Policy Brief

Regional cooperation is key for overcoming climate challenges along water-agriculture-energy nexus in Central Asia

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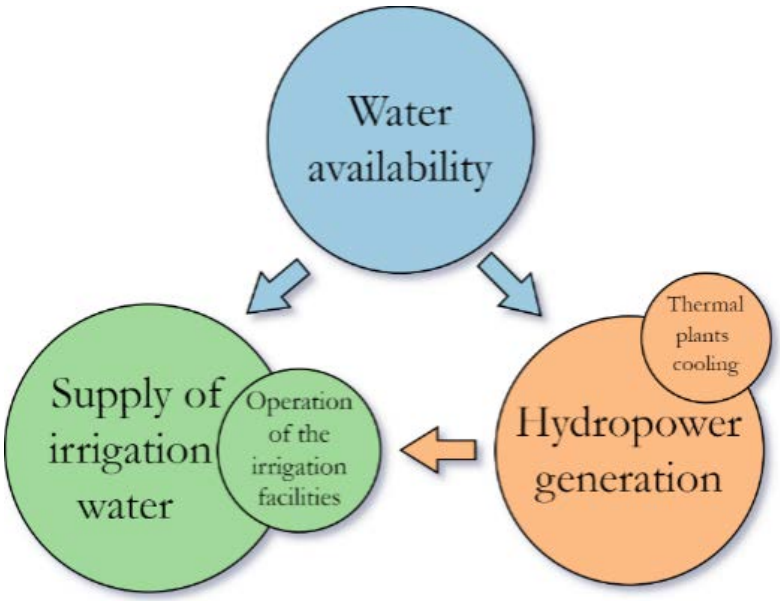
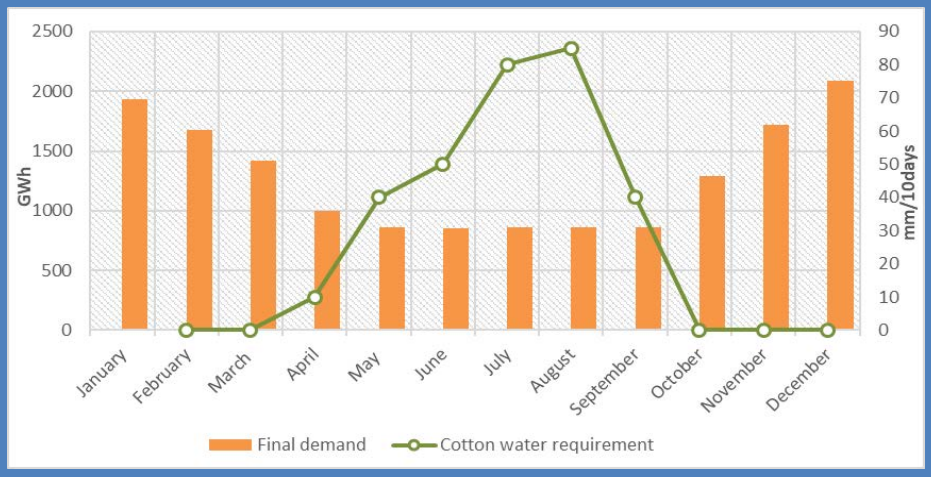
Shared resources but divergent needs: water-agriculture-energy nexus in Central Asia

Water is a scarce and unevenly distributed resource in Central Asia with a significant transboundary context. The transboundary links are particularly strong in the region's south, where most river runoff originates in the highlands of Tajikistan and the Kyrgyz Republic, while the bulk of water withdrawals occur in irrigated plains of Uzbekistan, Turkmenistan, and southern Kazakhstan. However, the reliance on water resources across the upstream and downstream states has contrasting patterns. Due to the absence of fossil fuel reserves, Tajikistan and Kyrgyzstan obtain more than 90% of their electricity from hydropower. In the downstream states, water is a critical resource for irrigated crop production, which accounts for more than 90% of total water withdrawals (FAO, 2022).The water-agriculture-energy nexus in Central Asia, as shown in Figure 1, is augmented by the high energy consumption of the agriculture sector for pumping irrigation water during the vegetation season (Shenhav et al., 2017), producing fertilizers, and mechanizing agriculture.There are also substantial links between the water and energy systems in downstream countries rich in fossil resources, such as Kazakhstan, which use considerable amounts of water for the extraction and processing of fossil fuels, particularly for cooling power plants (Karatayev et al., 2017). However, the annual cycles of water demand across the agriculture and energy sectors do not match, placing considerable reliance on countries located downstream of the respective river basins on the timely release of water from large hydro dams upstream (see Case study 1).

Figure 1. Key connections of the water-agriculture-energy nexus in Central Asia.



Case study 3: Power demand upstream (Kyrgyzstan) and crop water requirements downstream (Ferghana valley, Uzbekistan) of the Syrdarya river.



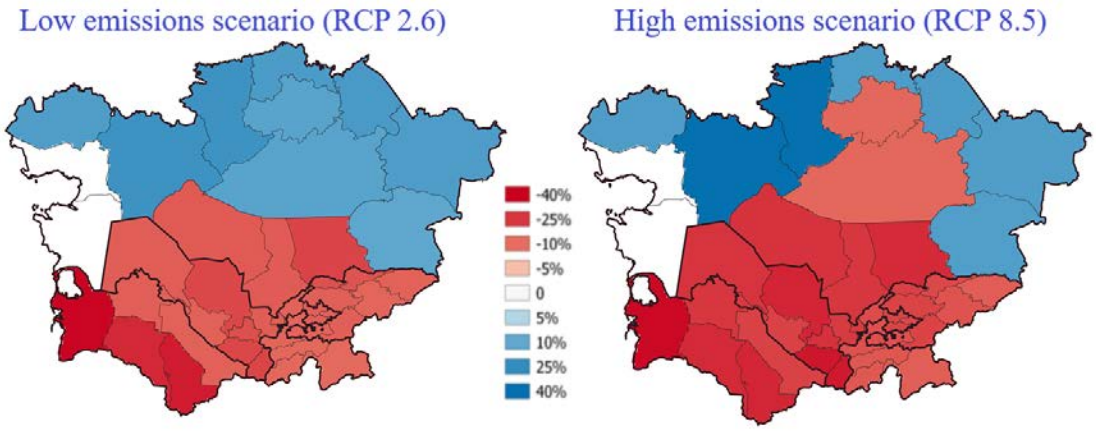
Source: adapted from KESC, 2021 (electricity demand, left axis), Conrad et al., 2013 (cotton crop water requirement. right axis).

- Hydropower accounts for 90% of total annual electricity generation in Kyrgyzstan. Most hydropower plants and the largest dam in the country were built on the tributaries of the Syrdarya river.
- Power demand during the winter in Kyrgyzstan is double that of the summertime, mainly due to increased consumption from residential heating. In the absence of transboundary agreement, this results in a higher discharge from the hydro dams during the wintertime and a reduced discharge during the summer.
- In contrast, the irrigated crop production in the downstream of the river has higher water demands from April to September, with the summer months being the highest.

Climate change may increase Central Asia's interdependencies along the water-food-energy nexus

Climate change may alter water resource availability in Central Asia with contrasting trends across the provinces. The hydrological projections, though these are subject to uncertainty, indicate that natural discharge may decrease in the river basins of the larger Aral Sea basin in the south, whereas river discharge may increase in the region's north (CAREC Institute, 2022; Jägermeyr et al., 2021). The shifts in river flows may be more pronounced during the vegetation season when water is most needed for irrigation in the southern part (Jägermeyr et al., 2021).

Figure 2. Projected change in seasonal water availability during the vegetation season.



Source: Jägermeyr et al. (2021)

Projected changes in the water supply (Figure 2) may have far-reaching effects on other sectors, with agriculture bearing the bulk of water-related risks. Specifically, agricultural productivity in southern Central Asia may diminish due to the possible decline in irrigation water. On the other hand, future electricity demand is anticipated to increase by more than 50% of present generation levels, while the Paris agreement mandates that the bulk of power generation need to come from renewable sources. For the upstream countries Tajikistan and Kyrgyzstan, which are endowed with untapped hydropower potential, the construction of new hydropower plants and dams appears as the most feasible long-term solution for balancing electricity demand and supply. Climate change and its mitigation will thus likely increase intersectoral competition for water resources because downstream water levels will increasingly be under upstream control while water scarcity downstream exacerbates.

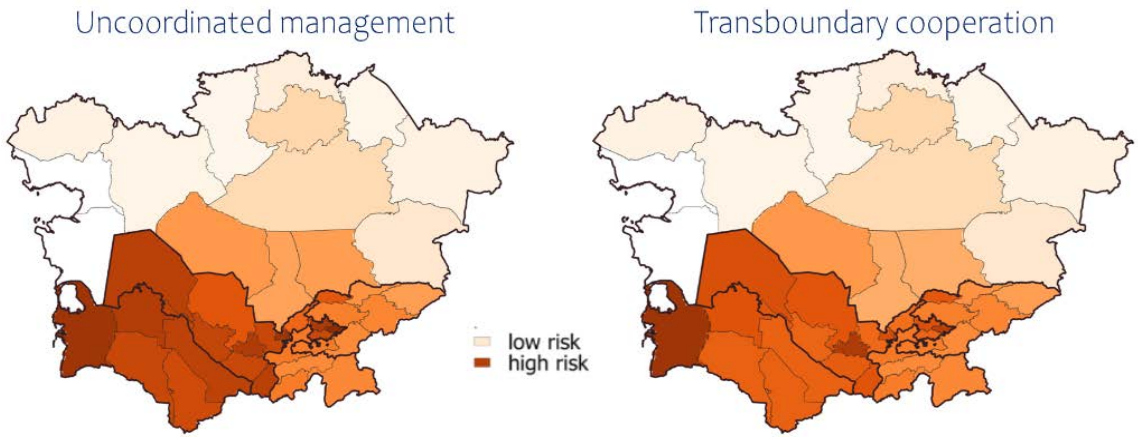
Regional cooperation is prerequisite for effective climate adaptation

Because crop production is highly dependent on timely water releases from upstream hydropower systems, the agricultural sector stands to gain the most from increased transboundary cooperation. During the Soviet era, the Central Asian nations were connected by a shared water-power system, in which water releases and electricity supplies from upstream states during irrigation season were compensated for by energy supplies from downstream states during the cold season. This cooperation ceased in subsequent decades as countries pursued self-sufficiency strategies in water and energy, which eventually resulted in disagreements about equitable water allocation. The situation complicated the energy security of the upstream countries, while jeopardizing downstream states' water supply security.

All prior studies conducted by independent parties and multilateral development organizations emphasized the critical role of regional cooperation in ensuring water, agricultural, and energy security in Central Asia (EIA, 2021; CAREC, 2021; Xenarios et al., 2017). Insufficient intraregional cooperation results in economic loss and missed opportunities. Considering the direct costs alone, the region loses $4.5 billion annually as a result of inadequate regional collaboration (Pohl et al., 2017). Other estimates predict that the costs of lacking transboundary water management may reach up to 10% of GDP by 2050 (World Bank, 2017).

Coordinated management of upstream water storage can enhance the region's resilience to hydrological droughts on seasonal and annual timescales (Figure 3). It decreases uncertainty of seasonal water supply in the irrigated basins of Turkmenistan, Uzbekistan, and southern Kazakhstan, which rely on water resources from the upstream counties.

Figure 3. Climate-induced water stress under two cooperative performance scenarios under RCP 8.5.



Note: the "Transboundary cooperation" scenario accounts for interannual regulation of water storage and ignores as a sensitivity factor the water dependency ratio of the countries.

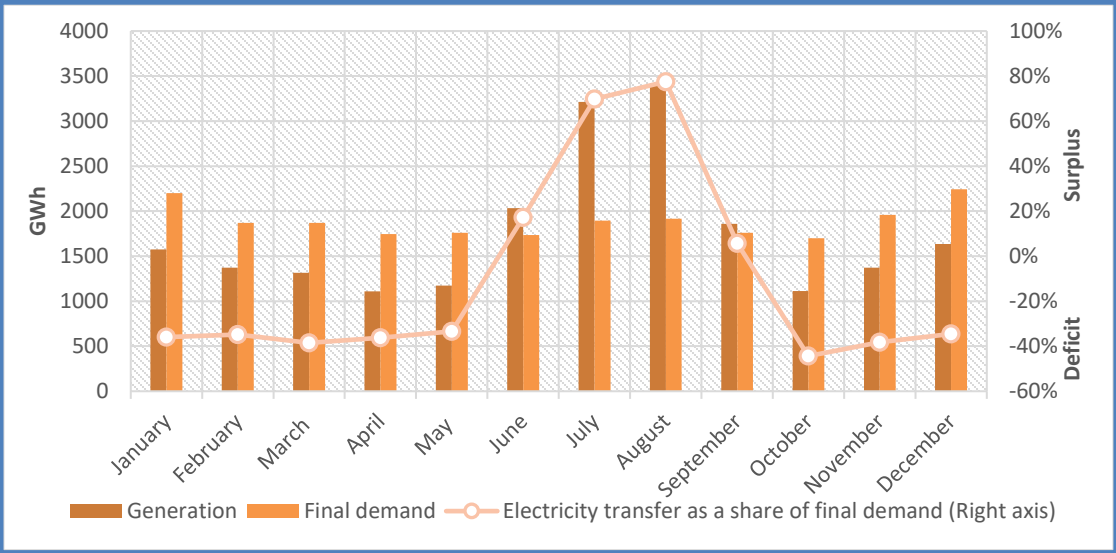
Source: CAREC Institute (2022).

In addition, the countries have ample opportunities from regional trade of agricultural products, whose advantages extend to food security. Food security is not defined by production self-sufficiency at the national level, but by the ability to meet food demand regardless of the supply origin. International trade has been shown to contribute to food security in countries where crop-specific farming is hampered by certain circumstances, such as meteorological conditions (Baer-Nawrocka & Sadowski, 2019). Thus, it is suggested that countries would be better off concentrating their agricultural sectors on the production of crops and livestock products in which they have a comparative advantage due to climatic and institutional conditions (Lombardozzi & Djanibekov, 2021), while compensating for deficient production of other crops through international trade.

Energy security and climate mitigation also to benefit from regional cooperation

Cooperative management of the transboundary water resources entails stronger collaboration on electricity exchanges between the countries. In particular, the joint water resource management implies that the upstream countries have more flexible possibilities to offset seasonal shortages and surpluses through transboundary electricity trade (see Case study 2).

Case study 4. Monthly power balance in Tajikistan, when the hydropower system favours downstream irrigation.



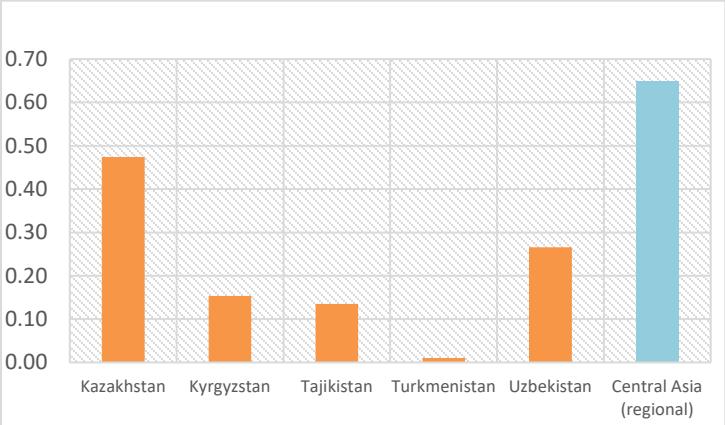
Source: based on data from IEA (2021a).

- The figure above illustrates disparities between electricity demand and supply in Tajikistan when its hydroelectric facilities operate in a manner that benefits timely water availability for the downstream states.
- Under such mode of operation, the discharge of water from hydroelectric dams reaches its peak during the summer, resulting in a high surpluses of power electricity above summertime demand levels.
- In contrast, throughout autumn and winter, dams store water for the following irrigation season. This results in decreased hydropower generation, which is significantly below the nation's need.

Rising incomes and a growing population will likely affect both supply and demand of energy, particularly in the power sector. The ever-growing power demand requires a long-term strategy based on cost-effectiveness and availability to achieve energy security. Electricity is a non-fungible commodity; hence, its supply diversification could be achieved through either regional trade or the production of renewable energy. The former requires a robust and reliable operation of existing and new power networks, while the latter is crucial to meet the climate mitigation goals, yet necessitates substantial upfront investments.

In this regard, overall benefits of regional cooperation are far greater than simply offsetting seasonal imbalances in power supply and demand. It results in lower power generation costs and avoided capital expenses for redundant power capacity, as well as better options for long term GHG emissions reductions and favourable conditions for use of intermittent renewable energy sources (World Bank, 2017; Sadrina, 2019). Additionally, it contributes to a higher diversity of power supplies and the primary energy sources upon which they are based (Figure 4), which is another important component of the energy security concept.

Figure 4. Power diversity index in Central Asia on country vs regional level.



Note: the index reflects diversity of primary energy sources in the electricity generation.

Key policy messages

Water is a scarce and valuable resource that is unevenly distributed across the Central Asian countries. Moreover, water resources are strongly interconnected with the agriculture and energy sectors. Divergent water needs and their temporal patterns impose considerable interdependencies between the sectors and countries. **Inadequate regional cooperation during past decades has resulted in direct economic losses and in wasted opportunities.**

Climate change may alter the availability and annual cycle of water supplies with negative consequences for irrigated agriculture in the region. The development of untapped hydropower potential in upstream countries would likewise alter natural flows. **In the absence of coordinated management of the transboundary water resources, these trends would exacerbate intersectoral rivalry for water resources.**

Water cooperation is a fundamental prerequisite for enhanced resilience to climate change that disentangles multiple benefits for all parties. **Coordinated management of upstream water storage is crucial for enhancing a region's resilience to hydrological droughts on seasonal and annual timescales.** In turn the upstream states benefit from an enhanced energy security. **Regional cooperation on water resources is underpinned by the development of a comprehensive and transparent framework for regional energy trade.**

The advantages of regional collaboration extend far beyond the lower seasonal water and electricity supply-demand mismatches, but also facilitate sustainable energy development in the region. **The region's long-term energy security would be substantially bolstered by more diverse power supply, and the countries would have better alternatives for long-term GHG emissions reductions in the power sector.**

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