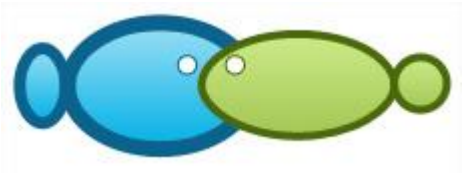

Water and environmental cooperation in Central Asian countries: a historical and comparative analysis (1990s to present)

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Abstract. Transboundary water cooperation in Central Asia links irrigation needs, energy security and environmental risk management. The study aimed to trace the evolution of water and environmental cooperation in Central Asia between 1991-2025, using Kyrgyzstan, Kazakhstan and Uzbekistan as examples. The study was conducted as a historical and comparative analysis based on intergovernmental agreements, coordination protocols, materials from regional institutions and project documents, comparing their content with the actual parameters of seasonal interaction and the environmental agenda. In the water-energy relationship between Kyrgyzstan and Kazakhstan, a shift in discharge regimes from irrigation to energy was recorded: between 1990 and 2000, the share of summer discharges decreased to about 45%, while winter discharges increased to about 55% (under the Soviet scheme, approximately 75% fell in summer and 25% in winter). In the trilateral coordination, in years of resource shortages, coordination shifted to a mode of specific parameters. In 2021, additional water volumes for irrigation were agreed at a level of about 700 million m^3 compared to the previous year, and in 2025, decisions were made on energy supply for winter water conservation and summer water discharge. In terms of the environment, there has been a shift in focus towards monitoring water quality, land degradation and salinisation of irrigated areas, which reached 40-60% in regional assessments. These results can be used by the relevant water, energy and environmental authorities of Kyrgyzstan, Kazakhstan and Uzbekistan, regional coordination structures for transboundary waters, as well as international donors and project institutions to design procedures for seasonal coordination and reduction of environmental risks in transboundary river basins.

Keywords: transboundary river basins, mechanisms of intergovernmental compensation, environmental risks of water use.

Introduction. Transboundary water resources in Central Asia in the 1990s and 2020s remained the basis for renewable interdependence between upstream and downstream states, as seasonal water release regimes simultaneously determined irrigation parameters and energy supply conditions during the heating season (Weinthal, 2006; World Bank, 2004; Ziganshina & de Schutter, 2022). During this period, water use coordination was combined with the environmental consequences of water management decisions, in particular the risks of land degradation and salinisation of irrigated areas, which made it necessary to consider cooperation not only as a distributional issue, but also as a water and environmental issue (Food and Agriculture Organization, 2020; United Nations General Assembly, 2022). For Kyrgyzstan, Kazakhstan and Uzbekistan, this issue was linked to different positions in river basins, differences in energy structures and irrigation scales, as well as the need to coordinate actions during periods of drought, low water levels and peak water consumption seasons.

Earlier studies on Central Asian water governance showed that post-Soviet water cooperation was shaped by the dissolution of the Soviet water-energy exchange system, the institutionalisation of ICWC and IFAS formats, and repeated attempts to stabilise

seasonal water and energy compensation (Bjorklund, 2001; Weinthal, 2006; Diebold, 2012; Sokolov et al., 2013). These works provide the historical basis for analysing the 1990s and 2000s, while recent studies clarify how climate adaptation, infrastructure investment and environmental monitoring have changed the agenda in the 2020s.

Modern Kyrgyz studies, in particular by Yusupova et al. (2024), demonstrated that infrastructure development of water resources in the Kyrgyz Republic was associated with the potential for conflict and the need to coordinate interests at the intergovernmental level, as technical solutions changed the configuration of water availability and its use regimes. In this logic, infrastructure was defined as a factor influencing negotiating positions and the stability of agreements in changing hydrological conditions. The legal focus of Dzhumagulov et al. (2024) outlined that transboundary water management in Kyrgyzstan was based on international law and contractual practice, which defined the procedural framework for coordination, data exchange and the responsibilities of the parties. This interpretation led to an analysis of how legal instruments were transformed into specific mechanisms for implementation and dispute resolution in basin formats. Institutional mechanisms for transboundary water management in Kyrgyzstan in the context of climate change were linked to agricultural sustainability due to the dependence of production on irrigation regimes and the predictability of water supply, as studied by Batykova (2025). The study emphasised the importance of institutional capacity and procedural coherence as conditions for reducing risks to agriculture in the context of increasing climate variability.

At regional level, Prniyazova et al. (2025) summarised that sustainable transboundary water governance in Central Asia was shaped by a combination of challenges, conflicts and cooperative practices that recurred at different times and depended on the balance of interests between states. In this framework, cooperation was interpreted as a process where formal agreements coexisted with informal coordination mechanisms and crisis decision-making regimes. The evidence-based approach to cooperation was elaborated by Ziganshina and de Schutter (2022) through the requirement for data, common indicators and procedures that moved negotiations from political declarations to verifiable water use parameters. This framing reinforced the need to analyse data transparency and monitoring mechanisms as elements of agreement enforceability. Environmental cooperation was considered by Mez (2024) as part of broader regional changes in a multipolar environment, where internal transformations and external actors influenced coordination priorities and practices. In this context, environmental agendas were linked to institutional formats of regional interaction and the possibility of implementing joint programmes within specific political cycles. The dynamics of "water policy" in transboundary basins in Central Asia were traced by Wang et al. (2021) through changes in water use and political interactions, accompanied by a reformatting of interests and management tools. This provided a basis for a historical and comparative analysis of how coordination regimes changed over different periods and how they correlated with infrastructure and climate factors.

The operationalisation of the water-energy-food nexus approach was presented by Hamidov et al. (2022) as an interdisciplinary way of explaining interrelated decisions in the socio-environmental systems of Central Asia, where changes in one sector had consequences for others. In this logic, the coordination of water regimes was linked to energy trade-offs and agricultural outcomes, reflecting the need to view cooperation as a complex circuit rather than isolated water allocation. Changes in the water footprint in Central Asia were explained by Hu et al. (2022) through trade and production drivers that influenced water consumption patterns and indirect water loads. This approach broadened the framework of analysis from intergovernmental agreements to economic factors that could change water demand and, accordingly, the configuration of water resource negotiations. The role of energy storage for water and energy security in Central Asia was revealed by Zakeri et al. (2022) through the link between the flexibility of the power system and the ability to reduce pressure on reservoir regimes during peak periods. This provided grounds for including technological and energy system parameters in explaining how compensation mechanisms and the predictability of seasonal decisions in transboundary basins could change. Scientific literature covered individual aspects of

the issue (legal, infrastructural, environmental, sectoral) in sufficient detail. However, these dimensions have rarely been analysed within a unified historical-comparative framework that simultaneously examines institutional evolution, seasonal coordination mechanisms, and environmental outcomes across Kyrgyzstan, Kazakhstan, and Uzbekistan. Therefore, a comprehensive assessment integrating the periodisation of cooperation from the 1990s to the 2020s with a comparative analysis of agreement stability, compensation mechanisms, and responses to water-scarcity crises is needed to better understand the evolution and effectiveness of regional water governance.

In this context, the study aimed to conduct a historical and comparative analysis of water and environmental cooperation between Kyrgyzstan, Kazakhstan and Uzbekistan from the 1990s to the present (as of 2025), establishing mechanisms to ensure the enforceability of decisions and the predictability of seasonal coordination. Within the scope of this objective, the following tasks were set: (1) to identify the stages of cooperation development and changes in the agenda between them; (2) to compare the institutional and legal frameworks with basin and bilateral practices for implementing agreements; (3) to reconstruct the evolution of water and energy compensation mechanisms and their consequences for reservoir regimes and environmental parameters in transboundary basins.

Material and Method. The study was conducted as a qualitative documentary analysis combined with historical-comparative analysis of the evolution of water-environmental cooperation between Kyrgyzstan, Kazakhstan and Uzbekistan from 1991 to 2025, with a focus on transboundary river basins, in particular the Amu Darya, Syr Darya and Chu-Talas, and on the relationship "water-energy-environmental impact". The reason for the selection of these countries and this period is due to the collapse of the Union of Soviet Socialist Republics in 1991, which was a driving force in changing the political and economic situation in Central Asia. This period made it possible to assess the evolution of cooperation in the context of the transformation of legal and institutional mechanisms for water resource management at the level of the new independent states. The materials were compiled from two groups of sources. Open primary sources included intergovernmental agreements, statutes of regional water institutions, ICWC/IFAS materials, official project documents of international organisations, and public communications on seasonal coordination protocols. Verified secondary publications included peer-reviewed articles and analytical reports identified through Scopus, Web of Science, Google Scholar and institutional databases using the keywords "Central Asia", "transboundary water", "Syr Darya", "Chu-Talas", "water-energy nexus", "ICWC", "IFAS", "salinisation", and "water cooperation". Sources were included if they addressed Kyrgyzstan, Kazakhstan and/or Uzbekistan during 1991-2025 and contained legal, institutional, hydrological or environmental information relevant to the study. News materials were used only as chronological markers for recent protocol events and were not used as independent analytical evidence unless confirmed by official or project sources. The corpus included intergovernmental regulatory documents that established the framework for cooperation (in particular, the Agreement between the Republic of Kazakhstan, the Kyrgyz Republic, the Republic of Tajikistan, Turkmenistan and the Republic of Uzbekistan on Cooperation in the Field of Joint Management on Utilization and Protection of Water Resources from Interstate Sources (1992) and Agreement between the Governments of the Republic of Kazakhstan, the Kyrgyz Republic, and the Republic of Uzbekistan on the Use of Water and Energy Resources of the Syr Darya Basin (1998) and specialised agreements on the operation of water management facilities (the Statute of the Commission of the Republic of Kazakhstan and the Kyrgyz Republic on the Use of Water Management Facilities of Intergovernmental Status on the Rivers Chu and Talas, 2000). The Statute of the Interstate Commission for Water Coordination of Central Asia (1992) were used as institutional "anchors" of periodisation (Altynsarina, 2018), as well as documents of the Scientific-Information Center of the Interstate Commission for Water Coordination, Central Asian Water Yearbook, sections on IFAS, regional organisations and key water developments in Central Asia. A separate set of documents included project and programme documents of international organisations reflecting the infrastructural

and environmental tracks of cooperation, including materials on the Syr Darya and Northern Aral Sea control project and preparatory documents on Kambar-Ata-1 (World Bank, 2008; World Bank, 2025). For the environmental dimension, international assessments of land degradation, salinisation and related dust storm risks were used, as well as data on the proportion of salinised irrigated areas (Food and Agriculture Organization, 2020). To record events and dates of protocol coordination, reports from specialised media and analytical platforms were used as time markers, using them only to determine the date of episodes and then compare them with official/project materials (Kazinform International News Agency, 2025; Kwan, 2025).

The analytical procedure included the construction of a chronological matrix of events and decisions at three levels of coordination (regional, basin/bilateral, trilateral), followed by a comparative reconstruction of changes in the agenda and instruments of cooperation between periods. To construct a chronological matrix of events and decisions, the study used a set of variables that provided a structured way to track the evolution of water and environmental cooperation. This set included: the date of the event or decisions, which determined the time limits for each stage of cooperation; the parties to the cooperation, in particular the countries (Kyrgyzstan, Kazakhstan, Uzbekistan) that participated in the coordination processes; the basin/object that determined the geographical and environmental component (Syr Darya, Chu-Talas); the subject of cooperation (water distribution, energy exchange, environmental measures, infrastructure); the type of instrument that characterised the legal and administrative mechanisms used (agreements, protocols, project documents); the implementation mechanism that indicated the methods of implementing decisions (commissions, data exchange, compensation); mention of disputes/arbitration, which reflected the existence of procedures for settling differences between the parties when necessary. This approach was used to reconstruct in detail the changes in cooperation between countries at different stages.

To make the coding procedure verifiable, the chronological matrix is presented in Table 1. Each event was coded according to seven variables: date, parties, basin/object, subject of cooperation, type of instrument, implementation mechanism, and dispute/coordination procedure (Table 1). The content of agreements and protocols was compared with actual interdependencies recorded in the results: seasonality of upstream/downstream needs, compensation mechanisms, and practices for coordinating water release schedules. To summarise the effectiveness, a criteria-based sustainability scheme was applied. The five criteria were derived from the institutional and legal content of the analysed agreements and from the practical requirements of transboundary water governance: continuity of agreements, predictability of seasonal allocation, availability of comparable data, enforceability through responsible bodies and resources, and dispute or consultation procedures. Each criterion was scored on a three-point scale: 0 – absent or not specified; 1 – partially present or dependent on ad hoc negotiation; 2 – clearly specified and repeatedly applied. On this basis, a typology of cooperation models was developed according to the dominant instrument, trigger, time horizon and implementation mechanism of each coded episode. Scenario-based generalised results for 2030 were formed through a structured synthesis of drivers identified in the source corpus. A driver was included when it appeared in at least two source groups and had a direct link to water allocation, energy compensation, infrastructure planning or environmental risk. Four drivers met these conditions: climate variability, energy constraints, infrastructure projects and digitalisation of management. They were synthesised into scenarios by comparing whether each driver strengthened long-term cooperation, maintained seasonal protocol coordination, or reproduced fragmented crisis-based negotiation. The typology of cooperation models was not assigned post hoc, but derived from the coded matrix. Episodes were classified as "pragmatic/technical" when they concerned specific facilities, operating rules and cost-sharing procedures; as "crisis-compensation" when coordination was activated by water shortage, winter energy demand or drought risk; and as "institutional-declarative" when cooperation was expressed mainly through regional platforms, framework documents or broad programme agendas.

Table 1

Chronological matrix of key events and decisions in water and environmental cooperation, 1991-2025

Date/ period	*Parties*	*Basin/object*	*Subject of cooperation*	*Instrument*	*Implementation mechanism*	*Dispute/coordination procedure*
1991	Kyrgyzstan, Kazakhstan, Uzbekistan	Post-Soviet water and energy systems	Transformation of water and energy coordination after the collapse of the Soviet system	Historical boundary of the study period	Transition from union-wide allocation to interstate coordination	Need for new interstate coordination procedures
1992	Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan	Interstate water sources	Joint management, use and protection of water resources	1992 Agreement and ICWC Statute	ICWC and basin water organisations	Coordination through ICWC meetings
1993	Central Asian states	Aral Sea basin	Regional environmental cooperation and Aral Sea crisis response	Establishment of IFAS	Programme coordination and mobilisation of intergovernmental support	IFAS-based intergovernmental coordination
1997	Central Asian states	IFAS institutional system	Legal status of IFAS and its organisations	Agreement about the status of IFAS and its organisations	Distribution of institutional functions within IFAS structures	Consultation and intergovernmental coordination
1998	Kazakhstan, Kyrgyzstan, Uzbekistan	Syr Darya basin	Water-energy regulation and compensation	1998 Syr Darya Agreement	Seasonal water release and compensation arrangements	Intergovernmental consultations
2000	Kazakhstan, Kyrgyzstan	Chu-Talas facilities	Operation and maintenance of interstate water facilities	2000 Chu-Talas Agreement and Commission Statute	Standing commission, annual operating coordination and cost sharing	Commission-based negotiation
2008	Kazakhstan and international partners	Syr Darya and Northern Aral Sea	Engineering regulation and environmental restoration	Syr Darya Control and Northern Aral Sea project materials	Infrastructure measures linked to environmental objectives	Project-based implementation procedures
2009	Central Asian states	Regional water and environmental framework	Preservation of regional cooperation formats and risk-sensitive agenda	IFAS summit and regional coordination practice	Political and institutional agenda-setting	Regional consultation format
2018	Central Asian states	IFAS regional framework	Reactivation of political attention to regional water cooperation	IFAS Founders Summit	Renewal of regional programme discussion	Political coordination through IFAS

Date/ period	*Parties*	*Basin/object*	*Subject of cooperation*	*Instrument*	*Implementation mechanism*	*Dispute/coordination procedure*
2021	Kazakhstan, Kyrgyzstan, Uzbekistan	Syr Darya and Toktogul Reservoir	Additional irrigation water during shortage	SIC ICWC Yearbook materials	Negotiated adjustment of water volumes	Operational coordination without arbitration
2022	Central Asian states and international partners	Regional water security and environmental risks	Integration of water cooperation with climate adaptation and dust storm management	International water platforms and UN materials	Linking water, land and climate policy instruments	Regional and international consultation
2024	Kyrgyzstan, Kazakhstan, Uzbekistan	Kambar-Ata-1	Long-term infrastructure and energy-water cooperation	Kambar-Ata-1 cooperation materials	Joint preparation of infrastructure cooperation	Intergovernmental investment coordination
15 May 2025	Kazakhstan, Kyrgyzstan, Uzbekistan	Syr Darya basin	Coordination of water allocations for the growing season	Seasonal protocol notification	Agreement of release and allocation parameters	Seasonal protocol coordination
22 Nov. 2025	Kazakhstan, Kyrgyzstan, Uzbekistan	Syr Darya basin	Winter energy supply and summer water conservation	Trilateral protocol/public coordination materials	Energy supply linked to water storage and summer release	Seasonal protocol coordination

Note: compiled by the authors.

The identified drivers were synthesised by analysing the interrelationships between various factors affecting the water and environmental situation in Central Asia. This included an analysis of existing trends in climate variability (temperature changes, frequency of extreme weather events), energy resource constraints (including access to energy, energy needs of the region) and infrastructure development (new water supply projects, energy networks, infrastructure initiatives). Another substantial element was the impact of digitalisation of management (introduction of new technologies for monitoring water resources, management of water systems using digital platforms). These drivers were combined into an integrated model that considers their interaction and mutual influence to identify possible development scenarios until 2030. The quantitative indicators in the study were secondary data from documents and reports (shares of seasonal discharges, additional agreed water volumes, salinity intervals), so inferential statistical tests were not applied; consistency of measurement units, logical compatibility of numbers between sources and tabular comparison of indicators over time were verified.

Results. Periodisation of water and environmental cooperation (1990s to present). The material on the interaction between Kyrgyzstan, Kazakhstan and Uzbekistan in the water and environmental sphere in the post-Soviet period was structured in four stages, the boundaries of which were marked by the emergence or change of framework agreements, the transition from general regional rules to more applied coordination regimes, as well as by a shift in the dominant themes from maintaining traditional principles of water distribution to the inclusion of climate adaptation and infrastructure investment arguments on the agenda. Acts and events that formally marked a change in the format of coordination were used as "anchors" (Table 2).

Table 2

Generalised periodisation of cooperation between Kyrgyzstan, Kazakhstan and Uzbekistan in the water and environmental sphere (1990s-2025)

Stage	*Reference years*	*Institutional/documentary "anchors"*
I. Post-Soviet consolidation of frameworks	1991-1997	Agreement between the Republic of Kazakhstan, the Kyrgyz Republic, the Republic of Tajikistan, Turkmenistan and the Republic of Uzbekistan on Cooperation in the Field of Joint Management on Utilization and Protection of Water Resources from Interstate Sources, ICWC; IFAS (1993)
II. Basin water and energy agreements	1998-2008	The 1998 trilateral agreement on water and energy resources in the Syr Darya basin, and the establishment of bilateral mechanisms in Chu-Talas
III. Review of modes and increased sensitivity to risks	2009-2016	Preservation of regional frameworks (ICWC/IFAS) while security and risk issues gain prominence on the agenda
IV. Reorientation and climate adaptation agenda	2017-2025	Reactivation of political attention to IFAS (2018 summit); international platforms 2022; Kambar-Ata-1 project cooperation (2024 agreement); water and energy coordination protocol (2025)

Note: ICWC – Interstate Commission for Water Coordination of Central Asia; IFAS – International Fund for Saving the Aral Sea. Source: compiled by the author based on Sokolov et al. (2013), Agreement between the Governments of the Republic of Kazakhstan, the Kyrgyz Republic, and the Republic of Uzbekistan on the Use of Water and Energy Resources of the Syr Darya Basin (1998), Statute of the Interstate Commission for Water Coordination of Central Asia (1992), Scientific-Information Center of the Interstate Commission for Water Coordination, Central Asian Water Yearbook.

In the first stage (1991-1997), cooperation was recorded as the restoration of formal water distribution management after the collapse of the union system through framework agreements and the launch of regional coordination mechanisms. The Statute of the Interstate Commission for Water Coordination of Central Asia (1992) enshrined the principles of coordination of the use and protection of transboundary water sources, and

the emergence of the ICWC and IFAS provided a permanent organisational framework for the water and Aral Sea environmental agenda. This period was dominated by issues of coordination of limits and procedures, while the environmental component was most often articulated through the problems of the Aral Sea basin as a common space of environmental consequences of water management regimes (Altynsarina, 2018). The second stage (1998-2008) was marked by a transition to more applied, basin-oriented solutions, when cooperation began to be structured around linking water distribution with energy parameters within specific river systems. The Agreement between the Governments of the Republic of Kazakhstan, the Kyrgyz Republic, and the Republic of Uzbekistan on the Use of Water and Energy Resources of the Syr Darya Basin (1998) was used as a marker of the institutional shift towards "water-energy" coordination at the basin level, and the formation of bilateral mechanisms in Chu-Talas as an indicator of the entrenchment of a more "operational" logic of interaction. In the context of periodisation, this stage was marked not by detailed procedures, but by a change in the dominant type of agenda: from framework water distribution to seasonal coordination of decisions linking water and energy needs. The third stage (2009-2016) was reflected as a period when the basic regional framework remained in place, but cooperation was increasingly linked to issues of predictability of regimes, water fluctuations and practical implications for water security. Within this periodisation, the emphasis was on a shift in topics from predominantly distributional issues to a combination of distribution with risk components (water quality, infrastructure resilience, sensitivity to hydrological variability), without prejudice to the analysis of specific institutional gaps or settlement mechanisms, which logically belonged to the following sections (Sokolov et al., 2013; Ongayev et al., 2024; Montayev et al., 2024).

The fourth stage (2017-2025) was characterised by a reorientation of cooperation towards a broader agenda, where water coordination began to be systematically described through climate risks, adaptation tasks and long-term investment configurations. The 2018 IFAS Founders' Summit was used as a political marker of renewed attention to regional formats, and the events of 2022 on international platforms as an indicator of the inclusion of regional water cooperation in the broader framework of water security and development (Altynsarina, 2018). The Kambar-Ata-1 project (World Bank, 2022; World Bank, 2026) was classified as an "anchor" as it transferred part of the cooperation to the plane of long-term project co-financing, while the 2025 protocol was recorded as an example of the reproducibility of seasonal coordination in an updated format, without duplicating the content of water and energy parameters, which were disclosed further (Kwan, 2025). The periodisation was derived from a comparison of three criteria: the legal or institutional anchor of cooperation, the dominant level of coordination, and the main cooperation agenda. On this basis, the evolution of cooperation in the 1990s-2020s was recorded as a sequence of shifts: from framework procedures, to basin-level applied coordination, then to water-security risk components, and finally to the combination of climate adaptation, seasonal coordination and long-term infrastructure decisions.

Institutional and legal architecture of cooperation between countries. The institutional and legal system of water and environmental cooperation in Central Asia during the 1990s-2020s was built as a multi-level structure in which the "regional framework" set common principles and coordination bodies, while basin and bilateral formats ensured annual working arrangements (Maharramova et al., 2026; da Silva et al., 2025). The legal starting point for the regional framework was the Agreement between the Republic of Kazakhstan, the Kyrgyz Republic, the Republic of Tajikistan, Turkmenistan and the Republic of Uzbekistan on Cooperation in the Field of Joint Management on Utilization and Protection of Water Resources from Interstate Sources (1992) on cooperation in the joint management, use and protection of transboundary water resources, which established approaches to coordination, procedures for agreeing on usage regimes and organisational support for joint decisions. In practical terms, the Statute of the Interstate Commission for Water Coordination of Central Asia (1992) was institutionalised through the Interstate Water Management Coordination Commission, as

well as through basin water management associations and a scientific and information framework that ensured the coordination of limits, data exchange and technical preparation of decisions (without transferring political discussions to "manual mode" every season). This separation of the "political level" and the "technical circuit" was described in specialised reviews of the institutional evolution of the ICWC and in the statutory documents of the commission itself.

In parallel with water management coordination, an "environmental programme" framework was developed, prioritising long-term programmes in the Aral Sea basin, mobilisation of funding and intergovernmental coordination of project packages. Its institutional basis was the International Fund for Saving the Aral Sea, as well as related bodies (executive structures, coordination commissions), whose status and composition were recorded in documents on the legal regime of IFAS and the list of its organisations (Scientific-Information Centre of the Interstate Commission for Water Coordination of Central Asia, 2026). Within this framework, functions were typically divided: the water block focused on resource use regimes and technical coordination, while IFAS structures provided the "program shell" for international support, project management, and intergovernmental legitimisation of large packages of measures. Basin and bilateral formats acted as the "working level" of coordination, where the general framework required specific procedures for individual river systems and water management facilities. For the Syr Darya basin, the key instrument was the 1998 Agreement on the Use of Water and Energy Resources of the Syr Darya Basin. It created a formal basis for coordinating reservoir operation regimes and linking water releases with energy compensation.

The most bilateral "object-type mechanism" was evident in the management of infrastructure and water distribution in the Chu-Talas basin. The 2000 Chu-Talas Agreement formalised cooperation around specific water management facilities, their operating regimes and maintenance costs. It also established the need for a standing bilateral commission and annual coordination procedures. The Statute of the Chu-Talas Commission further specified the commission's powers, scope and organisational procedures, which made coordination more reproducible under changing political conditions. Therefore, the Chu-Talas format was described in sources as an example of institutionalising "technical" cooperation through a commission and secretariat with a defined mandate, financial procedures and a decision-making calendar (Organisation for Security and Co-operation in Europe, 2007).

The practice of implementing agreements in regional architecture demonstrated recurring organisational patterns. First, regular coordination was maintained through a combination of meetings of commissions, working groups and secretariats, as well as through the preparation of technical materials at the level of specialised institutions. The Statute of the Interstate Commission for Water Coordination of Central Asia (1992) and the Statute of the Commission of the Republic of Kazakhstan and the Kyrgyz Republic on the Use of Water Management Facilities of Intergovernmental Status on the Rivers Chu and Talas (2000) directly linked procedures to mandates and lists of functions). Secondly, the discipline of implementing decisions depended to a large extent on the availability of financial and technical "leverage": where operating costs were formalised and responsible bodies were identified, coordination was transferred to routine procedures (this was tracked in materials on Chu-Talas and in descriptions of donor-supported components of secretariats and commission documents) (Organisation for Security and Co-operation in Europe, 2007). Thirdly, the mechanisms for resolving differences mainly boiled down to consultations and negotiations within the coordination bodies; the relevant formulas were established both in the framework documents and in the Agreement about the Status of IFAS and its Organizations (1997) (Table 3). Throughout the 1990s and 2020s, the institutional and legal architecture of cooperation was organised as a combination of regional framework bodies, a programme-environmental framework, and "operational" basin/bilateral mechanisms that translated general principles into procedural decisions. Regional frameworks ensured the stability of the organisational structure and the legitimacy of coordination, while basin and site agreements established repeatable procedures for coordination and responsibilities.

Table 3

Levels of institutional architecture and their practical functions

Level/ format	*Legal "anchors"*	*Practically recorded functions (operational content)*	*Typical capacity limit*
Regional framework (intergovernmental)	Agreement between the Republic of Kazakhstan, the Kyrgyz Republic, the Republic of Tajikistan, Turkmenistan and the Republic of Uzbekistan on Cooperation in the Field of Joint Management on Utilization and Protection of Water Resources from Interstate Sources; ICWC statutory documents	Agreement on coordination principles and procedures; preparation of technical solutions; support for regular coordination through commissions, secretariats and Basin Water Organizations (BVOs)	Dependence on related sectors (energy/agriculture) requiring special tools
Programme-environmental framework	Documents on the status of IFAS and its organisations	Programme coordination of intergovernmental initiatives; institutional framework for projects and donor packages; interaction between water and environmental authorities	The gap between the programme framework and annual operational decisions, without separate basin procedures
Basin format (Syr Darya)	The 1998 Agreement on the Syr Darya	Formalisation of special procedures for basin coordination; grounds for regular coordination of system operating modes	Specific compensation schemes and their evolution required separate analysis
Bilateral "object" format (Chu-Talas)	2000 Agreement of Chu-Talas; statutes of the Commission/ Secretariat	Commission-based coordination regime for the list of structures; rules for financing operations; procedural consistency of decisions through the secretariat and coordination calendar	Limitations on scalability to other basins without a similar "object" design and financial procedures

Source: compiled by the authors based on Agreement between the Republic of Kazakhstan, the Kyrgyz Republic, the Republic of Tajikistan, Turkmenistan and the Republic of Uzbekistan on Cooperation in the Field of Joint Management on Utilization and Protection of Water Resources from Interstate Sources (1992), Statute of the Interstate Commission for Water Coordination of Central Asia (1992), Scientific-Information Center of the Interstate Commission for Water Coordination, Central Asian Water Yearbook, Statute of the Commission of the Republic of Kazakhstan and the Kyrgyz Republic on the Use of Water Management Facilities of Intergovernmental Status on the Rivers Chu and Talas (2000).

Water and energy interests of Kyrgyzstan and Kazakhstan. The water and energy interdependence of Kyrgyzstan and Kazakhstan in the Naryn-Syr Darya basin during the 1990s-2020s was shaped by the asymmetry of seasonal needs and the spatial configuration of "upstream/downstream". The regulatory role of the Toktogul Reservoir and the cascade of hydroelectric power plants on the Naryn River determined the possibility of accumulating water during the growing season and its subsequent controlled release downstream for the irrigation needs of the southern regions of Kazakhstan, while for Kyrgyzstan, winter demand for electricity and heat remained critical. As a result, in practice, there was an exchange of two "seasonal deficits": water in summer for downstream and energy in winter for upstream, which indicated the logic of negotiations, reservoir operating modes and compensation parameters (World Bank, 2004). After the collapse of the Union of Soviet Socialist Republics, the Toktogul operating regime changed in line with the transformation of the energy balance and fuel price conditions. During the Soviet period, irrigation dominated, with most discharges occurring in spring and summer, while in the 1990s, there was a shift towards energy production, with an

increase in winter discharges for electricity generation (World Bank, 2004; Diebold, 2012). Published reconstructions of Toktogul operating data indicate that, in the Soviet period, about 75% of releases occurred during the growing season, whereas after the shift toward winter energy generation, summer releases decreased to about 45% and winter releases increased to about 55% of annual discharge (Diebold, 2012; Abbink et al., 2005). Because a complete open hydrometric series for the 1990s was not available, these figures were treated as published comparative estimates rather than independently recalculated primary measurements. This shift meant that the compensation component ceased to be an "add-on" and became a condition for the reproducibility of agreements: upstream needed to replace winter generation (with fuel, electricity or payments), while downstream needed predictable summer water releases (World Bank, 2004). The normative "anchor" for the water-energy link was the intergovernmental Agreement between the Governments of the Republic of Kazakhstan, the Kyrgyz Republic, and the Republic of Uzbekistan on the Use of Water and Energy Resources of the Syr Darya Basin (1998) on the use of water and energy resources in the Syr Darya basin, in which the concept of compensation for seasonal water regulation services was enshrined as an intergovernmental principle (government compensation in fuel/electricity or cash equivalents) (Weinthal, 2006). For the Kyrgyzstan-Kazakhstan bilateral agreement, this involved the institutionalisation of a practice whereby Kazakhstan's participation in compensation schemes was viewed not as a one-off "delivery" but as part of a coordinated cycle: reducing winter discharges/upstream generation, ensuring energy support, increasing and ensuring the predictability of summer water releases downstream. At the same time, sources emphasised that even with a framework agreement in place, the details of the parameters continued to be implemented on an annual basis (water release volumes, schedules, type and amount of compensation), which made the outcome dependent on current hydrology, the state of the power systems and the fulfilment of obligations by the parties (World Bank, 2004).

The evolution of compensation models in bilateral relations occurred as a change in the "form of equivalent" rather than in the logic of exchange. In the 1990s, barter formats dominated (coal, gas, fuel oil or electricity in exchange for accumulation and summer water discharge), continuing the Soviet practice of inter-republican balance, but without a supranational enforcement mechanism. In the 2000s, the materials recorded an increase in the role of situational bilateral agreements and ad hoc decisions, especially in periods when the coordination of annual parameters became difficult or was interrupted (Water Unites, 2026). In the 2010s and 2020s, electricity supplies and flow balancing were more often used as compensation instruments, which corresponded to the technological and market transformation of the energy sectors and the practice of shorter-term but recurring agreements (Kwan, 2025). The practical implications for reservoir regimes were primarily reflected in the fact that the coordination of water release schedules gradually shifted from a "single optimal plan" to regular adjustment procedures. Due to the seasonal conflict between winter generation and summer irrigation, typical "adjustment points" were recreated: the end of the autumn-winter period (assessment of reservoir levels and energy balance) and the pre-sowing/growing season (confirmation of summer discharges and readiness of downstream infrastructure to receive water). In this context, it remained critical for Kazakhstan to combine summer water supply with the ability to manage the consequences of winter discharges through downstream capacities, and for Kyrgyzstan to reduce winter generation in the presence of external energy supplies or compensation (Diebold, 2012). It was advisable to expand on the topic of joint response to "critical" hydrological episodes and trilateral coordination formats in a separate analytical section to maintain the priority of the section on the bilateral configuration of Kyrgyzstan-Kazakhstan interests (Table 4). The bilateral water-energy circuit between Kyrgyzstan and Kazakhstan in the 1990s-2020s was reproduced as a recurring cycle of seasonal exchange: upstream capacity to manage storage and water release was combined with downstream demand for a stable summer resource, while compensation (fuel/electricity/equivalent supplies) served as a mechanism for reconciling conflicting winter and summer priorities without changing the basic distribution of water resources, but with a change in the timing of their use.

Table 4

Seasonal structure of interests in Kyrgyzstan and Kazakhstan and reproducible compensation instruments

Seasonal mode	*Dominant need of Kyrgyzstan*	*Dominant need of Kazakhstan*	*Typical compensation/coordination mode*	*Operational consequence for the Toktogul regime*
Heating (autumn-winter)	Electricity generation and peak demand coverage	Minimisation of unwanted winter discharges and controllability of downstream modes	Electricity supplies/fuel equivalents/coordination of winter restrictions	Incentive to reduce winter generation when external energy supplies are available
Watering (spring-summer)	Water accumulation and preparation for regulation	Irrigation water supply and predictability of summer volumes	Coordinated schedules for summer water discharge and confirmation of compensation parameters	Maintenance of summer water releases under compensated winter conditions
Transitional months (spring/ autumn)	Balancing the power system and reservoir levels	Correction of water use plans/preparation of infrastructure	Regular adjustments to parameters and coordination of "control points"	Transition from a fixed plan to cyclical refinements

Source: compiled by the author based on World Bank (2004), Diebold (2012), Kwan (2025).

The trilateral dimension in transboundary river basins and the environmental component. Trilateral coordination in the Syr Darya basin in the 1990s-2020s functioned as a recurring seasonal coordination mechanism for reservoir operating regimes and related energy and irrigation parameters. Its regulatory and procedural basis was set by intergovernmental Agreement between the Government of the Republic of Kazakhstan, Government of the Kyrgyz Republic and Government of the Republic of Uzbekistan on Use of Hydro-Electric Resources of River Basin Syr Darya (1998) and annual protocol decisions of relevant agencies, which set the boundaries of the growing and inter-growing seasons, the logic of equivalent compensation and dispute resolution mechanisms. The configuration of interests in the "upstream-downstream" triangle was showed by different seasonal demand structures. Kyrgyzstan's upstream position was dominated by winter energy logic (increasing production during the cold period), while Kazakhstan and Uzbekistan, in downstream positions, were tied to summer-vegetation water intake for irrigation. This asymmetry shaped the practical content of the trilateral protocols: not a general declaration of cooperation, but an agreement on the "water balance" between the winter and summer periods to prevent a gap between the release regime from regulating reservoirs and irrigation needs (Kwan, 2025).

During "critical" periods (droughts, low water levels, shortage of reservoir filling at the start of the growing season), trilateral coordination became as practical as possible: coordinated additional discharges/supplies to the southern regions of Kazakhstan and downstream areas, clarification of release schedules and operational adjustments based on actual stock levels became key. For 2021, industry reviews noted the situation with the incomplete filling of the Toktogul reservoir at the beginning of the season and the coordination of additional water volumes for irrigation needs in Kazakhstan through negotiations with upstream countries in the Syr Darya basin. In contrast, during periods of winter energy consumption peaks, the priority was to "conserve water" in regulating reservoirs through compensatory energy supplies (to reduce incentives for increased winter discharges), which in 2025 was formalised as a trilateral protocol for the winter heating period and the following agricultural season (Kwan, 2025). Thus, crisis episodes not only exacerbated the conflict of seasonal interests but also prompted more detailed parameterisation of decisions in protocols (volumes, deadlines, links to reservoir regimes and energy flows) (Water Diplomat, 2025).

At the same time, during periods of excess discharges in the cold season (when electricity production in the upper reaches increased during winter holidays), the environmental and infrastructural consequences downstream became part of the negotiating field: water losses and flooding/redistribution in receiving systems were problematised, which historically manifested itself through cases of excess discharge into the Arnasay system. Legal and analytical materials emphasised the "operational" nature of this imbalance: changes in the cascade's operating modes led to an increase in winter discharges and the need to discharge excess water into downstream receiving water bodies, which created additional transboundary effects (Khamidov, 2026) (Table 5).

Table 5

Crises in the Syr Darya basin and parameters of trilateral coordination (examples)

Case	*Recorded as a matter of coordination*	*Documentary/review "anchors"*
Low filling/risk of deficiency at the start of vegetation	Additional water volumes for downstream irrigation; adjustment of release schedules depending on actual reserves	Industry review for Kazakhstan for 2021 (an additional 700 million m^3 compared to 2020, based on the results of negotiations)
Winter peak in upstream energy consumption and the risk of reserves being depleted by summer	Compensatory energy supplies/flows to encourage water conservation; agreement on parameters for the winter period and the following season	Tripartite Protocol of 22 November 2025 (Almaty) on water and energy coordination for winter and the 2026 season
"Balancing" modes at the turn of seasons (spring/autumn)	Operating modes of energy facilities and water distribution procedures for the future	Protocols for the growing season (in particular, notification of the protocol dated 15 May 2025)

Source: compiled by the author based on Scientific-Information Center of the Interstate Commission for Water Coordination, Central Asian Water Yearbook, Section 5 "Key water developments in the countries of Central Asia (Kazakhstan)" (2021), Kwan (2025), Kazinform International News Agency (2025).

In summary, the trilateral format in the Syr Darya basin in the 1990s and 2020s functioned not as a permanent "universal" regime of joint management, but as a recurring tool for coordinating parameters in situations of seasonal imbalance and during crisis episodes. During low water levels and energy peaks, coordination shifted to the most specific decisions (volumes, deadlines, regimes), which was confirmed by both industry reviews and protocol agreements in recent years.

In the 1990s, the central environmental issue in regional cooperation remained the crisis of the Aral Sea and the associated transformations of delta ecosystems and land degradation in the lower reaches (Alexyuk et al., 2021; Pilecka et al., 2017). The Aral Sea environmental framework provided the basis for the inclusion of environmental provisions in water and energy documents as a separate condition (Agreement between Government of the Republic of Kazakhstan, Government of the Kyrgyz Republic and Government of the Republic of Uzbekistan on Use of Hydro-Electric Resources of River Basin Syr Darya, 1998). In the 2000s, environmental issues became more closely linked to infrastructure decisions and monitoring practices. A key factor in this transition was the project to regulate the Syr Darya riverbed and the Northern Aral Sea, which defined the engineering components (in particular, those related to the Kok-Aral dam) and declared environmental goals for stabilising conditions in the northern part of the Aral Sea (World Bank, 2008). At the same time, in the 2010s and 2020s, the environmental agenda shifted significantly towards issues of soil degradation, salinisation and dust storms as "slow" risks that directly affected the productivity of irrigated agriculture and public health. Food and Agriculture Organization (2020) data for the region recorded a high proportion of salinised or waterlogged irrigated land in Central Asia (40-60% on average for the region; with details by country), which set the measurable scale of the problem for public policy and regional initiatives. Regional Midterm Strategy for Sand and Dust Storms Management in Central Asia for 2021-2030 (2021) emphasised the role of

land degradation and land use change in the increasing frequency/intensity of dust storms, as well as the need to combine land, water and climate policies. Scientific publications in recent years have further operationalised this risk through the spatial localisation of dust sources in the Aral Sea region and quantitative estimates of dust emissions in 2010-2020, which shifted the issue from political rhetoric to the measurable realm of environmental monitoring (Rakhmatova, 2025; Wójcik et al., 2022).

In practical terms, environmental initiatives were most often implemented through project formats, where the "outputs" were the creation/support of monitoring systems, engineering and restoration work in specific areas, the development of the capacity of national services, and the formation of cross-sectoral programmes in the affected regions. In this sense, the activities of the United Nations Multi-Partner Human Security Trust Fund (2026) for the Aral Sea Region in Uzbekistan were indicative, described as an instrument for consolidating multi-agency solutions (environmental, social, water, health and sanitation) to increase the resilience of communities in the area affected by the Aral Sea crisis and related environmental changes. In the 2020s, some materials from the United Nations and partner organisations linked the environmental track to a broader set of "new frameworks" – of climate adaptation, ecosystem restoration and the security implications of land degradation, broadening the basis for cooperation beyond narrow water distribution (United Nations General Assembly, 2022). The coherence of water and environmental policies emerged as an area of potential divergence, as short-term water and energy solutions could generate downstream environmental "side effects". This was evident in cases where winter release regimes, driven by upstream energy needs, led to the need to redistribute surpluses to downstream receiving systems, which was described in the sources as a factor of additional load on the territory and infrastructure and as an element of transboundary environmental impacts (Khamidov, 2026) (Table 6).

Table 6

Environmental issues and cooperation instruments (1990s-2020s)

Problematic node	*Cooperation tool/programme*	*Monitoring output (project/institutional)*
Consequences of the Aral Sea crisis, degradation of ecosystems in the lower reaches	IFAS and Aral Sea Basin Programs (ASBP)	Programme frameworks, coordination structures and donor projects on water and the environment
Regulation of the Syr Darya riverbed and the state of the Northern Aral Sea	Projects with an engineering component (in particular, SDCNAS)	Infrastructure solutions and accompanying environmental objectives/components within the project logic
Salinisation and waterlogging of irrigated land	Regional capacity building programmes and mapping of saline soils	Confirmed estimates of the scale of the problem and the development of monitoring/mapping tools
Dust and salt storms, land degradation and climate risks	Regional SDS strategies and related initiatives	Strategic framework integrating land, water and climate policies
Human security and community resilience in the Aral Sea region	United Nations Multi-Partner Human Security Trust Fund for the Aral Sea Region	Multi-sector programmes, consolidated reports and project portfolio in the region

Source: compiled by the authors based on Agreement between the Governments of the Republic of Kazakhstan, the Kyrgyz Republic, and the Republic of Uzbekistan on the Use of Water and Energy Resources of the Syr Darya Basin (1998), World Bank (2008), Food and Agriculture Organization (2020), Regional Midterm Strategy for Sand and Dust Storms Management in Central Asia for 2021-2030 (2021), United Nations Multi-Partner Human Security Trust Fund (2026).

The environmental dimension of cooperation in the 1990s and 2020s took shape as a separate set of practices and programmes that were not limited to seasonal water distribution decisions but were systematically dependent on them. The transition from framework declarations to practical outcomes took place mainly through project formats

(infrastructure, monitoring, restoration, capacity building) and through the expansion of the agenda in the 2020s to include land degradation and dust storms, which were quantified and included in strategic documents.

Comparative assessment of cooperation effectiveness and current stage. The comparison of the effectiveness of water and environmental cooperation in the 1990s and 2020s was appropriately focused on five indicators of practical sustainability: the duration of agreements over time, the predictability of water distribution regimes, the transparency of data, the enforceability of decisions, and the availability of dispute resolution procedures. Within these indicators, it was noted that the most formalised elements of cooperation arose where permanent or regular technical procedures were established, while seasonal coordination formats reproduced the logic of short "winter-summer" cycles linked to reservoir storage/discharge regimes and the energy needs of the heating season. This distinction was evident both in the materials on the work of basin and bilateral commissions and in reports on trilateral protocols for seasonal coordination.

The stability of agreements over time varied depending on the institutional "bearer" of obligations. Agreements with defined objects of joint management and distributed functions of operation/maintenance (primarily regarding inter-state water management facilities) formed the basis for repeatable procedures and regular contacts between authorised bodies. This created a framework within which technical decisions could be made without having to completely "reapprove" the entire interaction scheme each time. In contrast, seasonal balancing protocols, despite their practical significance for a specific season, mostly fixed parameters for a limited period and left room for revision depending on hydrological conditions, energy shortages and negotiation dynamics. The predictability of water distribution in cooperation practice was supported by two types of mechanisms. The first type was based on regular coordination of water release schedules and infrastructure operation, with the subject of coordination being mainly the parameters of the facilities' operation and the distribution of maintenance costs. The second type emerged as energy-compensation coordination, where winter water storage parameters were linked to agreed electricity supplies or other compensation solutions at the intergovernmental level; predictability was achieved within a specific cycle but required regular political confirmation before each season. Public announcements of the 2025 trilateral agreements explicitly described this link as a coordination of winter energy supplies and summer irrigation needs (Kwan, 2025).

Data transparency in the 1990s-2020s was linked to the development of regional information infrastructure and data support by specialised organisations, in particular through specialised portals and analytical units. In this context, the role of Scientific-Information Center of the Interstate Commission for Water Coordination, Central Asian Water Yearbook and related information resources as platforms for the accumulation and dissemination of reference and analytical materials used to coordinate positions and verify individual parameters of water use regimes was evident. At the same time, the mere existence of an information resource did not eliminate sensitivity to access regimes, differences in national accounting systems, and differences in operational monitoring capabilities. The enforceability of decisions depended on funding and technical capacity, which is reflected in both narrow tasks (maintenance of specific objects) and broader programmes. An example of the instrumentalization of external support for environmental purposes was the Northern Aral restoration projects, where the implementation of infrastructure measures was linked to international funding and project discipline. This made it possible to measure interim results but did not change the fact that broader basin coordination remained multi-level and dependent on intergovernmental decisions on water withdrawals (World Bank, 2008). Dispute settlement procedures existed both in the form of formal provisions in intergovernmental agreements and in the form of negotiation practices through meetings of authorised ministries/agencies. Formalised provisions (regarding the procedure for resolving disputes) did not always mean frequent use of "quasi-arbitration" mechanisms in practice; Instead, everyday coordination was dominated by consensual formats based on political agreement and technical compromises at the level of relevant bodies (World

Bank, 2026). A summary of the factors that accompanied the reproduction of successful or problematic patterns revealed several recurring links. These included political cycles and shifts in priorities, energy prices and shortages during winter periods, physical infrastructure constraints (including losses in irrigation systems), and uneven institutional and technical capacity (monitoring, modelling, demand management). The impact was further exacerbated by the risks of climate variability and the increasing frequency of extreme events, which increased the burden on coordination mechanisms and heightened the importance of flow forecasting (World Bank, 2024).

Based on the identified features, it was appropriate to describe the typology of developed cooperation models. The "Pragmatic/technical" cooperation was evident where tasks were operationalised in the form of facility operating procedures, agreed rules for access and cost sharing, and regular contacts (examples included mechanisms for specific transboundary river systems). The "Crisis-compensation" cooperation was manifested as seasonal water-energy balancing, where the key was to coordinate the parameters of water storage in reservoirs with parallel decisions on energy supply for the winter and irrigation for the summer; this model was replicated in the event of shortages and during the risk of drought/low water levels. The "Institutional-declarative" cooperation was manifested through umbrella organisations and forums, where general principles and agendas were developed, and the legitimacy of common priorities was coordinated, but the practical results depended on funding, project design and coordination at the "operational level" (Table 7).

Table 7

Comparative scoring of cooperation sustainability criteria, 1990s-2020s

Criteria	*Bilateral/basin mechanisms (operational procedures)*	*Score*	*Tripartite seasonal coordination protocols*	*Score*	*Regional frameworks (institutional platforms)*	*Score*
Stability of agreements over time	Supported through fixed objects/ procedures and repeatability of technical solutions	2	Limited by the horizon of the season and required periodic renewal of the political mandate	1	Maintained through regular meetings/ agendas, but the "practical content" depended on projects and bilateral decisions	1
Predictability of water distribution	Formed through agreed schedules and operating regulations	2	Formed through the agreement of "water-energy" for a specific winter-summer cycle	1	Depended on coordination at lower levels and data availability	1
Data transparency	Supported by technical data exchange within the scope of specific tasks	2	Depended on the timeliness of data on flow/reservoirs and on protocol parameters	1	Relied on regional information tools, but remained sensitive to differences in national accounting	1
Enforceability of decisions	Determined by the availability of funding for the maintenance of facilities and the clarity of responsibilities	2	Determined by the fulfilment of reciprocal obligations (supply/ accumulation/ discounts) within the season	1	Determined by project financing and the ability to transform frameworks into specific programmes	1
Dispute resolution	Mostly based on conciliation procedures and technical compromises	1	Mostly based on negotiations within the framework of ministerial contacts	1	Existed as a political and diplomatic platform; solutions were transferred to the bilateral/trilateral level	1

Note: 0 = absent; 1 = partially present; 2 = clearly specified and repeatedly applied. Source: compiled by the authors based on World Bank (2008; 2026).

In this article, practical sustainability means the capacity of a cooperation format to be repeated across seasons or political cycles through written procedures, data exchange, identified responsible bodies, financing or compensation arrangements, and dispute or consultation mechanisms. Each criterion was scored as 0, 1 or 2, where 0 means that the criterion was absent, 1 means that it was partially present or dependent on ad hoc negotiation, and 2 means that it was clearly specified and repeatedly applied.

In the 1990s and 2020s, the practical sustainability of cooperation was related to the extent to which interaction was translated into procedures that could be repeated without a complete political "restart" each time. Where coordination was based on specific management objectives, regular operating rules and confirmed responsibilities, technical cooperation was replicated. Where seasonal water-energy balancing became key, a cycle of short protocols and negotiations responding to shortages and climate fluctuations was replicated. Framework institutions provided legitimacy for shared priorities and platforms for agreeing on agendas, but real practical results depended on funding, data and coordination at the bilateral/basin level.

Materials from the late 2010s to mid-2020s recorded a shift in focus from predominantly "contentious" water distribution to the broader framework of water security, climate adaptation and energy transition. At the level of regional events and partnership platforms, the need to strengthen cooperation was emphasised as a condition for risk management and as a tool for coordinating investments in water and energy infrastructure. At the same time, there was an increase in the number of thematic forums where water issues were combined with the climate agenda and sustainability issues (World Bank, 2022). The actual practice has been reflected in the strengthening of seasonal coordination at the trilateral level, where water storage and discharge parameters were directly linked to agreed energy supply volumes for the winter period and water supply for summer irrigation. Public announcements about the 2025 protocol described the agreement in precisely these terms: winter energy supplies were accompanied by conditions for water storage with subsequent summer water release for agricultural needs. Such agreements pointed to the institutionalisation of a negotiated "working regime" at the water-energy interface but did not change the fact that the stability of this regime depended on hydrological conditions, the state of the energy system and the discipline of meeting reciprocal parameters (Kwan, 2025; Bruno et al., 2019). Climate risks have increasingly become a system-forming factor at the current stage. Reports from international partners provided estimates of the possible reduction in average water resources in the Amu Darya and Syr Darya basins by the middle of the century, which in practical terms meant increasing the importance of flow forecasting, demand management, irrigation modernisation and coordination of reservoir regimes. In addition to water scarcity, regional documents highlighted the role of land degradation, dust storms and desertification risks as factors that increased the vulnerability of agricultural areas and heightened the need for the integration of water and environmental policies (World Bank, 2024).

In this context, in 2024-2025, open materials and partnership programmes described a return to large infrastructure "anchors" of cooperation, where water and energy interdependence was translated into joint preparations, consultations and the attraction of international financing. The Kambar-Ata-1 project was cited as an example, presented as a regional initiative involving Kyrgyzstan, Kazakhstan and Uzbekistan, with expected effects on energy supply and water resource use regimes in a broader cooperative logic. In this approach, the water component was effectively treated as part of the long-term architecture of energy transition and risk management, rather than just a subject of seasonal negotiations (World Bank, 2025).

The scenario-based generalised results for 2030 in publicly available materials and cooperation programmes were logically grouped into three trajectories. The first trajectory was described as infrastructure and investment cooperation, in which the coordination of water and energy regimes was supported by joint projects and external financing, as well as the development of environmental and social risk assessment procedures. The second trajectory was described as managed seasonal coordination, where the "core" remained protocols for coordinating water storage/energy supplies with

greater attention to data, forecasts and monitoring procedures. The third trajectory was described as maintaining a fragmented negotiation regime, where coordination was mainly activated during droughts, shortages or emergencies, and inter-crisis periods did not lead to long-term coordination of investments and rules (World Bank, 2026). The final comparative summary for the three countries identified a common "core" of problems and solutions in terms of upstream/downstream logic: reservoir regulation of flow and power generation in the upper reaches were linked to irrigation needs and water quality in the lower reaches. At the same time, differences were determined by the structure of energy and agricultural water use: for Kyrgyzstan, the water-energy cycle was more closely linked to internal energy security and winter deficit regimes; for Kazakhstan, the water component was combined with issues of irrigation and ecological rehabilitation of certain territories (in particular, within the framework of the Northern Aral projects); for Uzbekistan, the water cycle was determined by the scale of irrigation and the consequences of land degradation and salinisation, which increased the importance of environmental parameters in water distribution decisions (Table 8).

Table 8

Scenario-based generalisation trajectories to 2030, as described in the 2021-2025 materials

Trajectory	*How the preconditions were described in public materials*	*What consequences for cooperation were outlined*	*What "bottlenecks" were highlighted*
Infrastructure and investment cooperation	Joint projects + external financing + risk assessment procedures	Water-energy coordination was postponed to a longer planning horizon	Environmental/social risks, financial model approval, and intergovernmental coordination
Managed seasonal coordination	Regular protocols + strengthening of data/forecasts + monitoring	Seasonal cycles became more procedurally "tied" to data and rules	Discipline in execution, accuracy of forecasts, and infrastructure constraints
Fragmented negotiation mode	Activation during droughts/shortages without lengthy planning	The agreements were short-term and dependent on market conditions	Recurrence of crises, low coordination of investments, and lack of trust

Source: compiled by the authors based on World Bank (2008; 2022; 2024; 2025).

At the modern stage (late 2010s to mid-2020s), water-environmental cooperation can be described as simultaneously maintaining the seasonal nature of coordination and gradually integrating into the broader framework of climate adaptation, water security, and energy transition. The 2025 public coordination protocols demonstrated the replicability of "working" mechanisms at the water-energy interface, while large infrastructure initiatives such as Kambar-Ata-1 outlined a transition to a longer horizon of interest alignment. When comparing the three countries, the upstream/downstream core of interdependence remained common, while the differences were determined by the structure of the energy sector, the scale of irrigation and environmental constraints, which set different "configurations" of priorities in negotiations and in the implementation of agreements.

Discussion. The results on the evolution of cooperation in transboundary basins in Central Asia were compared with contemporary research on intergovernmental coordination, compensation mechanisms, water-energy interdependencies, and the environmental effects of water management. This comparison clarified which conclusions coincided with international patterns and which were explained by the specifics of seasonality and the upstream/downstream configuration in the region. Ding and Gong (2023) demonstrated that intergovernmental cooperative policies, supported by joint oversight and the use of monitoring station data, were associated with improvements in integrated water quality indicators, while the impact on individual pollution indicators remained limited. A historical comparative analysis of water-environmental cooperation

similarly found that practical environmental effects depended on the regularity of coordination and the availability of comparable data, but a sustained "improvement" in water quality indicators was not always achieved due to the dominance of water distribution and water energy solutions over pollution control instruments. Cooperation in transboundary water relations prevailed over conflict, although episodes of non-military tension over resource distribution and management remained frequent, as studied by Bernauer and Böhmelt (2020). In the cooperation of three Central Asian countries, this configuration was reproduced through the alternation of "pragmatic/technical" interaction with "crisis-compensation" cycles that arose during the coordination of seasonal water releases and compensation mechanisms between upstream and downstream participants.

The study by Li and Lu (2022) determined that intergovernmental coordination within horizontal environmental compensation was associated with curbing cross-border illegal discharges and strengthening surveillance at administrative monitoring "borders". In contrast, a study on Central Asia found that water-energy/fuel compensation schemes prevailed, and the environmental component was more often implemented through project-based monitoring formats and infrastructure measures, which limited the possibility of directly linking the implementation of agreements to water quality indicators. Cooperative approaches to water allocation could address spatial and temporal constraints, seasonality of demand and differences in the usefulness of water use, formalising the exchange of benefits between participants, as shown by Liu et al. (2020). A historical comparative analysis determined that it was the lack of an agreed compensation "formula" and the asynchrony of data on reservoirs and water releases in different periods that caused repeated cycles of agreement revisions, even in the presence of framework institutions and coordination protocols. Skoulikaris (2021) demonstrated that the implementation of the European Union's water directives created common rules, planning tools and communication channels that structured cross-border interaction in shared water basins. The study revealed that regional frameworks and basin mechanisms existed, but their enforceability and regularity of coordination were more dependent on political cycles and funding than on supranational procedures, which affected the predictability of decisions during peak seasons.

The analytical suitability of linking water, economic and environmental parameters in a single assessment framework, since gaps between subsystems were identified as a source of development imbalances, was demonstrated by Cheng et al. (2023). The study found a "discrepancy" between water and energy solutions and environmental impacts (water quality, land degradation in irrigation areas, the state of the delta and coastal ecosystems), which justified the introduction of nexus logic at the current stage and scenario generalisations until 2030. Yu et al. (2024) found that horizontal environmental compensation was associated with a reduction in industrial discharges and water pollution, with the effect being more pronounced in the upper reaches than in the lower reaches. A study of transboundary river basins in Central Asia showed that upstream/downstream asymmetry determined recurring "points of tension" during the coordination of water release schedules, and the most reproducible compromises were decisions where upstream incentives were combined with transparent data and procedural fixation of seasonal regimes. Zhu et al. (2022) showed that the mechanism of environmental compensation in interregional water transfers could be more sustainable when the incentives of the parties were formalised as a recurring strategic interaction rather than a one-off agreement. In this analysis, similar logic was reproduced in the material on water-energy compensation: the stabilisation of seasonal water discharge regimes depended on the procedural linking of compensation to water parameters and reservoir schedules, and the disruption of this link at various times caused a cyclical return to the revision of agreements.

Water management policy in developing countries requires prioritising institutional capacity, supporting monitoring systems and investing in basic infrastructure, as these components determine the enforceability of decisions, as summarised by Bjorklund (2001). The results of the study on Central Asia were consistent with this conclusion in terms of the "working level" of coordination: the effectiveness of agreements was most often ensured by technical procedures, funding and data availability, while the weakness

of monitoring tools and uneven technical capacity limited the environmental impact of cooperation. Ide and Detges (2018) showed that international water cooperation could serve as a form of "environmental peace-making" when joint environmental initiatives created channels of communication and reduced the risks of escalating tensions. The study revealed that the environmental track was indeed used as a platform for maintaining interaction (monitoring, project formats, institutional forums), but its integration into seasonal water-energy decisions remained incomplete, which meant that environmental programmes did not always translate into mechanisms for preventing water distribution crises. For transboundary basins in Central Asia, mutual constraints in the water-energy-food nexus remained key, where seasonality and upstream/ downstream asymmetry shifted governance into a mode of compromise between sectors, as systematised by Bamgboye et al. (2025). The results obtained specified this framework through a historical reconstruction of compensation mechanisms and periods of their failure, showing that the stability of agreements was determined not by the general declared nexus logic, but by the existence of reproducible procedures for coordinating water release schedules and energy support tools during the winter period. Han et al. (2022) demonstrated that after the Aral crisis, agricultural growth and production structure in the countries of the region were characterised by unevenness, which exacerbated differences in water demand and sensitivity to irrigation deficits. In the study of cooperation, this was reflected in the different "costs" of water shortages for downstream areas during peak seasons and in the fact that the stability of trilateral coordination depended on the ability to transform these differences into parameterised decisions on water supply volumes and timing.

Pérez Pérez et al. (2025) demonstrated that system dynamics was used to reproduce feedback loops between water distribution, energy decisions, and food consequences in the Aral Sea basin, making delays and cumulative effects of management decisions visible. In the results obtained, similar feedback loops were identified empirically and historically: changes in reservoir regimes during the winter affected the predictability of irrigation in the summer, and the recurrence of crises was explained precisely by the "delays" between energy needs and water management consequences in the following season. Hydropower in Central Asia developed as a strategic sector, which at the same time generated cross-border externalities through changes in flow regimes and reservoir operation, as summarised by Pedroni et al. (2025). The results of the study support Pedroni et al.'s thesis that hydropower development in Central Asia creates cross-border effects when reservoir operation is not coordinated with downstream irrigation and environmental needs. At the level of coordination mechanisms, infrastructure projects and capacity dispatching influenced negotiating positions and compensation schemes, while "points of tension" occurred where energy decisions were not procedurally aligned with downstream irrigation needs and environmental constraints. In conclusion, the study determined that repetitive coordination procedures, data transparency and stable incentives are key to the sustainability of agreements, while the cyclical nature of tensions is reproduced by the gap between compensation and seasonal water release parameters. The environmental track often had limited practical effects when it was not integrated into decisions on reservoir regimes and water supply schedules.

Conclusions. Water and environmental cooperation between Kyrgyzstan, Kazakhstan and Uzbekistan from 1991 to 2025 evolved as a system of multi-level agreements, in which real manageability was determined by the ability to translate framework policy decisions into repeatable procedures for seasonal coordination and technical management of facilities. The study determined that the periodisation of cooperation reflected the transition from the early post-Soviet stage to phases of institutional stabilisation, periods of tension/revision and the current stage of reorientation, where, alongside water distribution, the role of water security, climate risks and infrastructure "anchors" of interaction grew. In the water-energy interdependence of Kyrgyzstan and Kazakhstan, a quantitatively expressed shift in discharge regimes was recorded in 1990-2000: the summer share decreased to approximately 45%, while the winter share increased to

about 55%, implying a structural dependence of summer irrigation predictability downstream on winter energy compensation mechanisms upstream. In the trilateral dimension, the study noted that during the crisis years, coordination took the form of parameterised decisions on volumes and schedules; A notable example was in 2021, when additional water volumes of around 700 million m3 were agreed compared to the previous year, as well as the formalisation of protocol decisions in 2025, which combined winter energy supplies with the task of conserving water for the next growing season. In terms of the environment, there was a shift in the agenda from predominantly "Aral" issues to a combination of water quality monitoring, land degradation and salinisation of irrigated areas, the scale of which reached 40-60% in regional assessments, justifying the need to integrate water and environmental policies. Practical recommendations included standardising seasonal coordination protocols (single control points for coordination, minimum requirements for data exchange, procedural linking of compensation to hydrological indicators), strengthening basin monitoring and data transparency, and directing investments towards reducing losses in irrigation systems and increasing the flexibility of reservoir management. The limitations of the study were related to the uneven completeness of open data for individual years and the fact that some decisions were recorded in protocols and communications that reflected political agreements but could not always be used to track the level of actual implementation using a single methodology. Further research should develop a comparative database of the feasibility of seasonal agreements (by year and basin area), quantitative assessment of the impact of water discharge regimes on water quality and salinity indicators, as well as scenario modelling until 2030, incorporating climate trends, infrastructure constraints and energy transition opportunities.

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