying existing allocation pressures. Observational data suggest substantial reductions in glacier mass across high-altitude zones, with long-term projections pointing toward significant contraction of remaining ice reserves over the coming decades. [46] These environmental transformations compound structural vulnerabilities within transboundary river systems, reinforcing the urgency of adaptive regulatory and cooperative mechanisms capable of addressing climate-induced variability in water availability. In the Tien Shan region of Central Asia, an estimated 4–5 billion tons of ice from approximately 10,960 natural glaciers melt annually, reducing glacier-covered areas by up to 3,000 square kilometers. Glacier melt is expected to generate large volumes of water in northern China, Kazakhstan, Uzbekistan, Turkmenistan, and Kyrgyzstan, increasing the risk of catastrophic flooding. [47]

Hydrological patterns across Central Asia reveal pronounced territorial imbalances in freshwater availability. The concentration of primary headwaters within Kyrgyzstan and Tajikistan generates structural interdependencies with downstream countries, including Kazakhstan, Turkmenistan, and Uzbekistan.[48] This asymmetry complicates coordinated basin governance and influences national development strategies. Climate projections suggest increasing aridity across significant parts of the region, accompanied by accelerating glacier retreat in mountainous zones. Recent

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international assessments further warn that environmental stress may trigger substantial population displacement within Central Asia in the coming decades. In this context, cross-border infrastructure initiatives require prior consensus-building and cooperative planning among neighboring states. [49] The study underscores that unilateral, interest-driven regulation of shared river basins undermines long-term effectiveness. The growing tendency to treat water primarily as an economic asset risks marginalizing cooperative obligations embedded in international legal frameworks. Strengthening basin-oriented governance, embedding compulsory cross-border impact evaluation procedures within domestic legislation, and establishing coordinated institutional mechanisms for monitoring and information exchange are essential for enhancing regional regulatory coherence.[50]

A comparison with international practice shows that in states which have adopted special legislation on hydraulic structure safety, mechanisms for risk assessment, continuous monitoring, and public notification are clearly defined. In Kazakhstan, however, such a comprehensive approach is absent, which reduces the effectiveness of legal regulation. [51] The study also reveals that hydraulic structures located within transboundary river basins generate specific legal challenges, while existing national legislation insufficiently regulates transboundary information exchange, joint monitoring, and cooperation mechanisms. Consequently, there is a need to abandon sectoral and reactive approaches in favor of a comprehensive, preventive, and risk-oriented legal model. Such a model should include the adoption of a special law on hydraulic structure safety, clear allocation of competences, mandatory monitoring, and harmonization with international standards.[52]

It should be noted that globally, approximately one out of every thousand dams experiences an accident. Dam failures cause serious harm to human life and health, socio-economic development, and sustainable progress. In the Central Asian region, the safety of hydraulic structures is of particular importance, as these facilities are directly linked to the production of about 90 percent of agricultural output, approximately 40 percent of electricity generation, and the livelihoods of around 15 million people. As a consequence, 45 people lost their lives and approximately 300 individuals sustained injuries of varying severity. Nearly 80 percent of residential buildings were damaged, and 251 houses were completely destroyed by the flood. Experts identified the failure to discharge water from the reservoir in a timely manner as the primary cause of the accident. Similarly, on 31 March 2014, a dam failure in the

[49] Orazaliev, K., Mukasheva, A., Ybyray, N., & Nurekeshov, T. (2024). Current regulation of water relations in Central Asia. Regional Science Policy & Practice, 16, 100038. https://doi.org/10.1016/j.rspp.2024.100038

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[51] Anusha Sanjeev Mehta and Jeroen F Warner, 'Multi-Level Hegemony in Transboundary Flood Risk Management: A Downstream Perspective on the Maritsa Basin', *Environmental Science & Policy*, 129 (2022), 126–36 https://doi.org/https://doi.org/10.1016/j.envsci.2021.12.014

[52] Jianglei Zhang and Shaohui Chen, 'Evaluating Water Conservation Capacity in the Yellow River Water Conservation Area Integrating Ecological Model and Machine Learning', *Journal of Hydrology*, 663 (2025), 134202 https://doi.org/https://doi.org/10.1016/j.jhydrol.2025.134202

village of Kokpekty near the city of Karaganda led to the flooding of approximately 650 houses.[53]

Ensuring the six dimensions of sustainable development encompasses eight key targets: access to safe drinking water (6.1); international cooperation in the water supply sector (6.a); and ensuring public participation (6.b). [54] In Kazakhstan, a major challenge lies in the absence of a unified, coordinated institutional structure and a common strategic framework for the operation, management, and oversight of water bodies and hydraulic structures. Such institutional fragmentation increases the risk of low effectiveness in responding to water-related crises. In this context, improving the state mechanism for the legal regulation of the operation and safety of hydraulic structures is of critical importance for fulfilling commitments undertaken to implement sustainable development principles. According to experts, state policy in the field of water resources management is often formulated on the basis of unreliable or insufficient data. Special attention to the problem of aging hydraulic infrastructure is given in paragraph 2.10 of the "Concept for the Development of the Water Resources Management System in the Republic of Kazakhstan (2024–2030)".[55]

The Concept notes that approximately 60 percent of hydraulic structures have not undergone repair for a prolonged period and therefore constitute high-risk facilities.[56] Hydraulic structures are defined as engineering facilities serving the following purposes: water resource management; delivery of water to users; water supply and drainage; and prevention of the harmful effects of water. However, the Water Code contains only two provisions regulating the operation of hydraulic structures. [57] Although the latest revision of the Water Code reflects an attempt to improve legal regulation in this area, issues related to the operation and safety of hydraulic structures have not been addressed in a comprehensive manner. Pursuant to Order No. 19-2/1054 of 2 December 2015 "On Approval of the Rules for Classifying Dams as Declarable Facilities and the Rules for Developing Dam Safety Declarations," hydraulic structures are classified into four categories based on the level of socio-economic responsibility and the potential consequences of accidents. [58]

Most accidents that have occurred in recent years are associated with human factors, primarily due to insufficient legal regulation of the operation of water and

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[54] Bureau of National Statistics of Kazakhstan. Sustainable Development Goals: Goal 6 (Clean Water and Sanitation). Official resource. Accessed via stat.gov.kz.

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hydraulic structures, the absence of mechanisms for preventing foreseeable accidents, and the deterioration of infrastructure quality. Hydraulic facilities located on transboundary waters pose particular risks, as accidents at such sites may threaten the safety of neighboring states. Accordingly, timely information exchange between bordering countries regarding the condition of shared water facilities is of paramount importance. To ensure the safety of hydraulic structures, including. 1)Establishing clear normative and legal regulation of the operation of hydraulic structures. 2)Conducting systematic monitoring and oversight of their technical condition. 3)Carrying out routine and capital repairs in a timely manner. 4)Modernizing and reconstructing equipment, or, where facilities fail to meet regulatory requirements, placing them under conservation or decommissioning. 5)implementing preventive measures aimed at averting potential accidents. 6)Training qualified specialists for the operation and maintenance of hydraulic structures. 7) Ensuring strict compliance with established requirements during the construction of hydraulic structures, among other measures.[59]

These considerations confirm the necessity of adopting a separate normative legal act regulating the operation and safety of hydraulic structures.[60] Accordingly, there is a clear need to enact a special Law "On Hydraulic Structures" that would comprehensively define the legal regime governing such facilities. The role of hydraulic structures in ensuring sustainable development has not been sufficiently examined. Kazakhstan's geographical location and climatic characteristics increase the risk of rising water levels, resulting in a significant escalation of the load placed on hydraulic structures.[61]

Current national legislation provides that hydraulic structures may be owned by the state, municipalities, or private entities.[62] In this regard, clearly defining their legal status and forms of ownership constitutes a priority task.[63] Although legislation allows state-owned water resources and hydraulic structures to be transferred to trust management, the legal liability of the trustee for failure to properly fulfill management obligations is not clearly regulated. This legal gap complicates effective management, contributes to the deterioration of technical conditions, and ultimately increases the risk of accidents. In conclusion, under conditions of implementing sustainable development principles, improving the legal foundations for the operation and safety of hydraulic structures represents one of the most urgent and strategically significant tasks of the contemporary period. The findings of the study indicate that the absence of a systematic determination of the legal status of hydraulic structures, as

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[62] Akmal Juraev, 'New Trends in the Solution of Systemic Problems in Central Asia', *Oriental Journal of History, Politics and Law*, 2.2 (2022), 340–352, https://doi.org/10.37547/supsci-ojhpl-02-02-44
[63] Aigul Mukasheva, Nurbek Ybyray, and Timur Nurekeshov, 'Current Regulation of Water Relations in Central Asia', *Resources, Conservation & Recycling Advances*, 20 (2024), 200167, https://doi.org/10.1016/j.rcradv.2024.200167

well as the insufficient regulation of their management and oversight in legislation, leads to an increased level of environmental and technogenic risks.[64]

At present, the aging of hydraulic structures, the deterioration of their technical condition, and the incomplete regulation of owners' obligations and liabilities pose serious threats to public safety and environmental security.[65] Its alignment with international standards on hydraulic structure safety, clarification of legal regulation mechanisms, and strengthening of liability measures. In addition, the adoption of a special law governing the legal regime of hydraulic structures and the establishment of a systematic model of state governance in this field are required. Addressing the identified issues through in-depth scientific and legal analysis is of decisive importance for the implementation of sustainable development principles and should be regarded as a priority direction for future research.[66]

CONCLUSION

The analysis reveals that transboundary water governance in Central Asia operates within a legally dispersed and institutionally segmented framework that does not fully correspond to contemporary sustainability requirements. In the Amu Darya and Syr Darya basins, upstream–downstream asymmetries, sectoral prioritisation of hydropower and irrigation, and limited cross-border coordination weaken regulatory coherence. The absence of integrated safety standards for hydraulic infrastructure, combined with overlapping institutional mandates, creates structural vulnerabilities that heighten environmental and technological risks, particularly under conditions of climate variability and infrastructure ageing. The case of Kazakhstan illustrates how fragmented legislative approaches to hydrotechnical safety constrain preventive and risk-based regulation. Addressing these shortcomings requires moving beyond declarative recognition of international water law principles toward enforceable basin-level governance mechanisms. Strengthening legal interoperability, clarifying institutional competences, and embedding coordinated safety standards within transboundary cooperation frameworks are essential steps toward reducing hydropolitical tensions. Such reforms would enhance regulatory certainty, improve environmental safeguards, and support the long-term resilience of regional water systems in line with global sustainability objectives.

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