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## International Legal Regulation of Transboundary Waters of Central Asia

This study examines the legal regulation of transboundary waters in Central Asia, focusing on the Amu Darya and Syr Darya basins. The objective is to assess how international and regional legal frameworks, institutional mechanisms and procedural tools—including transboundary environmental and social impact assessment (ESIA), annual operating protocols and compensation mechanisms—support cooperative, sustainable basin management. The methods combine normative legal analysis of international conventions and basin treaties, a comparative case study approach (Rogun and Toktogul), a documentary review of ESIA reports and basin organization, and a synthesis of secondary literature. The key findings indicate that the existing multi-layered architecture provides essential procedures for cooperation but leaves practical gaps in transparent compensation formulas, transboundary groundwater governance and sustainable financing for shared monitoring. The Rogun case highlights the need for early, jointly agreed ESIA terms, enforceable mitigation and multi-year contractual arrangements. The Toktogul case demonstrates the operational necessity of formulaic annual protocols, interoperable real-time data exchange and timely compensation mechanisms. The conclusions stress that harmonizing national law with basin agreements, establishing neutral technical secretariats, implementing interoperable monitoring and verification systems, and creating formal compensation facilities increase predictability, reduce transaction costs and strengthen resilient and mutually beneficial management of transboundary waters in the region.

*Keywords:* Transboundary waters, Amu Darya, Syr Darya, Environmental and Social Impact Assessment (ESIA), Equitable and reasonable use, Prevention of transboundary harm.

### Introduction

Transboundary water resources in Central Asia are central to regional security, economic development and food stability. Climate change, infrastructure expansion and evolving national priorities increase the risk of interstate tensions and underscore the need for updated legal and institutional responses.

To evaluate the effectiveness of international, regional and national legal and institutional arrangements governing the Amu Darya and Syr Darya basins and to propose practical measures to address identified gaps. Tasks.

1. Describe the current multi-level legal architecture and institutional mechanisms.
2. Analyze two case studies (Rogun and Toktogul) with respect to legal claims, technical drivers and institutional responses.
3. Identify key gaps-transparent compensation, aquifer governance, sustainable monitoring finance, and dam safety.
4. Propose concrete legal and institutional measures to enhance predictability and resilience.

Debates center on balancing state sovereignty with the duty not to cause transboundary harm, the flexibility of equitable and reasonable use versus the need for predictable, formulaic mechanisms, and the role of external financiers in conditioning project legitimacy.

Empirical evidence on the effectiveness of contractual compensation mechanisms is limited; transboundary groundwater governance remains underdeveloped; and sustainable financing models for interoperable monitoring platforms are insufficiently explored.

The analysis adopts an applied legal-institutional approach that privileges implementable, verifiable and financeable solutions compatible with the region's existing multi-level architecture.

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### *Methods and materials*

Normative legal analysis: Examination of international instruments (UN Watercourses Convention, UNECE Water Convention, ILC Draft Articles) and basin treaties to identify core obligations and procedural duties.

Comparative case studies: Detailed review of the Rogun hydropower project and Toktogul reservoir operations using ESIA, basin organization reports, donor project documents and scholarly analyses.

Documentary review: Systematic analysis of annual protocols, dam safety assessments, hydrometric reporting standards and technical guidelines from ICWC, BVOs and multilateral agencies (period covered: 1992–2024).

Synthesis and policy analysis: Integration of legal norms and empirical findings to formulate practical recommendations; where applicable, expert assessments and secondary quantitative indicators (e.g., storage capacities, reported exchange volumes) were used to illustrate operational dynamics.

### *Results*

The legal and policy framework for rivers and aquifers shared by two or more countries provides a practical foundation for cooperative, sustainable and mutually beneficial management. A small set of interlocking principles—equitable and reasonable utilization, prevention of significant transboundary impacts, cooperation, prior notification, and shared scientific assessment—creates predictable conditions for planning, investment and joint development. These principles are reflected in global and regional conventions, model provisions and draft articles, basin treaties and national laws; when translated into clear operational rules and routine institutional practices they enable riparian states to realize shared value from water resources while strengthening regional integration and resilience [1].

Equitable and reasonable utilization is a flexible allocation approach that balances diverse needs and promotes efficient, sustainable use. Rather than fixed numerical shares, it asks parties to weigh relevant factors—hydrogeology and seasonal variability, population and development needs, existing and planned uses, conservation objectives and available alternatives—and to negotiate arrangements that maximize basin-wide benefits. This encourages practical, win-win solutions such as coordinated reservoir operation, seasonal exchange schemes, conjunctive use of surface and groundwater, and benefit-sharing mechanisms that align hydropower, irrigation and ecosystem services so the basin as a whole gain more than any single country would on its own. Because the focus is on fair outcomes, allocations and operational rules can be reviewed and adjusted over time as new data, technologies or socio-economic priorities emerge, supporting adaptive governance and long-term cooperation [2].

The duty to prevent significant transboundary impacts complements equitable use by ensuring development protects shared interests. Framed positively, it promotes early planning, joint assessment and mitigation measures that preserve water quality, maintain recharge regimes and sustain ecosystem functions. For groundwater systems—where effects can spread slowly and across wide areas—this duty highlights the need for integrated management that links water use with land-use planning and pollution control. Joint monitoring, common assessment methods and shared databases help parties detect risks early and design coordinated responses such as managed aquifer recharge, targeted pollution controls or harmonized agricultural practices that enhance sustainability and deliver mutual benefits.

Procedural obligations turn principles into routine cooperation. Timely notification of planned measures, structured consultation, joint environmental and social assessment, and transparent data exchange create a predictable environment for decision makers, investors and communities. Agreed timelines and standardized technical formats speed review and collaborative project design, while joint fact-finding and technical working groups provide neutral, evidence-based inputs that support consensus building. These routines reduce transaction costs, accelerate implementation and build confidence among partners, enabling basin-wide initiatives to proceed with clarity and mutual support [3; 68].

A layered legal architecture underpins effective governance. Global and regional instruments set core obligations and procedural duties; draft articles and model provisions offer practical templates for aquifer-sensitive rules; basin and bilateral treaties translate general norms into operational arrangements tailored to local hydrology and institutional preferences; and national legislation supplies enforcement tools—licensing, permitting, effluent standards and land-use controls—that make cooperative arrangements effective on the ground. This multi-level design provides legal certainty for stakeholders while preserving flexibility for bespoke solutions that reflect basin-specific realities.

Institutional arrangements are central to sustaining cooperation. River basin commissions, joint technical bodies and shared monitoring platforms provide continuous forums for dialogue, coordination and implementation. These institutions harmonize data collection and analysis, coordinate operational routines (for example, reservoir releases and irrigation schedules), administer joint projects and investments, and facilitate stakeholder engagement. By embedding technical, legal and policy expertise in permanent structures, basin institutions lower transaction costs, speed decision making and create durable channels for innovation, joint investment and climate adaptation.

Harmonizing domestic law with international commitments is a practical priority that unlocks the full potential of basin agreements. Clear national procedures for abstraction permits, discharge authorizations and environmental safeguards translate treaty provisions into enforceable practice, creating predictable conditions for users and investors. Aligned legal frameworks reduce cross-border regulatory friction and enable joint enforcement, cooperative monitoring and shared compliance mechanisms that sustain trust and long-term partnership.

Adaptive management and periodic review keep governance responsive and future-oriented. Agreements that include review clauses, trigger points for joint reassessment and mechanisms for incorporating new scientific knowledge allow parties to refine allocations, update operational rules and adopt innovative technologies as circumstances change. This dynamic approach encourages pilot projects, learning from shared experience and scaling up successful practices across the basin, balancing legal stability with operational flexibility.

Data, transparency and shared science are foundational enablers. Common monitoring networks, interoperable databases and agreed quality standards create a shared evidence base for equitable decision making and efficient project design. Transparent information flows reduce transaction costs, facilitate joint investment planning and enable meaningful stakeholder participation. Joint scientific programs such as hydrogeological surveys, coordinated modelling and collaborative research, build mutual understanding and open opportunities for co-financing infrastructure and knowledge platforms that deliver basin-wide benefits [4].

Benefit-sharing approaches expand cooperative options and attract financing. Framing cooperation around shared gains—energy trade, coordinated irrigation, joint infrastructure and payments for ecosystem services—helps distribute value equitably and aligns economic incentives with sustainable resource management. Capacity development and institutional strengthening multiply returns from legal and technical cooperation: training, joint workshops and exchange programs build the human capital needed to operate complex governance systems and foster a culture of cooperation and shared problem solving.

Integrated planning that links water, land use and energy objectives produces synergistic outcomes. Coordinated reservoir operation, conjunctive use strategies and land-use protection for recharge areas raise basin productivity and resilience. Strategic investments in modern irrigation, efficient pumping and nature-based recharge solutions deliver economic, social and environmental benefits across the basin. Embedding climate-adaptive provisions—flexible allocation adjustments, contingency operation rules and joint drought and flood planning—ensures governance remains aligned with evolving climatic conditions and the best available science.

Inclusive stakeholder engagement broadens legitimacy and durability. Involving local communities, water users, civil society and the private sector in planning and monitoring builds shared ownership, taps local knowledge and mobilizes resources. Inclusive processes improve decision quality, increase transparency and strengthen social acceptance of joint measures, supporting equitable benefit distribution.

In short, a coherent mix of clear principles, practical procedures, layered legal instruments and capable institutions creates an actionable roadmap for transboundary water governance. By adopting aquifer-sensitive provisions, harmonizing domestic and international rules, investing in shared science and capacity, and designing agreements that emphasize transparency, adaptability and benefit sharing, riparian states can transform shared water resources into lasting engines of regional cooperation, resilience and sustainable development.

The Amu Darya and Syr Darya basins form Central Asia's hydrological backbone, delivering seasonally regulated flows that sustain irrigated agriculture, hydropower and a range of ecosystem services. The Syr Darya concentrates runoff in the Naryn and Kara Darya sub catchments, regulated by major reservoirs such as Toktogul and Kayrakkum, while the Amu Darya's Pamir and Hindu Kush headwaters feed glacier and snow-dominated tributaries (notably the Vakhsh and Panj) that generate spring-summer runoff

converted into reliable seasonal supplies by downstream irrigation systems and multipurpose reservoirs [5; 91].

Seasonal snow and glacier melt is the principal driver of annual hydrographs, and high-altitude accumulation zones naturally complement downstream irrigation demand; reservoir cascades and engineered storage transform this seasonal pulse into managed flows that serve hydropower, irrigation, flood moderation and environmental objectives, with coordinated cascade operation maximizing basin-wide benefit [6].

Mid-20th century development of reservoirs, canals and hydropower plants created a technical foundation for integrated basin management—many facilities were designed as multipurpose structures to provide seasonal irrigation storage and peak hydropower generation, and their combined operation remains central to modernization efforts. Since independence, institutional evolution—high-level declarations, regional agreements and intergovernmental commissions—has translated that technical legacy into cooperative practice, enabling routine information exchange, joint monitoring and harmonized seasonal scheduling [7; 93–99].

Operational cooperation is pragmatic and benefit-oriented: upper-basin reservoirs provide regulation services valued by downstream irrigators, and downstream partners reciprocate with energy, fuel or financial transfers formalized through framework agreements and annual protocols that align incentives for cooperative operation.

Data sharing, joint monitoring and forecasting (harmonized hydrometric networks, shared reservoir reporting and common modeling platforms) reduce uncertainty and support anticipatory management, while targeted investments (irrigation conveyance upgrades, improved reservoir models, automated gates and metering, and infrastructure rehabilitation) increase water-use efficiency and expand effective supply [8]. Conjunctive surface-groundwater management, joint aquifer mapping and coordinated use strengthen resilience by supporting baseflows and augmenting supplies during dry periods. Adaptive governance, periodic review clauses and mechanisms for incorporating new science keep arrangements responsive to changing conditions, and inclusive stakeholder engagement through basin councils, technical working groups and user associations broadens legitimacy and shared ownership of operational rules and investment priorities. Environmental stewardship like maintaining environmental flows, protecting wetlands and managing salinity are integral to long-term planning because it sustains ecosystem services that underpin livelihoods.

Priorities going forward include expanding joint forecasting services, deepening groundwater integration, accelerating irrigation modernization, and refining transparent compensation mechanisms for seasonal services; continued emphasis on technical cooperation, transparent data exchange and adaptive investments will strengthen the basins' capacity to deliver water, energy and agricultural services in a resilient and mutually beneficial manner [9].

The legal and institutional framework governing the Amu Darya and Syr Darya basins is a multi-layered architecture that combines high-level political declarations, basin-level agreements, standing regional commissions and basin organizations, national water and sectoral laws, and relevant international conventions and soft-law instruments.

Foundational post-Soviet instruments, beginning with the 1992 Almaty cooperation framework and reinforced by the Nukus declarations, established the premise that Aral basin waters are a shared regional asset and created the mandate for interstate coordination mechanisms. The 1998 Agreement on the Use of Water-Energy Resources of the Syr Darya Basin (and its 1999 protocol) remains the principal basin framework for seasonal coordination, compensation for regulation services and the preparation of annual operational protocols that specify release schedules and energy-for-water exchanges [10]. Permanent regional bodies, most notably the interstate coordination commission and the basin water organizations, implement these frameworks by compiling basin water balances, hosting joint monitoring and forecasting, preparing seasonal operating plans and administering annual protocols.

National legal frameworks as water codes, environmental protection and energy laws provide the domestic machinery for implementing basin allocations, but harmonizing these instruments with basin agreements remains a priority to reduce regulatory friction and ensure predictable compliance. Operational practice relies on annual and bilateral protocols that translate principles into time-bound actions—agreed hydrometric reporting formats, reservoir rule curves, joint environmental and social assessment procedures, and standardized forecasting products.

International conventions and soft law supply normative anchors and procedural tools: the UN Watercourses Convention sets out equitable and reasonable use and the duty not to cause significant

transboundary harm [11], the UNECE Water Convention offers mechanisms for transboundary EIA, information exchange and joint bodies [12], and the ILC Draft Articles on Transboundary Aquifers provide templates for aquifer assessment, recharge protection and conjunctive management [13]. Donor-supported programs and multilateral financing (World Bank, ADB, GEF, UNDP and bilateral partners) have been instrumental in modernizing hydrometric networks, rehabilitating infrastructure and establishing joint information platforms that underpin legal commitments and institutional. Dispute management follows a graduated, pragmatic approach that privileges negotiation, mediation through basin institutions and joint technical fact-finding, with arbitration or adjudication as backstops. Important everyday instruments (ICWC seasonal water balance decisions and BVO technical guidelines) set data formats, quality standards and timelines that convert treaty principles into executable actions.

Remaining gaps include the need for transparent, binding compensation formulas and contractual instruments for upstream regulation services; stronger, basin-specific transboundary groundwater and aquifer governance; interoperable data systems and sustainable financing for shared monitoring platforms and technical secretariats; harmonized national permitting, environmental safeguards and licensing regimes; and codified dam safety, emergency notification and joint contingency planning. Strengthening compensation mechanisms, expanding explicit aquifer governance, securing long-term funding for interoperable data systems and harmonizing national implementation are practical next steps to increase predictability, reduce transaction costs and broaden mutually beneficial cooperative options for the Amu Darya and Syr Darya basins.

### *Discussion*

The Rogun and Toktogul cases together illuminate two complementary fault lines in Central Asian transboundary water governance: **strategic, project-level risks** created by large new storage and **recurring operational frictions** arising from seasonal trade-offs. Rogun shows how a national energy project becomes a regional legal and political issue when storage and filling regimes alter seasonal flows; Toktogul shows how long-standing operating practices generate repeated compliance disputes when incentives and compensation remain ad hoc. Interpreting these cases together highlights that legal claims (equitable use; duty not to cause harm) are often invoked to frame technical disagreements whose proximate drivers are reservoir design choices, rule curves, metering and the political economy of energy and irrigation exchanges.

These empirical patterns align with, and extend, prior analyses. Consistent with Petrov and Ahmedov, the cases confirm that reservoir cascades and multipurpose infrastructure create interdependent service trade-offs; they also corroborate Mallaev's observation that annual bargaining produces uncertainty for users. Where this study adds nuance is in tracing how donor conditionality and ESIA procedures have become leverage points: conditional financing can compel procedural safeguards and independent review, but it does not by itself resolve underlying incentive asymmetries unless outcomes are contractually linked to operational protocols and compensation instruments.

Assessing procedural tools reveals mixed effectiveness. Joint or independently validated ESIA processes improve transparency and reduce technical dispute when terms of reference are agreed early; however, in practice ESIA outcomes are often insufficiently tied to enforceable operational commitments. Annual protocols and seasonal exchanges provide pragmatic short-term relief, yet their reliance on political negotiation perpetuates structural vulnerability. Similarly, existing basin institutions (ICWC, BVOs) supply essential forums for coordination but lack predictable financing and enforcement mechanisms to administer formulaic compensation or escrow arrangements at scale.

Policy instruments proposed in the Results are technically coherent but face political and implementation constraints. Standardized formulas reduce transaction costs but require agreement on baseline hydrology, measurement standards and valuation metrics; escrow or trust funds lower default risk but need credible governance and seed financing (where donors can play a catalytic role). A neutral secretariat can improve verification and data management, yet its authority depends on member states' willingness to cede some operational discretion and to commit sustainable funding.

This analysis has limitations that shape interpretation and next steps. Public data on actual compensation flows and some operational records are incomplete, and technical assumptions about filling scenarios remain contested; these gaps constrain precise quantification of impacts and the calibration of compensation formulas. To address this, the next phase should prioritize pilotable interventions: (1) a joint ESIA TOR pilot linked contractually to a binding operational protocol for a defined filling phase; (2) a small-scale regional escrow or clearinghouse pilot to test payment flows and governance; and (3) an

interoperable monitoring pilot on a sub-basin with independent audit provisions. Evaluating these pilots against clear performance metrics (timeliness of transfers, compliance rates, reduction in negotiation frequency) will generate the empirical basis needed to scale reforms.

In sum, the cases suggest that durable improvement will not come from additional high-level principles but from operationalizing existing obligations: convert ESIA findings into enforceable protocols, finance and institutionalize independent verification, and design compensation mechanisms that are formulaic, funded and administratively feasible. Doing so will align legal duties with technical operation and economic incentives, reducing transaction costs and strengthening basin resilience.

### *Conclusion*

The analysis demonstrates that Central Asia's existing multi-level legal and institutional architecture is a workable foundation but requires targeted reforms to convert procedural commitments into predictable, enforceable practice. Practical governance gains will come less from new high-level principles than from operationalizing those principles through binding instruments, financed technical capacity and routine verification.

Key policy priorities are: adopt jointly agreed transboundary ESIA terms of reference that are linked contractually to operational protocols; develop standardized, formulaic compensation mechanisms (multiyear contracts, escrowed funds or regional clearinghouses) to remove annual bargaining; and establish neutral technical secretariats empowered to administer verification, data sharing and dispute-avoidance functions. These measures translate legal duties—notification, consultation, prevention of harm—into verifiable, financeable actions that reduce political risk and support donor engagement.

Technical and institutional enablers include interoperable real-time monitoring systems with sustainable financing, harmonized measurement and reporting standards, and explicit templates for conjunctive surface-groundwater management. Strengthening dam safety regimes, emergency notification procedures and joint contingency planning is essential to protect downstream users and to build trust in large infrastructure projects.

Capacity building and inclusive stakeholder processes are critical complements: training, joint modelling exercises and participatory ESIA processes increase the legitimacy and technical quality of decisions, while targeted investments in irrigation efficiency and nature-based recharge expand effective supply and reduce trade-offs between energy and agriculture.

Limitations of this study—data gaps on actual compensation flows, limited public access to some operational records, and evolving project timelines—underscore the need for continued empirical monitoring and pilot implementation of the recommended instruments. Future work should evaluate pilot compensation facilities, test joint ESIA modalities in practice, and develop basin-specific aquifer agreements that can be scaled regionally.

In sum, durable cooperation in the Amu Darya and Syr Darya basins depends on shifting from declaratory commitments to concrete, verifiable, and funded mechanisms that align technical operation with legal obligations and economic incentives, thereby converting seasonal hydrological services into stable regional benefits.

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### **Орталық Азиядағы трансшекаралық суларды халықаралық құқықтық реттеу**

Зерттеу Әмудария мен Сырдария бассейндеріне баса назар аудара отырып, Орталық Азияның трансшекаралық суларын құқықтық реттеуді қарастырады. Мақсаты — трансшекаралық ҚОӘБ (қоршаған ортаға және әлеуметтік салаға әсерді бағалау), жыл сайынғы пайдалану хаттамалары мен өтемақы механизмдерін қоса алғанда, халықаралық және аймақтық құқықтық шеңберлердің, институционалды механизмдер мен рәсімдік құралдардың бассейндерді бірлескен және тұрақты басқаруды қалай қолдайтынын бағалау. Әдістерге халықаралық конвенциялар мен бассейндік шарттарды нормативтік-құқықтық талдау, салыстырмалы кейс-стади тәсіл (Рогун және Токтоғұл), ҚОӘБ және бассейндік ұйымдардың есептерін құжаттамалық талдау және қайталама әдебиеттерді синтездеу кіреді. Негізгі нәтижелер қолданыстағы көп деңгейлі архитектуралық ынтымақтастық үшін қажетті процедураларды қамтамасыз ететінін, бірақ ашық өтемақы формулаларында, трансшекаралық жерасты суларын басқаруда және бірлескен мониторингті тұрақты қаржыландыруда практикалық олқылықтар қалдыратынын көрсетеді. Рогун мысалы ҚОӘБ шарттары, міндетті жеңілдету шаралары және көпжылдық келісімшарттық механизмдер бойынша ерте келісімге келу қажеттілігін анықтайды. Ал Токтоғұл мысалы формулаға негізделген жыл сайынғы хаттамаларға, үйлесімді нақты уақыт режиміндегі деректер алмасуға және уақтылы өтемақы механизмдеріне операциялық қажеттілікті көрсетті. Қорытындыда ұлттық заңнаманы бассейндік келісімдермен үйлестіру, бейтарап техникалық хатшылықтарды құру, үйлесімді мониторинг және тексеру жүйелерін енгізу, сондай-ақ ресми өтемақы қорларын қалыптастыру болжамдылықты арттырып, транзакциялық шығындарды азайтып, трансшекаралық суларды орнықты әрі өзара тиімді басқаруды күшейтетіндігі атап өтілген.

*Кілт сөздер:* трансшекаралық сулар, Әмудария, Сырдария, қоршаған ортаға және әлеуметтік салаға әсерді бағалау (ҚОӘБ), әділ және орынды пайдалану, трансшекаралық зиянның алдын алу.

А.Х. Омарова

### **Международно-правовое регулирование трансграничных вод Центральной Азии**

Данное исследование рассматривает правовое регулирование трансграничных вод Центральной Азии с акцентом на бассейны Амударьи и Сырдарьи. Цель — оценить, каким образом международные и региональные правовые рамки, институциональные механизмы и процедурные инструменты — включая трансграничную ОВОС (оценку воздействия на окружающую среду и социальную сферу), ежегодные эксплуатационные протоколы и механизмы компенсации — поддерживают совместное и устойчивое управление бассейнами. Методы включают нормативно-правовой анализ международных конвенций и бассейновых договоров, сравнительный кейс-стади подход (Рогун и Токтогул), документальный анализ ОВОС и отчетов бассейновых организаций, а также синтез вторичной литературы. Ключевые выводы исследования показывают, что существующая многоуровневая архитектура обеспечивает необходимые процедуры для сотрудничества, но оставляет практические пробелы в прозрачных компенсационных формулах, управлении трансграничными подземными водами и устойчивом финансировании совместного мониторинга. Пример Рогун подчеркивает необходимость раннего согласования условий ОВОС, обязательных мер по смягчению и многолетних договорных механизмов; пример Токтогула демонстрирует операционную необходимость

формульных ежегодных протоколов, совместимого обмена данными в реальном времени и своевременных компенсационных механизмов. В заключении отмечается, что гармонизация национального законодательства с бассейновыми соглашениями, создание нейтральных технических секретариатов, внедрение совместимых систем мониторинга и верификации, а также формирование официальных компенсационных фондов повысит предсказуемость, снизит транзакционные издержки и укрепит устойчивое, взаимовыгодное управление трансграничными водами региона.

*Ключевые слова:* трансграничные воды, Амударья, Сырдарья, оценка воздействия на окружающую среду и социальную сферу (ОВОС), справедливое и разумное использование, предотвращение трансграничного ущерба.

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