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BENEFITS OF REGIONAL CO-OPERATION ON THE ENERGY-WATER-LAND USE NEXUS TRANSFORMATION IN CENTRAL ASIA

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Foreword

This paper was developed as part of a project entitled "Regional mechanisms for the low-carbon, climate-resilient transformation of the energy-water-land use nexus in Central Asia" (the nexus project). The development of the paper was informed by exchange with a diverse range of stakeholders all with a stake in the security of energy, water, food and land resources within the region. This paper informed discussion at a high-level policy dialogue, held in Tashkent on 15 October 2021, with nominated senior decision makers from each of the Central Asian countries: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan [See https://oe.cd/NexusTashkent2021 for further information.].

This discussion paper provides a background analysis to support the dialogue on opportunities for co-operation around the energy, water, and land-use nexus. This discussion paper and the abovementioned dialogue were also intended to contribute to other emerging regional programmes aimed at supporting the long-term, sustainable use of energy, water and land resources, informing the framework for integrated planning and improved co-operation at a national and regional level.

This nexus project is a multi-year regional programme to support the "operationalisation" of the energy, water and land-use nexus in the five countries of Central Asia. The project is implemented by a consortium led by the Organisation for Economic Co-operation and Development (OECD). The European Bank for Reconstruction and Development (EBRD), the Food and Agriculture Organization of United Nations (FAO), the Scientific-Information Center of the Interstate Commission for Water Coordination of Central Asia (SIC-ICWC) and the United Nations Economic Commission for Europe (UNECE) also participate in the consortium. This project works with all five countries of Central Asia to operationalise the energy-water-land use nexus by providing a robust economic and financial analysis. The project works at both the regional and national levels to identify nexus opportunities, demonstrate the business case for co-operation and raise capacity, increasing trust within the region and creating political momentum. This project aims to pave the way for the countries to modify planning processes and adopt a whole-of-government approach to addressing the nexus related issues. It aims to provide mechanisms to quantify the benefits and trade-offs that are inherent to activities with a focus on the nexus, as well as develop and apply tools to increase private sector involvement in nexus-related investments.

The nexus project also has strong synergies with another IKI-funded, OECD-led project entitled, "Orientation of infrastructure investments on the goals of the Paris Agreement and the 2030 Agenda in Central and Southeast Asia" that started in 2021. The project on infrastructure investment aims to support selected governments to channel investment flows into infrastructure investments that are aligned with their climate goals, international standards and SDGs. It also aims to help public and private investors steer investment towards sustainable projects with a particular focus on the energy and transport sectors and hard-to-abate industry systems.

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This paper was prepared by the Secretariat of the Organisation for Economic Co-operation and Development (OECD). It was drafted by Enrico Botta, Matthew Griffiths (OECD Environment Directorate) and Takayoshi Kato (OECD Development Co-operation Directorate) with substantive input from Tatiana Efimova and Alexander Martoussevitch under the supervision of Kumi Kitamori (Environment Directorate). It is an output of the GREEN Action Task Force hosted by the OECD.

The paper benefited from the valuable inputs, analysis and comments of experts at the Scientific Information Center of Interstate Commission for Water Coordination in Central Asia (SIC – ICWC), including Professor Viktor Dukhovny, Director, and Dinara Ziganshina, Acting Director as well as Professor Saghit Ibatullin, Director of International Training Center for Dam Safety.

National advisors that contributed, reviewed and commented on earlier drafts of this paper are gratefully acknowledged, including: A.D. Ryabtsev and T.T. Sarsembekov (Kazakhstan), Ch.M. Uzakbaev (Kyrgyzstan), Professor Ya.E. Pulatov (Tajikistan), V.I. Sokolov and Kh. A. Shamsiev (Uzbekistan), G. B. Ovezmuradov (Turkmenistan). Valuable comments were also provided by Alexander Belokurov, Lucia De Strasser and Batyr Hajiyev (United Nations Economic Commission for Europe) and Caroline Milow and Dana Yermolyonok (the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH, GIZ)

Earlier drafts of the paper were reviewed by OECD colleagues: Guillaume Gruère (Trade and Agriculture Directorate), Jean-François Lengelle (Global Relations Secretariat), Xavier Leflaive, Virginie Marchal and Krzysztof Michalak (Environment Directorate).

The key findings and policy questions in this paper were initially discussed at a regional expert workshop on 8 June 2021. The workshop gathered over 80 participants with an interest in the energy, water, and land-use nexus including experts from all five Central Asian countries. The summary record of the expert workshop can be found on the dedicated OECD webpage[1]. Based upon the findings of this expert workshop, the discussion paper was updated and used to inform a high-level policy dialogue held on 15 October 2021 in Tashkent, Uzbekistan. The dialogue brought together over 30 senior-level policy makers from the five Central Asian countries and development partners. Details of the policy dialogue can be found on the dedicated OECD webpage[2].

[1] https://www.oecd.org/environment/outreach/expert-workshop-energy-water-land-nexus-transformation-central-asia.htm

[2] https://oe.cd/NexusTashkent2021

This paper benefited from financial support from GIZ and is part of the overarching GIZ program "*Capacity Development for Climate Policy in the countries of South East, Eastern Europe, the South Caucasus and Central Asia, Phase III*". This project is part of the International Climate Initiative (IKI) (www.international-climate-initiative.com/en). The Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) supports this initiative on the basis of a decision adopted by the German Bundestag. Substantive comments and advice from GIZ and BMUV colleagues were also gratefully acknowledged.

On behalf of:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

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of the Federal Republic of Germany

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Abbreviations and acronyms

ADB	Asian Development Bank
BATs	Best Available Techniques
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BRI	Belt and Road Initiative
CA countries	Central Asian countries
CAPS	Central Asian Power System
CASA	the Central Asia-South Asia power project
CAREM	the Central Asia Regional Electricity Market project
EAEU	Eurasian Economic Union
EBRD	European Bank for Reconstruction and Development
EU	European Union
FAO	UN Food and Agriculture Organisation
FDIs	foreign direct investments
GDP	Gross Domestic Product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
IEA	International Energy Agency
IFAS	International Fund for saving the Aral Sea
IKI	International Climate Initiative (IKI).
IPAs	Investments Promotion Agencies
IUCN	International Union for Conversation of Nature
IWA	International Water Association
JRC	Joint Research Centre
NDCs	National Determined Contributions
NGO	Non-Governmental Organisation
OECD	Organisation for Economic Co-operation and Development
RBO	River Basin Organizations
SDGs	Sustainable Development Goals
SIC - ICWC	Scientific Information Center of Interstate Commission for Water Coordination in Central Asia
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change

Executive summary

Regional co-operation towards Central Asia's resource security in a changing climate

Energy, water and food security has been a key factor of inter-state relations among Central Asian countries since their independence in the early 1990s. During the Soviet Union era, centrally co-ordinated mechanisms had facilitated the use of transboundary water in the Aral Sea basin for hydropower and agriculture. Yet, an externality of this mechanism was severe environmental degradation in the basin and sub-optimal management of water. Since independence and with the collapse of this centralised governance system, a number of challenges have emerged for the transboundary management of water and energy resources among countries that have varying resource endowments, and geopolitical and economic interests.

In recent years, the COVID-19 pandemic has hit hard citizens of Central Asia and their livelihoods. The war in Ukraine and the economic sanctions against Russia in response are also severely undermining the economies of Central Asia through declining remittances, rising food prices, increasing currency volatility, diminishing import of input material for food production, among others. The impacts of the geopolitical situation are being felt across the world, but particularly strongly by Central Asian countries given their close economic and political ties with Russia. These compounding external shocks have alerted the Central Asian governments to the importance of building the resilience of socioeconomic systems in the region.

Among the Central Asian countries, there has been continuous and constructive development in co-operation over natural resource management. This includes the roles played by institutions such as the International Fund for saving the Aral Sea (IFAS), the Interstate Commission for Water Cooperation (ICWC), the Interstate Commission on Sustainable Development (ICSD), to name a few. Pressure on the region's water, energy and land resources is however likely to further increase in the coming decades, as populations grow, urbanisation advances, and economies expand into manufacturing, processing and other industries. The region's population, for example, is likely to increase by over 30% from 75.6 million in 2021 to 100 million in 2050. These changes will add further demand for natural resources.

Climate change is emerging as a critical risk for national and regional security in Central Asia, posing additional challenges to the geopolitical, socioeconomic and environmental issues around water, energy and land use**.** The region is already highly exposed to natural hazards. For instance, floods already affect nearly a million people in the region every year and cause economic losses of USD 4.7 billion. Climate change is likely to amplify these impacts over the years to come. The negative impacts of climate change, which are already manifesting to varying extents in the region, include slow-onset changes such as glacial retreat and desertification, and extreme events such as floods and droughts. Increasing rates of glacial melt in the Tien Shan and Pamir mountains could lead to greater river runoff in the short term while decreasing water availability in the medium to long term. Climate change is projected to increase precipitation in the northern areas of Central Asia and decrease it in the south, which may widen existing economic disparities within the region.

Central Asian countries are increasingly developing and implementing national and sectoral policies to address the risks associated with climate change, and energy, water and land use management. In addition to national funding, billions of development finance have also been committed and disbursed to support the development of infrastructure, policies, institutions, capacities and information. In Central Asia, the scope of climate action spans wide areas from hydro and non-hydro renewable energy, resource efficiency, land-use management, reforms of water allocation regimes, climate-smart agriculture and pasture management. While these measures and funding are driving national and regional climate action in Central Asia, some of the thematic and sectoral actions may also heighten regional tension if left uncoordinated.

Economic, social and ecological benefits of co-operation on the energy-water-land nexus for sustainable development in Central Asia.

Pursuing regional resource security and socio-economic development in the face of climate risks in Central Asia requires coherent management of energy, water, and land resources throughout the region. Studies suggest that transboundary co-operation in water resource management in the Syr Darya River Basin, for example, can generate large regional economic benefits. On the contrary, a lack of such co-operation could leave the riparian countries more exposed to external shocks, such as climate-related disasters, global economic crisis and disruptions in supply chains.

The "energy, water and land use nexus" approach has been attracting attention of policy makers, development practitioners and academia in Central Asia as a tool to facilitate regional and cross-sectoral co-operation. Adopting a 'nexus approach' allows governments to move beyond traditional sectoral thinking, and simultaneously achieve the policy objectives for energy, water, food and environmental security. A number of initiatives on the nexus have been undertaken in Central Asia, for example: the Asian Development Bank, the European Union, Finland, the Food and Agriculture Organization (FAO), the International Fund for Agricultural Development (IFAD), the OECD, Organization for Security and Co-operation in Europe (OSCE), Switzerland, UN Economic Commission for Europe, the United States, the World Bank, among others, have implemented and supported such initiatives in collaboration with Central Asian governments and regional institutions. Tools to support application of the nexus approach have also been developed for Central Asia and beyond. They include the Transboundary Basin Nexus Assessment methodology, the Water-Hydropower Agriculture Tool for Investments and Financing (WHAT-IF) and the Basin Economic Allocation Model, to name just a few. Some of the methodologies for integrated water basin management plans developed in the region also include an implicitly or explicit reference to the nexus.

Benefits of greater regional co-operation within Central Asia for water, energy and land resource management are becoming evident. However, further work is still needed on robust economic and financial assessments to understand and communicate the benefits. Multiple studies project that greater regional co-operation in the energy sector could have brought an additional benefit of at least USD 0.5 billion to 6.4 billion per year to Kazakhstan, the Kyrgyz Republic (Kyrgyzstan), Tajikistan and Uzbekistan. Another estimate shows an annual loss of USD 4.5 billion (or 1.6% of the regional GDP) due to the lack of co-operation. This figure can be a significant underestimation, given its scope being only agricultural losses, inefficient electricity trade and a missed opportunity to access international finance. Such quantification still faces a number of technical challenges. Central Asian governments need further analytical work on robust economic and financial assessments to fully quantify and realise the benefits of regional co-operation through adopting the nexus approach. There is also a scope for improving awareness and capacity among relevant policy makers and stakeholders in the region for accessing and using results of the assessments.

The nexus approach can help governments identify cost-effective and inclusive solutions for low-carbon transition of the energy system in Central Asia, while also mitigating water stress. A study shows a larger uptake of wind and solar energy in the Syr Darya Basin would lower the dependency on the basin's water resources for electricity generation by 25% by 2030, compared to the business-as-usual scenario. Increased efficiency in the use of water and energy resources is also essential for reducing water stress, contributing to regional security and resilience to climate risks. The energy-water-land nexus assessments could also support Central Asian countries understand trade-offs between planned sectoral measures, such as any negative impacts of a new hydropower plant on ecosystem conservation, food production and flood risk management.

Nexus planning and development can also strengthen the resilience of population, assets and ecosystems in Central Asia to the negative impacts of climate variability and change. For example, payment for (water) ecosystem services (PES) could enable downstream and upstream areas to share the costs of water resources management and ecosystem conservation. PES could in turn contribute to managing climate risks for food and energy security. A case study on the Chon-Aksuu area in Issyk-Kul region, for instance, demonstrates that PES can address issues of overgrazed pastures and degraded forests, contributing also to enhanced water quality and availability.

Proposed actions for greater regional co-operation on the energy-water-land use nexus

Despite the well-documented benefits, there remain a number of technical, financial and political barriers to operationalising the nexus approach at scale in Central Asia. Key challenges include insufficient information available to support decision making, economic and policy incentives, and preparedness to make political decisions. Complex and fragmented institutional arrangements for the governance of energy, water and land resources also hinder cross-sectoral and transboundary co-operation in the region.

Consultations with stakeholders in Central Asia have highlighted the importance of certain action points for promoting the energy-water-land use nexus in the region. Examples of such actions are outlined below, aiming to address the abovementioned challenges and providing robust evidence on the effectiveness of the nexus approach in supporting regional security and low-carbon, climate-resilient development. These action points also must build on the countries' and development partners' experience of past and on-going initiatives in the nexus within the region and beyond.

Mainstream the nexus principles into development planning processes:

- ***Developing evidence that demonstrates economic and non-economic benefits for Central Asian countries from adopting nexus approaches to pursue low-carbon and climate-resilient development:*** Evidence on the "business case" for nexus approaches to facilitate the regional co-operation must be enhanced, based on robust economic and financial assessments. It could in turn underpin greater political support for regional co-operation on the nexus, and effective financing mechanisms and policy frameworks to enable co-operation.
- ***Integrating nexus considerations into regional, national and sectoral development policies as well as climate actions:*** For instance, linking the nexus considerations to public investment criteria may provide opportunities to understand economic benefits of transboundary co-ordination for water, energy and land use management in Central Asia. Other opportunities for such integration may include improved planning processes, development of flexible legal frameworks including compensation schemes and water and energy trade schemes. Lessons should be learned from previous efforts to establish water and energy trade frameworks, as well as to facilitate regional and global agricultural trade.

Finance pilot projects to demonstrate benefits of investments in the "nexus"

- ***Taking the nexus approach as a way of enhancing access to finance:*** Access to finance for projects in support of energy, water and land management has consistently been among the greatest challenges facing the countries. Tools for robust economic analysis and investment decision making could help countries identify potential project concepts with a focus on the nexus, and turn them into attractive funding proposals. There would also be a scope for designing a dedicated financing mechanism to invest in such nexus projects. The mechanism would need to demonstrate 'the art of the possible' for cross-sectoral projects, strengthening the enabling environments for mobilising finance, and attracting investments by public and private actors.
- ***Enhancing the use of decision support tools that explicitly consider benefits and trade-offs of adopting a nexus approach, and uncertainties presented by climate change:*** Financial decision making that considers the nexus can be complex, hence greatly benefit from well-functioning decision support tools that also reflect users' capabilities. These tools can help to integrate nexus approaches into individual investment projects, such as on modernising national and transboundary energy, water and agriculture infrastructure that was built during the Soviet era.

Organise regional policy dialogues and facilitate capacity development:

- ***Designing regional capacity development for promoting a shared understanding of priorities for energy, water and land resource security:*** Climate vulnerability of Central Asian countries, especially of poorer, marginalised or discriminated populations, is augmented by significant constraints on their financial, technical and institutional capacity. Areas that capacity development activities could target include, for instance, water allocation, financial compensation and conflict settlement. Enhanced capacity in these areas can also support adherence to regional agreements on water and energy exchange.
- ***Fostering high-level political and technical dialogues***: Exchange through such dialogues can drive acceptance and mainstreaming of nexus principles and provide the political support for cooperation and action. Cross-sectoral dialogue supported by analytical work and capacity building will help build confidence in applying nexus approaches to planning and development. Technical confidence will help build the political support to drive change. Co-ordination with other actors, including the nexus-related platforms managed by the countries and development partners, will be essential. This will raise awareness of the benefits of this project and generate opportunities for investment in support of the low-carbon, climate-resilient transition.

1 Need for greater cross-sectoral and inter-state co-operation in Central Asia

Background

Energy, water and land management have been key factors that characterise inter-state relations in Central Asia since independence in the early 1990s. During the Soviet Union era, the use of transboundary water resources in the Aral Sea basin had been centrally managed primarily for hydropower and agriculture production (Granit et al., 2012[1]). An externality of this mechanism was severe environmental degradation and sub-optimal management of water.

The dissolution of the Soviet Union left an extensive transboundary water infrastructure that was built during the Soviet time. Technical, legal and economic frameworks to share energy and water resources however collapsed. Since then, five Central Asian countries have had to manage significant challenges related to water, energy and land use management (Adelphi and CAREC, 2017[2]). This has led to both some regional agreements on transboundary water resource management and tensions among the countries over water resources.

Co-operation will be essential between downstream and upstream countries due to future rises in water and energy stress, as populations and economies grow and resource availabilities and access shift. Co-operation around the management of resources between the upstream water-rich and downstream fossil fuel-rich states will require progressive policy frameworks and the strong political will of regional leaders.

Enhanced regional co-operation is crucial also for adapting to and coping with the negative impacts of climate change such as increases in temperature, extreme weather events, and glacial retreat. These changes will compound the existing challenges around energy, water and land-use management, increasing pressures on resource security, limiting regional socio-economic development and ultimately impacting jobs, health and the wellbeing of citizens (see also section 2.1).

In addition to all those existing challenges, the war in Ukraine and the economic sanctions in response have also severely hit the economies of Central Asia through declining remittances, rising food prices, increasing currency volatility, diminishing import of input material for food production, among others (Prashad, 2022[3]; Hess, 2022[4]). The impacts of the geopolitical situation are being felt across the world, but particularly strongly by Central Asian countries given their close economic and political ties with the Russian Federation (OECD, 2022[5]). The COVID-19 pandemic had already hit hard the livelihoods of Central Asian citizens over the past two years. These compounding external shocks have alerted the Central Asian governments to the importance of building the resilience of socioeconomic systems in the region.

Central Asian countries are increasingly recognising that the challenges and barriers to sustainable development in the Central Asia are interlinked. A sustainable use of water, energy and land resources underpins the Sustainable Development Goals (SDGs). It will also contribute to the implementation of national mitigation and adaptation goals included in the Nationally Determined Contributions (NDCs) submitted by all Central Asian countries to the Secretariat of the UN Framework Convention on Climate Change.

Towards a "nexus approach"

The international community has been increasingly interested in the interlinkages between the management of energy, water and land resources as an important consideration for countries' sustainable development (Pereira Ramos et al., 2021[6]; UNECE, 2021[7]) (See also Box 1). The term "**nexus**" in the context of water, energy and land use has been used to highlight that these sectors are inextricably linked. It also emphasises that actions in one policy area commonly have impacts on the others as well as on the ecosystems that natural resources and human activities ultimately depend upon (UNECE, n.d.[8]).

A focus on the nexus can provide opportunities to help Central Asian countries address various challenges to achieving water, water and food security for their citizens and ecosystems in a sustainable and equitable way (UNECE, 2021[7]; Adelphi and CAREC, 2017[2]; Jalilov, Amer and Ward, 2018[9]). The "nexus approach" moves beyond traditional sectoral thinking in order to achieve overall security and sustainability of all resources. The nexus approach stems from the realisation that water, energy, agriculture and natural ecosystems exhibit strong interlinkages. It is also based on the notion that under a traditional sectoral approach, attempting to achieve resource security independently often endangers sustainability and security in one or more of the other sectors. Under the nexus approach, interlinkages, synergies and trade-offs are analysed, with the aim of identifying priorities, primary interlinkages and solutions, fostering resource security and efficiency, and reducing impacts and risks on water-dependent ecosystems.

Opportunities exist to learn lessons from the region's Soviet heritage, learning from and building on previous practises of water and energy exchange and agricultural practises. A number of recent donor-funded projects in Central Asia have considered the nexus and applied pilot projects demonstrating potential for nexus-interventions. These projects also provide the region with examples of good practices and lessons learned.

Box 1. The water-energy-land nexus in the context of the sustainable development goals

Adopting a nexus approach could help countries to advance on the SDGs and improve indicators of energy, water and food security. The interlinked nature of the UN 2030 Agenda requires co-ordination between the water, energy, and land-use sectors along with other related sectors. The nexus approach, which is systemic in nature and helps to boost synergies while reducing trade-off between policy objectives, is well-positioned to enhance the coherence among policies on different SDGs.

Importantly, while the adoption of a nexus approach would benefit most of SDGs, five have a particularly strong link with the energy-water-land use nexus:

- SDG 2 on achieving food security and promoting sustainable agriculture,
- SDG 6 on sustainable water management and transboundary co-operation,
- SDG 7 on affordable and clean energy,
- SDG 13 on climate action, and
- SDG 15 on sustainable management of life on land.

Examples of SGDs that may indirectly benefit from the adoption of a nexus approach include gender equality (SDG 5), building a resilient infrastructure and sustainable industries (SDG 9), creating sustainable cities and communities (SDG 11), in particular SDG 11.5 concerning water related hazards for human settlements and economic assets, including agricultural land; and promoting responsible consumption and production (SDG 12) (Roidt and De Strasser, 2015[10]) (Grid Arendal, 2019[11])). SDG 17 on global partnership (especially in relation to target 17.14 on "enhancing policy coherence for sustainable development" and target 17.2 on increasing overseas development aid) would also be relevant.

2 The energy-water-land use nexus and its application in Central Asia

The nexus approach: linking energy, water and land use management for coherent policy design

Climate change is already affecting water, energy and land systems in Central Asia and the negative impacts are projected to further increase. The impacts of a changing climate are occurring on top of the existing socioeconomic challenges to managing water, energy and land in the region presenting a dynamic and uncertain future. Climate change scenarios for Central Asia suggest a considerable increase in average annual temperature in the future. For instance, the surface temperature in the region can rise by an average of 3°C to 7°C for the period of 2071-2100 compared to 1950-2001 (Liu, Liu and Gao, 2020[12]). The impacts of climate change drive changes in precipitation (e.g. changes in the frequency, intensity, and seasonality of rainfall), contributing to more frequent and intense natural hazards (e.g. heat waves, drought and floods) (IPCC, 2021[13]). In addition, some slow-onset climate induced changes such as glacial retreat and desertification have also been observed (Liu, Liu and Gao, 2020[12]).

These impacts of climate change will have large implications for water (e.g. changes in both surface and groundwater water resources, glacier melt), energy (e.g. seasonality of water available for hydropower) and land systems (e.g. impacts on crop and livestock productivity) in Central Asia (Reyer et al., 2017[14]; GIZ, 2021[15]). These predicted impacts can lead to expansion of deserts and arid areas, increased pressure on natural resources such as water, pasture and forests. This can also cause the degradation of biodiversity, natural habitats and ecosystems. Energy production can also be negatively affected by the impacts of climate change. For example, insufficient cooling and low water levels caused by higher evaporation with increasing temperature, heatwaves and limited precipitation during droughts, are likely to impair energy production in Kazakhstan. Glacier melting will also reduce the hydropower generation capacity in the long term (GIZ, 2021[16]).

There will be increased vulnerability of rural areas with already fast growing populations that face financial and technical constraint to manage negative impacts of climate change. Climate change is likely to bring about “winners and losers” in Central Asia. For example, longer growing seasons favour cereal production in some areas of the north of the region, while at the same time increasing drought frequency impacting production of crops including cotton, fruit and vegetables in the south (Liu, Liu and Gao, 2020[12]; Gerlitz, Vorogushyn and Gafurov, 2020[17]).

On the other hand, the systemic transformation required for the economies of Central Asia to enhance climate action - especially mitigation - is likely to have wide-ranging implications for current production and consumption patterns in the region. Policies for transformative changes include decarbonisation of energy production, which may negatively affect production and employment in fossil fuel rich countries such as Kazakhstan, Turkmenistan and Uzbekistan. Increased mining of certain materials may also have possible implications for water pollution and terrestrial ecosystems.

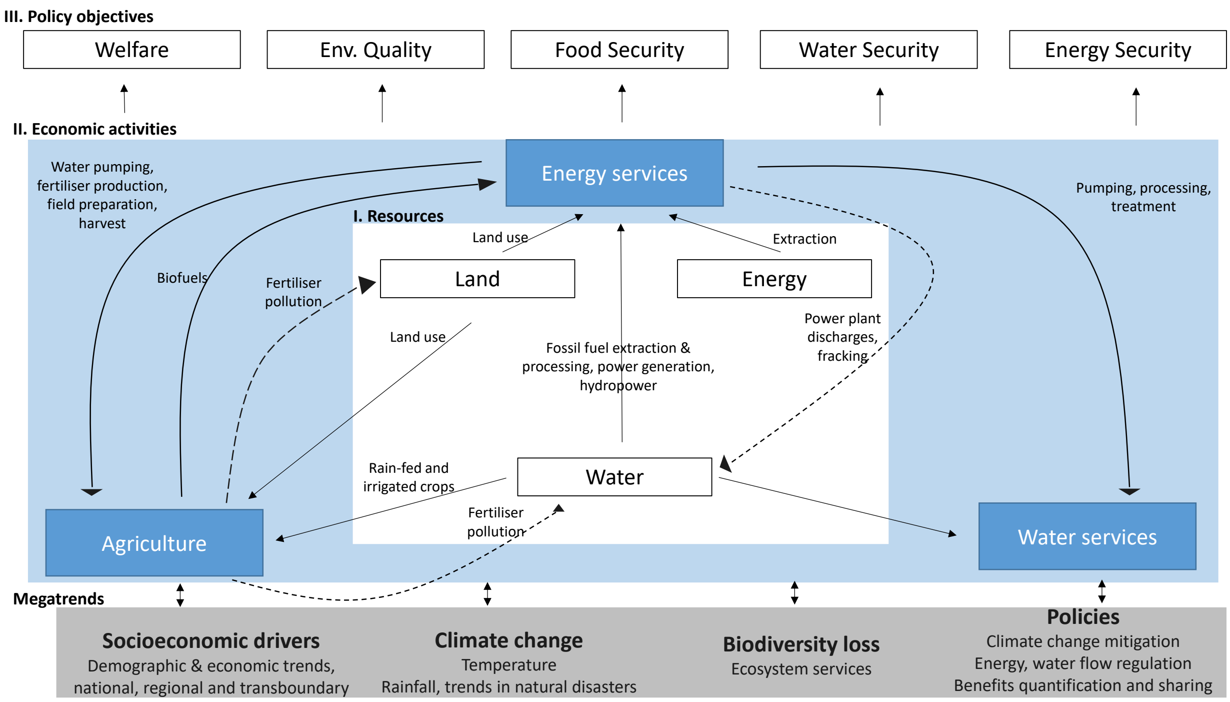
In this context, policies need to consider the interlinkages between water, energy and land systems. Energy is required for a number of water-related processes, such as water treatment and distribution, while wastewater treatment plants have potential to become a source of biogas. Water needs for energy production vary widely depending on the resource used and the production stage (extraction, processing and transport). For fossil fuels extraction and coal mining activities tend to be particularly water intensive with important differences according to depth (e.g. surface and underground mines) and geology of the sites. Similarly, significant amounts of water can be used in water injections to increase oil recovery and hydraulic fracturing (IEA, 2016[18]). In addition, hydropower is the principal source for electricity generation in Kyrgyzstan and Tajikistan.

These interlinkages entail that scarcity or unsustainable use of one of these systems can undermine the function of the other two as well as the wider ecosystems (see Figure 1). Importantly, the interlinkages also underline that – albeit these resources are not perfect substitutes – it may be possible to use more inputs of a resource to mitigate scarcity of another. For instance, countries may decide to allocate larger quantities of land to renewable energy (e.g. solar and wind farms, or production of biofuels) to compensate for a scarcity of energy. Similarly, large quantities of energy are used to desalinate water in several water-poor countries, noting desalination as an emerging technology under discussion and use in Turkmenistan. This energy use can also lead to foregone revenues from fossil fuel exports, pollution from combustion of fossil fuels and emission of greenhouses gases (OECD, 2017[19]).

The energy-water-land use nexus approach, which recognises that policy choices for each system has implications of the other two, supports coherent policy design. In a practical term, the nexus approach seeks to define the inter-relationship between the delivery of services or outcomes related to water, energy and land resources. The nexus approach also aims to help decision makers identify options for governance arrangement and policy measures across sectors that are usually addressed in isolation (Granit et al., 2012[1]). In so doing, the nexus approach moves beyond traditional sectoral thinking in order to simultaneously achieve water, energy and food security objectives in the light of rising climate risks.

Policies pertaining to the management of each of the three resources (water, energy and land) should be carefully assessed against their impacts on availability and quality of other resources of the energy-water-land use nexus. The implications of the policies for the wider ecosystems and the climate should also be carefully assessed**.** This is particularly important as other trends, such as population growth and income growth, could put further stress on more than one system at the same time (OECD, 2017[19]). The recognition of the interlinked nature of water, energy and land resources has led to the development of a number of frameworks to assist policy makers with planning and regulating the nexus. Importantly, such frameworks need to consider the spatial and temporal variations in both supply and demand of these resources, and how the impacts of their depletion can propagate through the nexus (Shannak, Mabrey and Vittorio, 2018[20]).

Figure 1. Main linkages in the energy-water-land use nexus



Source: (OECD, 2017[19]).

Existing tools for energy-water-land use nexus assessments

There have been various tools and methodologies developed to support nexus assessments. A number of tools are available to identify and assess the opportunities, challenges, risks and constraints presented by the energy-water-land use nexus. Assessment tools for the nexus support policy makers and practitioners in identifying and managing the complexities that emerge when several sectors are analysed jointly. The "infrastructural" nature of the energy, water and land sectors requires consultation with a wide variety of stakeholders during the nexus assessment. This helps to analyse a multiplicity of institutional settings, governance aspects and resource flows. Furthermore, it is not a static assessment, with climate change impacts meaning that the situation today will not be the situation of tomorrow.

A number of quantitative tools can be used to evaluate trade-offs and benefits of co-operation, including indicators, analytical frameworks and modelling software. Analytical frameworks are often designed to cover all nexus sectors while software tends to be sector-specific. As such, the use of multiple software may be needed. Examples of such frameworks and software with a transboundary or multi-sectoral scale include: the Multi-Scale Integrated Assessment of Societal and Ecosystem Metabolism (MuSIASEM); the Climate, Land-use, Energy and Water strategies (CLEWs), the e-nexus and the Water-Hydropower Agriculture Tool for Investments and Financing (WHAT-IF). The WHAT-IF model was used to assess multi-purpose water infrastructure in the Low Syr Darya Basin in Kazakhstan in 2016-17 (Roidt and De Strasser, 2015[10]; OECD, 2017[21]).

A number of methodologies have been developed for nexus assessments. For instance, the UNECE Transboundary Basin Nexus Assessment (TBNA) methodology has been applied in Syr Darya river basin (UNECE, 2015[22]). It entails six consecutive steps.

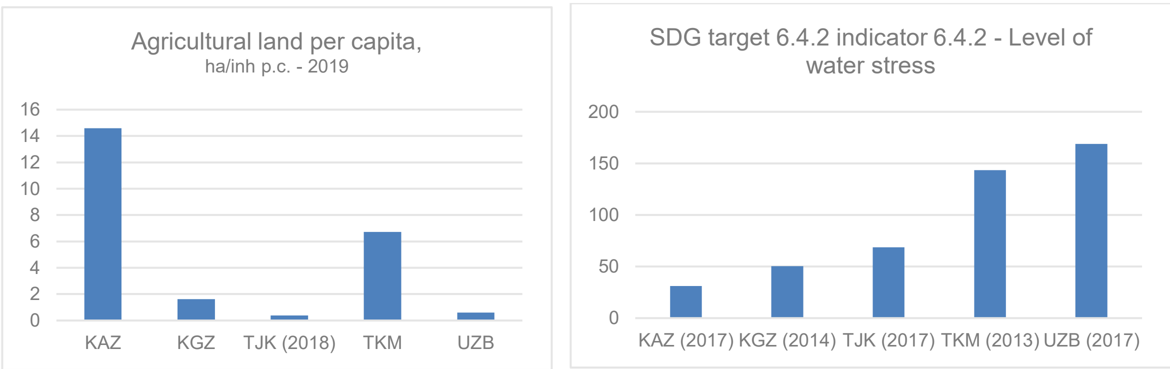
- First, analysts prepare a desk-study to identify the socioeconomic and natural context, including information on: (i) the current state of energy, food, water and environmental security; (ii) the relations that exist within the region; (iii) main strategic goals, development policies and challenges.
- A factual questionnaire is developed to identify the key sectors to be analysed in the assessment (e.g. power production, agriculture, transport) and relative key stakeholders (e.g. authorities, businesses, non governmental organisation (NGOs)).
- Thirdly, analysts start an in-depth analysis with the support of authorities. The analysis should focus on (quantitatively estimating) resource flows and the existing governance structure (e.g. strategies, policies, rules and regulations).
- Fourthly, a workshop is organised to start the inter-sectoral and transboundary dialogue. The desk-study is used to inform the debate and participants are asked to identify interlinkages and discuss them from a sectoral perspective.
- A dedicated plenary session of the workshop kicks-offs the nexus dialogue where stakeholders share their sectoral perspectives and identify key interlinkages. A questionnaire, which aims at identifying resource management issues from the sectors' and countries' perspectives, can be used to inform this process.
- Finally, the analysts investigate the identified issues with the aim of identifying technical and policy solutions to increase synergies. A final workshop, which is based on this in-depth analysis, is used to finalise the nexus assessment.

Endowments of natural resources in the region and the implications for the Nexus

The distribution of water, energy and land resources in Central Asia and how climate change may affect them provide a basis for designing and operationalising the nexus approach. Central Asian countries differ in terms of the resource bottlenecks and opportunities they face, in particular in terms of energy resources, arable land and freshwater endowment.

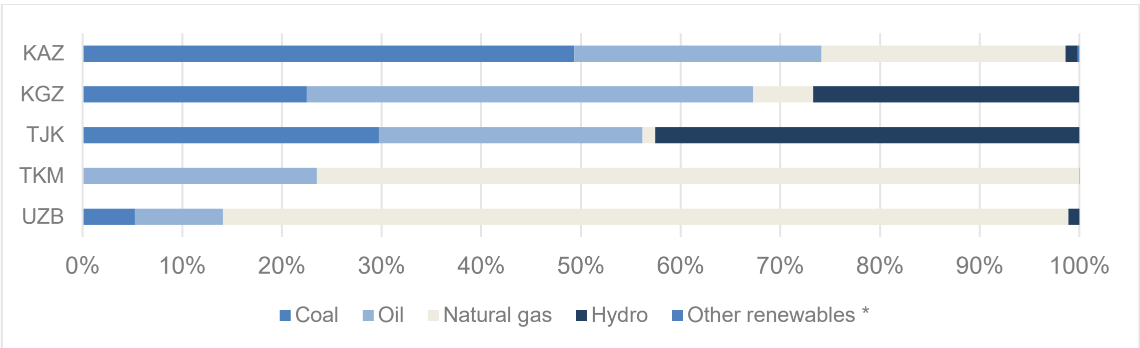
Central Asian countries are characterised by differentiated endowments of water, energy and land resources. The five countries share the Aral Sea basin with waters of the Amu Darya and Syr Darya rivers flowing from upstream mountainous countries of Kyrgyzstan and Tajikistan through Uzbekistan, Turkmenistan and Kazakhstan towards the Caspian Sea. Kyrgyzstan and Tajikistan are relatively water secure while water stress is highest in Turkmenistan and Uzbekistan (see Figure 2 and Figure 3) illustrating a dependence on transboundary water sources. The distribution of arable land is also highly differentiated in the region. Kazakhstan has the largest portion of arable land while Kyrgyzstan and Tajikistan account for a very limited share of arable land due to their mountainous topography. (Meyer et al., 2019[23])

Figure 2. Water and arable land resources in Central Asian countries



Source: Panel a (left): SIC – ICWC data. Panel b: SDG 6 data portal, available at: https://sdg6data.org/indicator/6.4.2, accessed on May 2021.

Figure 3. Share of total energy supply by source in domestic energy use



Note: Energy demand (measured by total energy supply). * Other renewables include solar, wind and biofuels & waste.
Source: IEA (2020), World Energy Balances 2020 (database), www.iea.org/statistics.

Downstream countries have large reserves of fossil fuels that are used for domestic energy use, and exported to other countries. In Kazakhstan, which holds the largest regional proven oil and coal reserves, coal accounts for nearly 50% of total energy supply, while natural gas provides 85% of energy in Uzbekistan and over 75% of energy in Turkmenistan, which also accounts for the 10% of world proved natural gas reserves (Table 1).

Due to their mountainous topography and water abundance, upstream countries account for the majority of hydropower resources (Figure 4). In Tajikistan and Kyrgyzstan water accounts for 43% and 26% of energy use respectively and the two countries account, respectively, for 62% and 19% of the region’s technically exploitable hydropower potential. Importantly, no country in the region uses its full hydropower potential (Ardelean, Minnebo and Gerbelová, 2020[24]) (Eshchanov et al., 2019[25]).

The solar potential is significant and increases from north to south with the highest potential in Uzbekistan and Turkmenistan. Wind potential is higher in the southern part of Kazakhstan and in the steppes along the Caspian Sea (Shadrina, 2019[26]). (See Figure 4).

Kazakhstan, Kyrgyzstan and Uzbekistan also plan to develop nuclear power plants. Uzbekistan has the plan to develop a nuclear power plant to be fully commissioned by 2030, with the first reactors online by 2028. The facility is expected to supply nearly 20% of the country's power needs (Bartlett, 2022[27]). While development of nuclear plants would have significant implications for energy, water and land use resources, it is outside the scope of this working paper, but could be a focus for future analytical work.

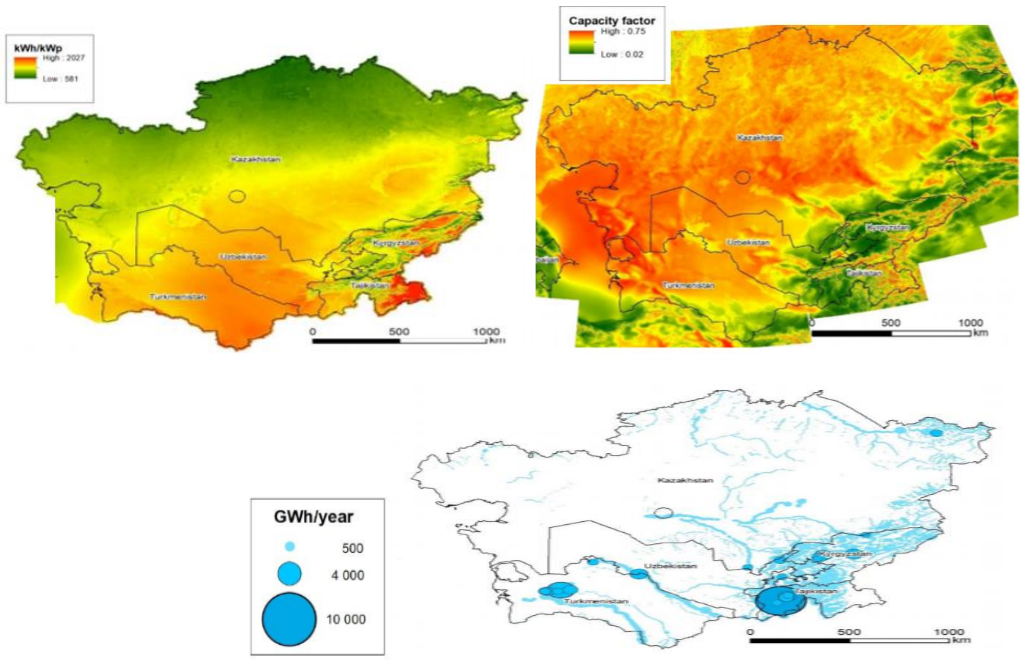
Table 1. Fossil fuel resources in Central Asia

	Oil reserves (thousand million barrels)	Share of world total	Gas reserves (trillion Cubic meter)	Share of world total	Coal reserves (Million tonnes)	Share of world total
Kazakhstan	30.0	1.7%	2.7	1.3%	25,605	2.4%
Turkmenistan	0.6	.	19.5	9.8%	. .	.
Uzbekistan	0.6	.	1.2	0.6%	1,375	0.1%

Source: BP Energy Statistics, 2020.

Figure 4. Renewable energy resources in Central Asia

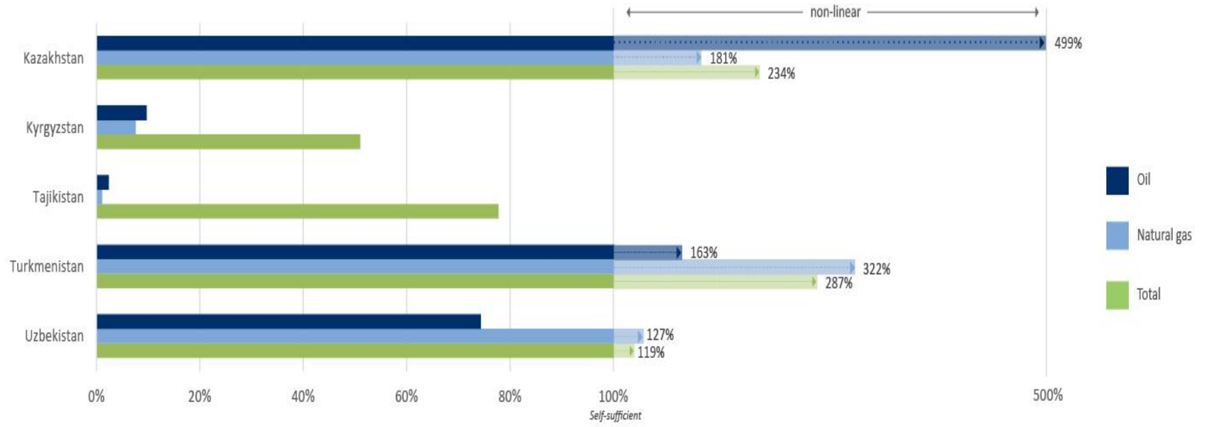
Panel a: Solar potential (left). **Panel b**: wind potential (right). **Panel C** (below): Hydro energy potential



Source: (Ardelean, Minnebo and Gerbelová, 2020[24]).

The difference in endowments of natural resources creates interdependences between the upstream and downstream countries in Central Asia, providing possible incentives for greater co-operation. The case of the water use in the region is a classic example of the nexus challenge. Downstream countries of Central Asia (Kazakhstan and Uzbekistan) depend on water from Transboundary Rivers to be stored in winter for the release in summer to meet their irrigation needs. However, upstream countries (Kyrgyzstan and Tajikistan) have a preference to use (release) water resources to generate energy from their hydropower plants in winter (Adelphi and CAREC, 2017[2]). At the same time, they also need to import fossil fuels to meet their winter power demand (Adelphi and CAREC, 2017[2]) (see Figure 5).

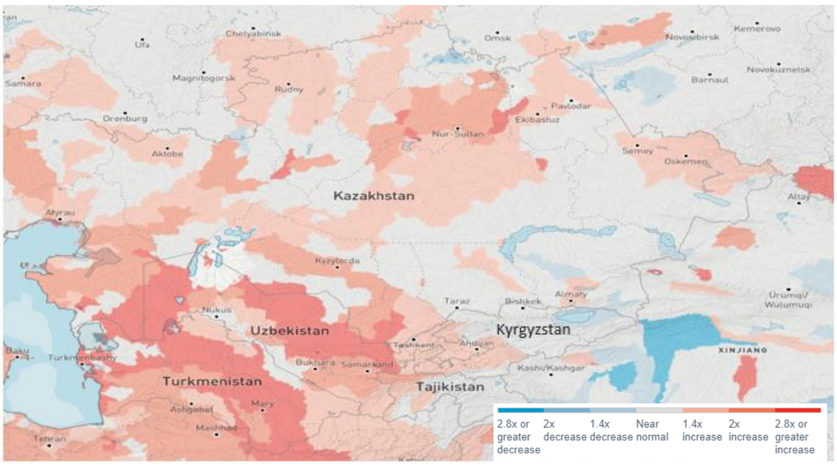
Figure 5. Energy self-sufficiency in Central Asian countries



Note: The chart shows the ratio between the energy production and consumption in Central Asia countries. If the ratio is smaller than "100%", the country produces less of certain energy than it consumes, meaning it must import the rest. In case it is indicated as greater than 100%, country is a net exporter. The 'total' bar represents all the energy produced in the country (e.g. coal, gas, oil, biomass, hydro, wind, solar).
Source: (EU4Energy, 2019[28]).

Climate change is expected to increase water stress in the region. Temperatures - depending on the location of the observation site - have already increased by 0.6-0.8°C in Turkmenistan, by 0.8-1.3°C in Kazakhstan and Uzbekistan, and 0.3-1.2°C in Kyrgyzstan and Tajikistan in the past 50-70 years (Chikalova, 2016[29]). It is projected that in the medium term, increasing water supply due to enhanced glacier melt rates are likely to counterbalance higher evaporation caused by temperature increase. In the long-run, further declining of glaciers and changes in precipitation patterns (e.g. rainfall replacing snowfall) may contribute to a decrease of total and seasonal water supply with important negative implications for water availability and agriculture productivity (USAID, 2018[30]). For instance, medium-term increases in water flow and long-term hydrologic flow reduction may take place in the Syr Darya and the Amu Darya rivers (GEF, 2017[31]; World Bank, 2014[32]) (see Figure 6).

Figure 6. Water stress in Central Asia in 2040.



Note: The scenario (SSP2 RCP4.5) represents a world with stable economic development and carbon emissions peaking and declining by 2040, with emissions constrained to stabilize at ~650 ppm CO_2 and temperatures to 1.1–2.6°C by 2100. The graph shows changes with respect to the baseline.
Source: WRI, aqueduct – water risk atlas. Accessed on March 2021.

The increased water stress would affect land use and energy systems across the region. Agriculture in Central Asia greatly depends on irrigation (e.g. 75 to 100% of cropland is irrigated in the region, except for Kazakhstan) (GEF, 2017[31]). The food system is therefore particularly exposed to climate-related hazards and vulnerable to water stress. Other factors, such as higher drought frequency, increasing temperatures and changes in river flows, represent a serious threat for the regional economies that heavily rely on the agriculture sector. Employment in this sector accounts for around 25% of total employment in Uzbekistan but 44% in Tajikistan. The 2008 humanitarian emergency, which was generated by a rise in food prices due to particularly dry summer and extreme cold winter, is a stark reminder of this vulnerability (IWA and ICUN, 2014[33]).

Changes in water flow can also affect energy security due to lower resources available for hydropower generation and for the cooling of fossil-based power plants, and risks of natural disaster. For instance, the flood in Almaty in 2015 damaged severely the power network (USAID, 2017[34]). Overall, the World Bank estimates that floods annually affect nearly 1 million people and cause USD 4.7 billion of economic losses in the region (World Bank, 2019[35]). The 2008 extreme temperatures generated economic losses equal to around 10% of domestic GDP in Tajikistan while the economic damages of the 2010 flood were estimated at around 2.5% of the country GDP (EMDAT, 2021). A drought in Kazakhstan resulted in USD 130 million of total economic damages in 2008 (EMDAT, 2021).

Some of socioeconomic trends, such as population growth and households' behaviour, can also exacerbate risks for water, energy and food security in the region. For instance, the population in Central Asia is projected to increase by a third and reach around 100 million people in 2050 (UN, 2021[3]). This would increase pressure on natural resources unless more sustainable production and consumption behaviours are adopted. Similarly, if per capita income growth would return to pre Covid-19 growth level (i.e. around 5.7% (IMF, 2020[36])), changes in households' behaviour (e.g. higher energy use) could aggravate these risks (IWA and ICUN, 2014[33]; IUCN, 2019[37]).

Accessing affordable energy has already been a challenge for certain groups of populations in the region, such as those living in remote areas and low-income households in both upstream and downstream countries (Mehta et al., 2021[38]; Shadrina, 2020[39]). The governments have already kept energy tariffs relatively low in order to prevent energy poverty and other disadvantages among the socially vulnerable groups. However, the current tariff levels do not reflect the real economic, environmental and social costs of use and consumption of energy, also undermining efforts to decarbonise the energy systems in the region and mobilise private-sector investments into the energy sector.

Soviet legacy

Until 1991, the five Central Asian countries were part of the Soviet Union where water, energy and land resources were collectively managed on behalf of the Union. This centrally co-ordinated mechanism primarily focused on the use of water in the Aral Sea basin for hydropower and agriculture. However, an externality of this focus was severe environmental degradation and sub-optimal management of water resources within the basin (Granit et al., 2012[1]).

The collapse of the Soviet Union brought an end to the centralised resource sharing mechanism and left the countries with two unique features of transboundary co-operation: an extensive transboundary water infrastructure that was originally built during the Soviet time; and a technical, legal and economic framework to share energy and water resources that had been in place but collapsed after the end of the Soviet Union. Furthermore, the economic environment surrounding the former Soviet countries has drastically changed over the past 30 years. With no centralised management of resource

[3] UN, World Population Prospects 2019. Accessed on Feb 2021. https://population.un.org/wpp/DataQuery/. The regional population grew by 50% between 1992 and 2018, reaching 72 MLN people (FAOStat, accessed on May 2021).

sharing and economic trade-offs, it is difficult to compare previous practises with the transboundary and economic situation of today.

In the Soviet Union era, republics tended to specialise in the production of goods that were then traded across the Union. Building on their resource endowment, a large agricultural production system and a fossil fuel-based energy sector were developed in Kazakh, Turkmen and Uzbek Soviet Socialist Republics (SSRs). In the Kyrgyz and Tajik republics of the Soviet Union, large dams and reservoirs were built. They were mainly operated to provide large water quantities to support irrigated farms in the downstream republics (JRC, 2018[40]), which hydropower generation was a secondary use of the infrastructure. This created a regional energy-water interdependence where downstream republics would supply fossil fuel-based energy to the upstream countries during the cold winter season. By way of return, upstream countries would store water in their reservoirs to meet downstream irrigation demand in the summer months. In addition, the upstream dams were also used to contain floods and avoid possible damages (Boute, 2015[41]).

This scheme in the Soviet era provided some benefits. First, the centralised system allowed increasing power plants' yearly utilisation rates and decreasing reserve capacity. Secondly, it optimised the use of fossil fuels and hydropower in the region. Hydropower was mainly used in the summer with the water released supporting agriculture, while fossil fuels were used mostly in the winter when the availability of hydropower was limited.

However, the high degree of specialisation led to undiversified economies and severe environmental degradation. For instance, the agriculture sector accounts for 30% and 19% of GDP in Uzbekistan and Tajikistan respectively. The mining sector accounts for 14.5% of GDP in the resource-rich Kazakhstan. This reliance on a small number of sectors leave the economies particularly vulnerable to economic shocks. For instance, oil accounts for more than 50 per cent of exports and a large percentage of government revenue in Kazakhstan, thus leaving the economy particularly exposed to variation in oil prices (EBRD, 2018[42]). Monoculture of water intensive crops, such as cotton, led to extensive damages to ecosystems and soil degradation. Intensive water use for irrigation led to progressive reduction of water flow to the Aral Sea. As the Aral Sea started to shrink, its water salt and mineral content increased with dramatic consequences for the once-thriving local fishing industries. Toxic sandstorms of dust, salt, fertilizer, and pesticides that are blown from the dried seabed have affected the health and well-being of nearby populations (Glantz, 1999[43]).

The infrastructure built over Soviet times does not correspond to today's national boundaries. For example, irrigation canals cross multiple times the boundaries between Uzbekistan, Tajikistan and Kyrgyzstan in the Fergana Valley. The reservoir of the Toktogul cascade is located in Kyrgyzstan, yet it was principally designed to regulate the flow of water to downstream agriculture in Uzbek and Kazakh SSRs.

In soviet times, centralised operations facilitated the management and compensation within the region for services provided. For instance, central-budget funding was allocated to the Kyrgyz SSR to cover part of the water-management costs of reservoirs operated in part for the benefit of Uzbek SSR (European Parliamentary, 2018[44]). Similarly, the power system was built as a regional integrated system in order to increase the power plants' utilisation rates, and make the best use of the hydropower potential of Tajik and Kyrgyz SSRs (in the summer) and the fossil fuels resources of Kazakh, Turkmen and Uzbek SSR (in the winter months) (Boute, 2015[41]).

After declaring independence from the Soviet Union in 1991, disagreements emerged between five new countries on how to trade water and energy in the region. As access to foreign markets and the price of fossil fuels increased, downstream countries started to request better financial conditions for their winter energy exports. To counteract these pressures, upstream states started to increase hydropower production and increasingly planned reservoir water releases in order to meet their winter electricity demand rather than downstream summer irrigation needs (Adelphi and CAREC, 2017[2]). To prevent further escalation of conflicts, Central Asian governments agreed to establish a number of institutions to promote co-operation and water sharing. The key bodies include the Interstate Commission for Water Coordination (ICWC) and the International Fund for saving the Aral Sea (IFAS) [see (Meyer et al., 2019[23]) for further information.]. However, as countries failed to reach an agreement on the remuneration of water and the costs of storing water for supply, these institutions came under pressure[4]. The relations deteriorated with serious consequences, as for example in 2009, when Tajikistan was cut off from the Central Asian Power System (CAPS) (EBRD, 2017[45]). (See also Box 2.)

The economic hardship that had started during the Soviet era and augmented after the dissolution of the Union did not allow the proper maintenance and upgrade of power and water networks. This has further complicated the management of the water-energy relations established during the Soviet times. Total expenditures for operation and maintenance of the water network returned to 1986 levels only by 1996 (Wegerich et al., 2015[46]).

The energy sector is still characterised by poorly functioning regional energy markets (JRC, 2018[40]) **and below cost recovery power tariffs (see section 3.1).** The Soviet time power grid still does not connect Turkmenistan, which withdrew from the grid Parallel Operation Agreement in 2003 (Mercados, 2010[47])https://www.carecprogram.org/uploads/Diagnostic-Study-CAREC-Energy-Strategy-Pillar2-Full-Report.pdf. In April 2018, Tajikistan started to export power to Uzbekistan on an "islanded" mode (i.e. outside of a regional grid). However, the relay protection system and interconnection infrastructure need to be upgraded in order to synchronize the power systems and achieve power trade targets (AdD and OSHC, 2021[48]). Losses in the power transmission and distribution networks, which point to the poor technical condition of national power grids, amounted to 13% of generated output on average between 2010 and 2014 with peaks of 22% in some countries. Similarly, both national and transboundary water networks are often inefficient and water losses amounted to 42% in 2017 (SIC ICWC, 2021). At the same time, the need for scaled up investment in low-carbon electricity and heat production infrastructure has been increasingly recognised in the context of the increasing momentum towards climate change mitigation commitments of some of the Central Asian countries such as Kazakhstan and Uzbekistan.

Box 2. Challenges and opportunities of reconnecting the Turkmen power system to the Central Asian Power System (CAPS)

The Turkmenistan power system discontinued parallel operations with the CA Unified Energy System in 2003 due to issues of power transit through Uzbekistan's grids and the lack of access to power export to other systems of CAPS and started operating in parallel with the energy system of Iran.

The re-integration of the Turkmen energy system in the CAPS may help to increase the reliability of the CA power market but would require connecting with Iran using the so-called "island" scheme since parallel operation of Iran with CAPS is not technologically feasible (SIC ICWC, 2021).

Emerging economic and geopolitical dynamics in Central Asia

Central Asia plays an important strategic role in global geopolitics and economy for a number of reasons, including its geographic position and natural resource endowment. First, the Central Asian Republics are located at a crucial link between global and regional economic powers, such as the People's Republic of China (China), the European Union, India, Iran, the Russian Federation (Russia), and Turkey. Secondly, the region is endowed with significant natural resources. For instance, the region has the world's

[4] An attempt to preserve the Soviet system of water-energy exchange was made in 1998 Agreement on the Syr Darya River among four countries but lasted only five years.

third largest natural gas reserves, while Kazakhstan is the largest producer of uranium. Central Asian countries are also major producers of mineral resources: for instance, antimony and mercury in Tajikistan, gold, rhenium, titanium and kaolin in Uzbekistan to name a few (OECD, 2019[49]). Thirdly, the region is close to the zones of conflicts and tensions that affected several neighbouring countries and regions in the recent decades, such as Afghanistan and the Xinjiang autonomous region of China.

China's influence in the region has been growing. Two out of the five corridors of the Chinese Belt and Road Initiative (or BRI), which is a USD 1 trillion programme to build an infrastructure network that connects China and countries across the globe, cross Central Asian States. In this context, Central Asian economies have become large recipients of Chinese investments that amounted to over USD 60.8 billion between 2005 and 2018 (OECD, 2019[50]). From a sectoral perspective, the energy (68%) and the transport sectors (11%) were the largest recipients. Kazakhstan and Turkmenistan have been the largest beneficiary with an FDI amounting to, respectively, over USD 32.6 and USD 6.8 billion (OECD, 2019[50]).

China is also an important export market for Central Asian countries. For instance, it accounted for more than half of Uzbek gas export in 2019 with the remainder split between Russia, Kazakhstan and other Central Asian countries (Reuters, 2020[51]). China is also an increasingly important market for agricultural products for the countries, including meat, which is incentivising them to scale up livestock production. Apart from the economic relationship, China is also a founding member of the Shanghai Co-operation Organization, which was established in 2001 to ensure co-operation, security and stability in Eurasian region and currently features eight member States[5] (SCO, 2021[52]).

Furthermore, China shares a border with many Central Asian countries with specific transboundary challenges. For instance, the Ili River, which flows between China (Xinjiang autonomous region) and South East Kazakhstan, is an important source of water for the growing cities, irrigated agriculture, and energy industries in both countries. However, socio-economic development in the basin has accelerated with implications for sustainable water use and water allocation between China and Kazakhstan (de Boer et al., 2021[53]).

These large financial flows from China represent both risks and opportunities for promoting the energy, water and land-use nexus approach. On the one hand, the large financial resources of the BRI could help to modernise the regional energy sector, build interregional connectivity and diversify the energy mix, thus helping to ease the pressure on the energy dimension of the nexus. However, for these benefits to be realised, reforms in several policy areas would be required. They include improving transparency, maintaining debt sustainability and ensuring that environmental, social and governance risks of investments are addressed (OECD, 2019[50])).

The European Union has been increasing its engagement with the region. While the previous EU Strategy for the region focused mostly on energy security issues, the recently endorsed updated Strategy (EC, 2019[54]) identifies three main pillars: "resilience", "prosperity" and "working better together". A new generation of enhanced partnership and co-operation agreements (or EPCAs) has been negotiated with countries in the region (European Parliament, 2019[55]). The EPCA with Kazakhstan envisages wide-ranging co-operation on topics such as investment, energy, transport, environmental matters, education and trade. The EEAS reports that the EU allocated EUR 1.1 billion to development co-operation with Central Asia for 2014-2020 (EEAS, n.d.[56]). Multi-annual Indicative Programmes for Central Asia for the period 2021-2027 have also been developed (European Union, 2021[57]). In addition, the EU–Central Asia Platform on Environment and Water Co-operation, which was established in 2009, provides a framework for the co-operation between EU and Central Asian countries in the field of environment, water and climate change (WECOOP, n.d.[58]). Individual European countries also support several co-operation programs in

[5] The Shanghai Co-operation Organization, which is a multilateral organization, comprises eight member states: India, Kazakhstan, China, the Kyrgyzstan, Pakistan, Russia, Tajikistan, and Uzbekistan. In addition, a number of States have an "observer" or "dialogue partner" status.

the region, such as Germany's Green Central Asia Initiative that aims at fostering dialogue among Central Asia countries and Afghanistan (deutschland.de, 2020[59]).

Importantly, the EU Strategy for Central Asia identifies a number of areas for enhanced co-operation that are particularly relevant for the energy-water-land use nexus. For instance, the EU strategy envisages co-operation on the Paris Agreement and tackling trans-regional environmental challenges under the first strategic pillar (i.e. resilience). The strategy also underlines a number of crosscutting actions, such as the EU-Central Asia dialogues and EU-funded regional programmes that aim at "promoting […] cooperative solutions at the regional level in areas such as the environment, water, climate change and sustainable energy" (EC, 2019[54]).

The implications of both China and EU ambitious climate targets for fossil rich countries should be assessed*.* The EU aims at being carbon neutral by 2050 and climate action is at the heart of the Commission's EUR 1 trillion "Green Deal". At the same time, China plans to be carbon neutral by 2060. How such ambitious climate mitigation plans and associated investment plans would affect fossil fuel rich Central Asian countries would require carefuly assessments.

Russia retains a significant influence in the region. Kazakhstan and Kyrgyzstan are members of Eurasian Economic Union (EAEU), which aims at creating a common space for the free movement of capital and labour across member States (OECD, 2018[60]). Uzbekistan became an "observer" to the EAUE in December 2020. The creation of a common energy market under the EAEU, which is under discussion, would have wide-ranging consequences for the nexus, some of which could be positive if renewables were considered at its core. Beyond economic ties, Russia has provided important development assistance to Central Asia, including favourable loans, to the countries in the region. Remittances from Central Asian migrants in Russia also contribute substantially to the GDP of several countries in the region. The Russian language is still the "lingua franca" in the region, while the position of local languages (i.e. the Kazakh, Kyrgyz, Tajik and Turkmen and Uzbek languages) has been strengthened in recent years (Liddicoat, 2019[61]).

Central Asia has been a geo-strategically important region for the United States in its national security interests, regardless of the level of the country's involvement in Afghanistan (U.S. Department of State, 2020[62]). The US' long-standing support for CASA-1000 project (see section 3.1) aims to bolster Central Asian economies by facilitating electricity exports from Central Asia to Afghanistan and Pakistan (U.S. Department of State, 2020[62]). The United States has also been supporting Central Asian through a USAID initiative on water and vulnerable environment on the management of shared water resources and mitigation of environmental risks in the Amu Darya and Syr Darya basins (USAID, 2021[63]).

Turkey is also an important player on the regional stage. The shared Turkish heritage of several countries in the region is underpinned by the Turkic Council, which is a regional institution aiming at promoting co-operation among its members[6]. Turkey is a promoter of the Trans-Caspian East-West-Middle Corridor, which aims at improving road connectivity between Turkey, Georgia, Azerbaijan and the Caspian Sea (Akman, 2019[64]; Köstem, 2019[65]). The Turkish Ministry of Foreign Affairs argues that shipment of goods from China to Europe through the Middle corridor would be 15 days shorter compared to the current sea route and frames the project as complementary to the Belt and Road Initiative (MFA, n.d.[66]). In addition, Ankara coordinates the High-Level Strategic Co-operation Councils, which bring together heads of states and high-level bureaucrats on a regular basis from Kazakhstan, Kyrgyzstan and Uzbekistan (Köstem, 2019[65]).

[6] Members include Azerbaijan, Kazakhstan and Kyrgyzstan. Uzbekistan has applied in 2019 to become a member.

3 Challenges to regional co-operation on the energy-water-land use nexus in the Central Asia Region

The need for regional co-operation: common benefits and challenges

The varying endowments of natural resources, and their interlinkages, across the region underline the importance of transboundary co-operation to ensure sustainable resource use. Furthermore, transboundary regional co-operation efforts addressing jointly water, energy and land resources should help ensuring that the concerns of each country are addressed in a mutually beneficial way and therefore potentially easing the sharing of costs and providing benefits within the region (World Bank, 2016[67]) (Adelphi and CAREC, 2017[2]).

Increased transboundary co-operation can provide large economic gains to all countries of Central Asia. There are a relatively limited number of scientific papers that model simultaneous co-operation along the three nexus dimensions in the region, due probably to the difficulties of modelling international co-operation among the five countries on three large sectors. Several studies however offer insights on the benefits of co-operation along specific nexus dimensions (e.g. energy or water) and a specific set of countries. Examples include the following:

- De Miglio et al. (2014[68]) find that the direct economic benefits of co-operation in the energy sector development for selected Central Asian and Caspian countries (Azerbaijan, Kazakhstan, Turkmenistan and Uzbekistan) would be around USD 0.5 billion annually over the period between 2011 and 2020.
- A study commissioned by the World Bank on the unrealised benefits from regional power trade for the four Central Asian countries of Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan estimate co-operation benefits to amount to nearly USD 1.5 billion if only fuel savings were taken into account for the 2010-2014 period. When additional benefits, such as avoiding unserved power demand are included, the benefits would range between USD 5.2 and USD 6.4 billion (Mercados, 2016 in (World Bank, 2016[67])).
- Adelphi and CAREC (2017[2]) estimate that costs of insufficient co-operation amount to more than USD 4.5 billion per annum (or 1.6 % of the regional GDP), based on a literature review. The study notes that this is a lower bound estimate since it includes only costs related to agricultural losses, inefficient electricity trade and lack of access to finance due to non-co-operation. It is noted that the estimation of these costs is challenging and methodologies require regular review and validation.
- Saidmamatov et al. (2020[69]) perform a strength, weakness, opportunity, threats (SWOT) analysis for Water–Food–Energy (WEF) integration in Central Asia and conclude that nexus transboundary co-operation is instrumental to mitigate the negative consequences of climate change in the region.

These figures could be a useful indication on benefits of cooperation. It however remains unclear to what extent the outcomes of these studies have been applied to political discussions and policy making related to natural resource security in the region. A consultation with experts from the region revealed that even results of economic analyses conducted at the request of governments may not always be used for policy processes.

Transboundary and cross-sectoral approaches can ease access to international financing because of higher expected return on investment without causing significant harm on the environment or society. The attractiveness of an investment is given by the risk-adjusted ratio between its costs and expected benefits. Transboundary co-operation can help to improve this ratio for a number of reasons. First, returns from the investment may be higher since positive impacts across multiple regions can be accounted for and/or because cost savings can be achieved by reducing the transaction costs of identifying, screening, structuring and implementing projects. Secondly, regional co-operation can help to decrease the risks of unintended negative consequences on economies, ecosystems and well-being of projects in neighbouring regions (i.e. maladaptation), thus decreasing investment risk. For instance, the construction of a large dam may help to protect against the risks of increased flooding due to climate change but may negatively affect aquaculture industries in regions further downstream. In addition, the wider the support for the project is, the lower the political risk of the investment is. These elements together can favourably affect the risk/return profile of the investment, thus making it more attractive to international financiers (UNECE, 2021[7]; World Bank, 2019[70]).

Nevertheless, a study on multi-purpose water infrastructure (MPWI) in Kazakhstan found that the more potential uses for an infrastructure project, the more difficult it was to secure adequate financing due to an increased perception of risks (OECD, 2017[21])**.** The study demonstrated that reservoirs and dams to support hydropower production, where there is a single, clearly saleable product, were "easier" to finance than reservoirs that supported a range of uses for example, hydropower, water supply and flood protection. The study demonstrated that multiple uses typically involve multiple stakeholders and different (sometimes conflicting) operating philosophies and therefore perceived risks. Given the long life of assets such as reservoirs, the day-to-day use generally evolves into providing additional services to citizens and the wider economy. It is therefore beneficial to consider this at project conceptualisation and to work with financiers and stakeholders to understand the risks and benefits of new schemes to maximise benefits for the whole economy (OECD, 2017[21]; Naughton, DeSantis and Martoussevitch, 2017[71]).

A number of challenges and "add-on" benefits are commonly found when applying the energy-water-land use nexus approach. The UNECE (2021[7]) has recently reviewed the experience of countries leveraging a nexus approach in transboundary basins in Central Asia and other regions. A literature review and interviews with experts through an ad hoc questionnaire were conducted for this study. The results show that experts (mostly coming from the fields of water and the environment) consider that most "add-on" benefits (i.e. beyond the direct, sectoral resolution of the problem in question) are linked to improved governance and institutions (see Table 2 and Table 3). The study identifies also eight key constraints encountered by stakeholders when trying to implement nexus solutions in transboundary basins. These are: politics; data and information shortcomings; inadequate institutions; financial constraints; persistent policy/sector silos; limited technical capacity; misalignment between time frames (e.g. a three- to four-year budget cycle vs long-term climate objectives over the next decades); and limited options for benefit-sharing. In addition, it may be complex to access international funding opportunities that narrowly target specific sectors or activities (UN DESA, 2014[72]).

Table 2. "Add-on" benefits of nexus solutions in transboundary basins

Benefit	Percentage (%)
Enhanced inter-sectoral co-operation	65
Enhanced transboundary co-operation	65
Better resilience or reduced risks	58
Establishment of improved planning practices and paradigms	52
Improved ecosystem services	52
Greater transparency	48
Improved infrastructural functionality	42
Improved resource security (water, energy or food)	42

Note: Top eight "add-on" benefits from *water-food-energy-ecosystems* nexus solutions in transboundary basins according to UNECE survey of experts.
Source: (UNECE, 2021[7]).

Policy silos and lack of coherence among and across policy objectives have been singled out as a barrier to nexus approaches in the region. For instance, investment decisions for water, agriculture and energy infrastructure are generally evaluated separately with the risk of missing synergies or triggering unintended consequences across the Nexus dimensions. In a review of findings from the assessments of the water-food-energy-ecosystems nexus in Alazani/Ganykh, the Sava and the Syr Darya Basins, the UNECE (2017[73]) identified a number of cross-sectoral areas where roles and responsibilities need to be clarified. These areas include the management and financing of irrigation schemes, monitoring basin resources (including groundwater and water quality management), and supporting the application of sustainable development principles in economic and sectoral planning and decision-making.

A multi-sectoral and multi-technology approach is needed to avoid biased assessments. Roidt and De Strasser (2015[10]) review lessons learned from applying the nexus framework under the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) across the world. This study underlines that all relevant sectors and specialties in participating sectors need to be included to avoid biased assessments. For instance, limiting energy-sector participation only to hydropower experts may lead to overlooking important synergies and trade-offs with other energy technologies (Roidt and De Strasser, 2015[10]).

In this context, it is important to ensure that functional and legitimate national focal points for operationalising the nexus approach are assigned, and that they have the necessary time and resources to engage a broad range of actors in productive discussion on the nexus process. The role of planning ministries such as economy and finance ministries is also particularly important in mainstreaming the nexus consideration into public financial management and investment planning.

Once the nexus assessment is completed, organisational inertia and the larger economic importance of certain stakeholders may hinder change, even if participants realise the importance of the conclusions of the assessment. To this end, it may be useful to couple the nexus analysis with a benefits assessments (Roidt and De Strasser, 2015[10]). Supporting targeted dialogue, sharing best practises and disseminating the findings in local language can also be instrumental to this end. Importantly, during this process, changes in national administration can create new opportunities and challenges (Roidt and De Strasser, 2015[10]).

Communicating benefits of nexus approaches to those who make policy and investment decisions is critical. Both domestic actors at the national and sub-national levels and their development co-operation partners have the important role to play in promoting dialogue across sectors and across levels of governance (from the regional to national, to local levels). Such horizontal and vertical interactions would help create demand for taking up policy measures based on the nexus assessment and mitigate barriers to the implementation of such measures.

Table 3. Examples of nexus interventions in transboundary basins

Type of intervention	Action	Type of intervention	Action
International co-operation	• Stronger transboundary co-operation • Increased awareness of the benefits accruable to cross sector transboundary trade-offs, compromise and synergies • Increased awareness of options for cross-sector, transboundary trade-offs, compromise and synergies • New, multi-purpose "basin" level infrastructure • Multi-purpose use of existing infrastructure	Economic and policy instrument	• Shift to demand management policies • Better legal arrangement • Better institutional arrangements • Economically mobile water[7] • Transparent and equitable terms of transboundary trade between the riparian countries
Governance	• Shared data and information • Common metrics for environmental and social impact assessments • Standardised social and environmental impact assessments between sectors and between riparian countries • Functional, transparent incentive structure • Appropriate, well enforced regulations	Infrastructure and Innovation	• Multi-purpose water infrastructure • Innovative infrastructure and operating rules • Innovative financing • Natural infrastructure[8] • Small and large scale conservation agriculture • Renewable energy • Smart energy strategies • Decentralised service delivery concepts • Decentralised service infrastructure

Source: (UNECE, 2021[7]).

Cross-sectoral issues

Upstream states (Kyrgyzstan and Tajikistan) plan to develop hydropower generation and interconnection capacity for meeting the demand for heating which is commonly based on electricity. Hydropower potential, which provides around 90% of total electricity generation in the upstream countries, is lower in the winter period. In this context, the countries are planning to tap their unused hydropower potential to increase their power generation capacity. For instance, the long-discussed Rogun Dam project could add 3 600 MW to Tajikistan capacity while Kyrgyzstan plans to add 240 MW to Toktogul hydropower plant (1 200 MW in total) (Ardelean, Minnebo and Gerbelová, 2020[24]). The increase in hydropower capacity is coupled with development of the Central Asia-South Asia power project (CASA-1000 project). It will allow exporting summer power surplus to neighbouring countries in South Asia (i.e. Afghanistan and Pakistan) (USAID, n.d.[74]) and the ADB funded project for the complete restoration and reconnection of the Tajik power system with Uzbek power system (Kim, 2020[75]).

These infrastructure investments create both opportunities for and challenges to promoting the energy-water-land use nexus in the region. On the one hand, inter-connection would facilitate power trade, thus potentially helping a more integrated nexus management. For instance, downstream countries such as Kazakhstan and Uzbekistan could purchase electricity from the upstream states during summer months. This may lead to much needed water releases for the agriculture in the downstream states and generate revenues that can be used by the upstream states to meet their winter power peak demand. In

[7] Water is economically mobile when the pertaining legal, regulatory and institutional framework allows it to be allocated to uses that reduce its opportunity cost which, simply stated, is the economic return of its most lucrative use minus its return on current use. (UNECE, 2021[7]).

[8] Natural infrastructure comprises investments in the conservation, adaptation or beneficial modification of natural landscape features – examples could be natural or man-made and include wetlands; reforestation; restored floodplains; catchment stabilisation etc (UNECE, 2021[7]).

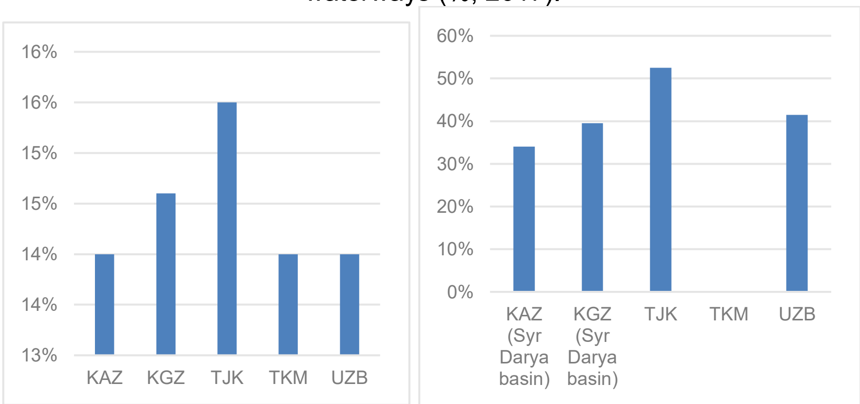
2020, Uzbekistan had in place an agreement to purchase Tajik electricity in summer in order to both meet its power demand and to lead to water releases but water scarcity led to its termination[9]. The CASA-1000 project and the improved Tajikistan–Uzbekistan connection would further strengthen such positive synergy. On the other hand, the downstream states have for a long time feared that expansion of hydropower generation, if not properly planned and integrated into the wider regional resource balance, may have a negative impact on water availability for irrigation, and in the past have opposed the creation of new dams. **Outdated infrastructure in both upstream and downstream countries adds pressure on both energy and water systems.** Water losses are high across Central Asian countries.

Figure 7 shows that about 15 % losses in electricity transmission and distribution systems while water losses in public waterways amount to around 30 to 50%. Studies also highlight particularly acute losses for the agriculture sector (e.g. losses account for 30 and 60% of total water consumed by this sector in Uzbekistan (UNECE, 2020[76]) and in Kazakhstan (UNECE, 2019[77])). The high level of electricity loss in Kyrgyzstan and Tajikistan suggests that part of the unmet power demand could be satisfied without the need of increasing capacity but through ensuring improved performance and operation of distribution networks.

Demand-side inefficiency is also undermining the water and energy resource management in the region. In Tajikistan and Kyrgyzstan water pumps are largely used for irrigation due to their mountainous geography (e.g., about half of the total service area of the Tajik national water supplier (ALRI) is pump-fed) but their poor state creates negative implications for the energy-water nexus. On the one hand, the generally low efficiency of old pumps leads to water losses and increases pressure on the energy sector due to additional power demand. On the other hand, power outages increase demand for water because the flows in the emptied pipelines and irrigation canals need to be re-established (UNECE, 2017[73]).

Figure 7. Water and power losses

Panel a: Electric power transmission and distribution losses (2020). **Panel b**: Water losses in public waterways (%, 2017).



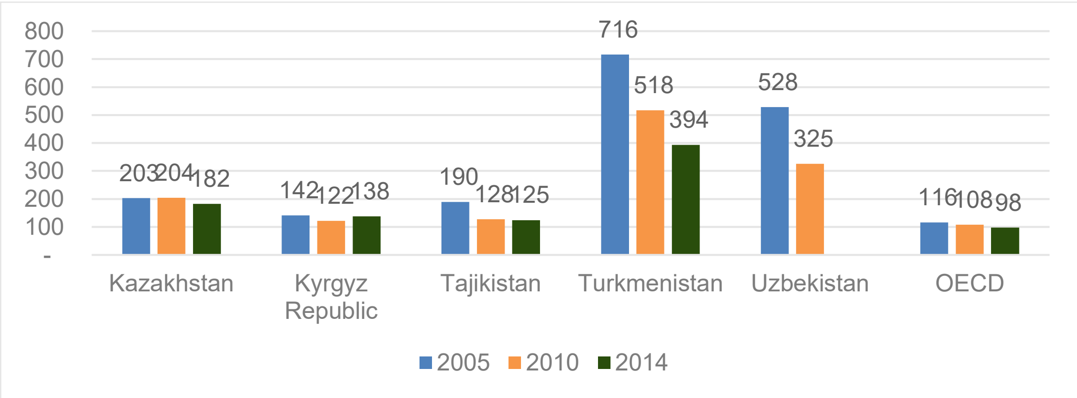
Note: Data on Turkmenistan (TKM) for Panel B was not available.
Source: SIC – ICWC data (2021)

[9] In 2020, an agreement was signed between Barki Tojik of Tajikistan and the National Energy Systems of Uzbekistan for the export of electricity from Tajikistan to Uzbekistan from May to September. In July, electricity imports from Tajikistan decreased due to water scarcity. In early August, Barki Tojik terminated the contract to meet domestic power demand. Uzbekistan signed an import electricity agreement with Turkmenenergo, and restricted domestic consumption ((SIC inputs, 2021. (CAWater-info, n.d.[106])).

The high-energy intensity of the Central Asian economies contributes to an increasing energy and water demand, which would also be compounded by the negative impacts of climate change. Despite improvements over the past years (see Figure 8), the energy intensity of the Central Asian economies remain high and well above the OECD country average. The high level of energy intensity increases energy insecurity with high energy consumption leading to higher water allocation to hydropower generation and/or cooling of fossil fuels based power plants. It is noted that the energy intensity of all Central Asian economies is forecast to increase in the coming years as countries look to diversify their economies into manufacturing, processing and other industries (SIC - ICWC inputs, 2021).

Figure 8. Energy Intensity of GDP

Energy use (kg of oil equivalent) per USD1000 GDP (constant 2017 PPP).



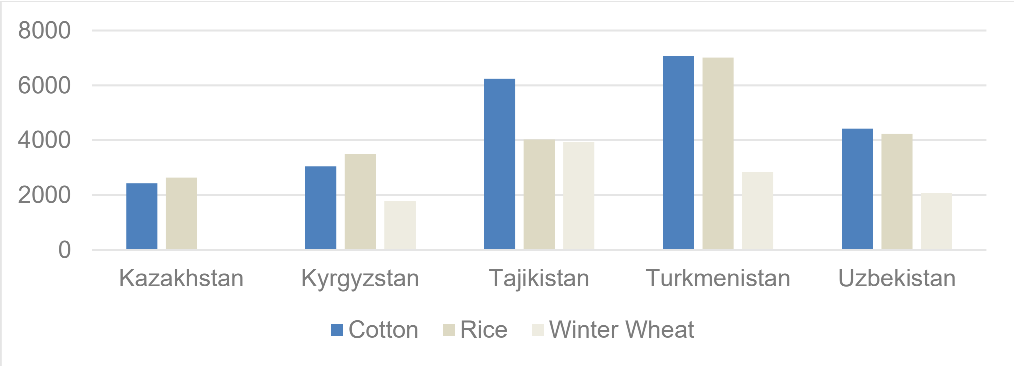
Source: World Bank Development Indicators (EG.USE.COMM.GD.PP.KD), accessed on Feb 2021.

Similarly, water intensive crops and use of high-altitude agricultural land increase pressure on the nexus. The water footprint of growing specific crops varies considerably among different crop types and countries in Central Asia (see Figure 9). For instance, Aldaya, Muñoz and Hoekstra (2010[78]) estimate that about 4 500 and 2 100 m^3 of water are needed to grow respectively 1 tonne of cotton and 1 tonne of wheat in Uzbekistan.

Government policies may aim at promoting crops that maximise return on investment and are resilient to climate change while reducing water consumption. For instance, the ongoing crop diversification strategy in Uzbekistan, which aims at promoting higher value crops, is expected to decrease water consumption (UNECE, 2020[76]). Similarly, according to available estimates, prioritising agricultural land in areas where water systems can be gravity-based rather than pump-based would lead to important efficiency gains in terms of energy consumption (UNECE, 2020[76]). The national water supplier "ALRI" could halve annual O&M costs saving up to USD 1.9 million (OECD, 2020[79]). In Uzbekistan, upgrading pumping stations with modern equipment or moving to gravity-fed systems would lead to a 5% power saving per year (UNECE, 2020[76]). However, these benefits should be carefully evaluated against the costs of relocating fields and settlements at lower altitudes.

Figure 9. Water footprint of selected crops in CA Countries

m³ /ton



Source: (Aldaya, Muñoz and Hoekstra, 2010[78]).

Investment and financing issues

Governments should also ensure that the broader policy framework is conducive to investment in green technologies by businesses and households. While governments are likely to remain the key investor in the energy and water sectors, the production decision of businesses can help to determine overall water and energy demand that these sectors need to meet. A policy framework that ensures that investment decisions are geared towards efficient resource use and the use of Best Available Techniques (BATs) can therefore contribute to the management of the regional energy-water-land use nexus. The OECD Policy Framework for Investment (PFI) provides a checklist of key policy issues for governments interested in facilitating private investment. While a discussion of all dimensions of PFI and its relevance to the nexus is beyond the scope of this paper[10], misalignments in a number of policy dimensions are likely to hinder the private sector participation in support towards a better nexus management. For instance, the very high lending interest rates observed in several countries (e.g. around 20% in Kyrgyzstan and Tajikistan (Shadrina, 2019[26])) are likely to represent an obstacle to the required (greener) upgrade of production equipment across several industries. This challenge is not only for scaling up the nexus related investment, but also applies to mobilisation of finance in Central Asia in general.

The continuing inflow of foreign direct investments (FDIs) towards extractive industries and fossil fuel based power generation is likely to continue undermining economic diversification efforts with detrimental impact on water systems. While some countries, such as Kazakhstan and Uzbekistan, are trying to diversify their highly dependent economies on fossil fuels and extractive industries, foreign direct investments (FDIs) still flow disproportionally towards these sectors. Around 43% of greenfield FDIs (or around USD 98 billion) targeted these two sectors between 2003 and 2017 (OECD, 2019[50]). Given the well-documented impacts and risks that these sectors create for water quantity and quality (i.e. pollution from discharges of wastewater and heat pollution from water-based cooling systems), these evolutions should be carefully monitored. In this context, OECD (2020[80]) points out that none of the national Investments Promotion Agencies (or IPAs) surveyed in the region has an official mandate to attract green investment.

Under-pricing of water and energy undermines the financial sustainability of utilities and network efficiency. In several Central Asian countries, consumption is often not metered (i.e. users pay for water services on an agreed periodic amount) and when it is, water tariffs are set at a level that is below cost

[10] For a discussion on the PFI and the low-carbon transition, see https://www.oecd.org/investment/pfi.htm

recovery for several types of users (e.g. households, farmers) (UNECE, 2020[76]; OECD, 2020[79]). Similarly, electricity tariffs are not cost-reflective[11] (Boute, 2015[41]). These low levels prevent suppliers from refurbishing existing networks, thus increasing losses and decreasing reliability. At the same time, water and energy subsidies also discourage users to rationally use these resources

Governance issues

Ensuring policy coherence not only within each single domain of the nexus (i.e. water, energy or land) but also across these domains faces several political and technical challenges associated with institutional arrangements. Applying the energy-water-land use nexus approach requires sound governance that aligns decisions across these different policy areas and administrative boundaries, and between public and private actors. The following section reviews some key challenges for the national and regional governance of nexus in the region.

Fragmented institutional arrangements within the governments complicates the management of the nexus. For instance, the responsibility for water resource management is still fragmented in many CA countries. Tajikistan's water management is based on administrative districts rather than river basins, thus making effective planning of water allocations and management of infrastructure problematic (OECD, 2020[79]). A study has pointed out insufficient co-operation among various institutions that are in charge of different water infrastructure in Kazakhstan (UNECE, 2019[77]). Similar findings are reported for Uzbekistan, highlighting that linkages between land-use planning and water management could be further strengthened in the country (UNECE, 2020[76]).

The lack of reliable and accessible data often prevents the development of governance arrangements for sound transboundary co-operation. The availability and reliability of data and information is considered as a key element to build confidence between transboundary water management organisations, and is an essential element for co-operation (OSCE, 2015[81]). However, limited information sharing mechanisms and common guidelines for harmonising monitoring and assessment of water quality of national bodies has been a persisting issue in the region. Evidence of this challenge was provided in the summary report of the 2014 IWA and IUCN workshop (IWA and ICUN, 2014[33]). CAREC (2018[82]) also highlights the need for stronger co-operation for the harmonisation of the regulatory and legal framework for water quality. A more recent study also highlights the lack of specific, robust and effective co-ordinating bodies for sharing such data as a key challenge to sustainable water, energy and land resource management (Liu, Liu and Gao, 2020[12]).

In addition, it is unclear to what extent River Basin Organisations have the capacity to access international funding and manage funded projects. The involvement of national River Basin Organizations (or RBOs) is critical to ensure the success of a transboundary approach to operationalise the energy-water-land use. However, RBOs often lack the required legal and financial status to access funding and the capacity to develop and manage complex projects (World Bank, 2019[70]). Regional transboundary Basin Water Organizations for Amu Darya and for Syr Darya have experience in accessing international funds and managing provided financial resources. The level of engagement with national RBOs in CA countries should be further investigated.

Reforming governance arrangements for energy and water sectors will also be essential for bringing together the two sectors and restoring power trade in the region. The Central Asia Regional Electricity Market (CAREM) project provides technical assistance and capacity building for the creation of a sustainable regional electricity market. It identified a number of obstacles that prevent power trade in the region. They include: gaps in the lack of regional network management and harmonisation; limited system

[11] A tariff is defined as "cost reflective" if it covers all the costs of supplying electricity and, in some case, a reasonable return on the investment for the operator.

synchronisation; and an absence of coordination in power generation (World Bank, 2020[83]). Importantly, the type of governance tools required would change according to desired level of integration for the national power market. For instance, the initial findings of the CAREM project suggests that the establishment of regional power spot day-ahead market would require only minor changes to the organisation of national power markets but further market integration may need larger reforms (CAREM, 2020[84]).

Effective multilateral co-operation for better governance of water and energy requires a trust among Central Asian countries. Several publications underline that a major problem in the region is insufficient trust between riparian countries (Adelphi and CAREC, 2017[2]; IWA and ICUN, 2014[33]). However, few discuss the reason behind this problem. Adelphi and CAREC (2017[2]) suggest that this is linked to the non-implementation of existing and past agreements for water and energy sharing. Any future agreements should have clear incentives for compliance among all parties. Continuous monitoring and periodical assessments of the implementation of the regional agreements could also support such compliance mechanisms.

It is also unclear to what extent national planning and assessment of policies promote cross-sectoral stakeholder involvement. Ex-ante impact assessment of policies, regulations and projects can facilitate broad consultations among stakeholders (e.g. central and subnational governmental agencies, the business sector, civil society). Broad engagement with relevant stakeholders could be instrumental in ensuring a mainstreaming of a nexus approach. However, it remains unclear whether and how these assessments are routinely applied in Central Asian Countries. Several countries in the region did not ratify the UNECE Convention on Environmental Impact Assessment in a Transboundary Context. The ratification of the convention could have encouraged countries to conduct broad stakeholder engagement in policy planning and assessments (UNTC, 2021[85]).

4 Possible regional approaches and benefits of addressing the nexus

Central Asia has a long experience of co-operation on energy and water, and while examples of good practice exist today, opportunities remain to expand co-operation based on bilateral or regional benefits and shared priorities and vision. This section outlines examples of approaches to promote harmonised, cross-sectoral planning at the regional and national levels. Those approaches could help Central Asian countries foster regional co-operation based on long-term strategic planning, sustainable development and the region's response to the challenges posed by climate change.

Dissemination of good practices and lessons learnt from recent collaboration experiences in transboundary water resource management in Central Asia and beyond could help build a trust among countries in Central Asia. Despite the lack of trust being often singled-out as a barrier to co-operation among the countries, several successful examples of bilateral and multilateral co-operation exist in the region. (See also Box 3 and Box 4.). The development and dissemination of case studies and in depth reviews of the challenges and benefits of these experiences could help to build a shared knowledge base and address the issue of lack of trust often mentioned in the literature. Certain agreements, for example the 1998 Syr Darya agreement have attempted to provide the general framework for co-operation around the nexus, and while with mixed success, provide an opportunity for lessons to be learned.

Data sharing on water availability, quality and use is often considered a necessary building block to enhance multilateral co-operation. To strengthen data sharing, the countries could work towards the harmonisation of procedures to collect, manage and disseminate hydrometeorological data, and the creation of data exchange practises (IWA and ICUN, 2014[33]). The ultimate objective could be to establish and maintain a harmonised and up-to-date integrated basin-wide information system. Such a system should aim to give a basis to foster power and water trade in the region.

Box 3. Joint Construction of the Dostluk Dam by Turkmenistan and Iran

The governments of Iran and Turkmenistan built and jointly operate a multipurpose use reservoir “Dostluk” (‘Doosti’ or ‘Friendship’) along the Tejen (Herirud) River. The project aimed to improve available water supply for irrigated land in Iran (25,000 ha) and Turkmenistan (25,000 ha), provide drinking water for the Meshkhed city in Iran (150 Mm3/year), and prevent damages from floods. Although initially the project also provided for power generation, this part has not been developed.

The two parties have been equally involved in the construction of the dam. The construction was implemented by a joint Turkmen-Irani administration – “Dostlukhovdangurlushyk” comprised of a department at the Turkmen Ministry of Water Management, the Irani “Gulkhan” construction company, and private companies. Design and construction supervision were under responsibility of the “Turkmensuvylymtaslama” Institute of the Ministry of Water Management and the Irani “TOOSS AB” engineering-consulting firm.

Currently, the Dostluk structures are operated jointly by the countries, including implementation of all measures related to accumulation and drawdown of the reservoir, passage of flood flow, current and capital repair and expenditures for strengthening of the dam. Interestingly, if one of the Parties fails to cover a portion of its expenditures, the other Party may compensate these expenditures in exchange for use of water and energy by the other Party proportionally to the expenditures that incurred.

Source: Authors based on SIC - ICWC data, 2021 and (Naughton, DeSantis and Martoussevitch, 2017[71])

Box 4. Integrated Water Resources Management Implementation in the Fergana Valley

Water infrastructure in the Fergana Valley crosses multiple times the boundaries between Uzbekistan, Tajikistan and Kyrgyzstan, thus requires a transboundary co-operation. A project to support the adoption of Integrated Water Resources Management (or IWRM) in the Valley started with a focus on the command areas of the Aravan-Akbura canal in Kyrgyzstan, Khodja-Bakirgan Canal in Tajikistan, and South-Fergana Canal in Uzbekistan.

Under the project activities, the institutional set-up for water delivery management was revised to align with hydrographic boundaries. Cross-sector integration and demand management were strengthened as a result. Furthermore, various management tools and best practise were introduced, such as a management information system for main and secondary distribution canals, updating hydro-module zoning, daily planning of water distribution among users, and hydrometric services for water users. Considerable attention was paid to social mobilisation and capacity development.

The project brought several benefits, including reduced water consumption per hectare, high uniformity and stability of the water supply, and reduction in water withdrawals from rivers (e.g. the total water withdrawal for the South Fergana canal in Uzbekistan decreased by 200 mln m^3). In addition to reduction of the total water intake for all needs, the total volume of agricultural production and the related industries was significantly increased leading to improvements in financial sustainability for farmers and WUAs

Source: SIC - ICWC data, 2021

A number of projects could be envisaged as a "proof of concept" of the nexus approach. For instance, while some upstream countries face important challenges in meeting winter power demand and are considering expanding hydropower generation, data on power losses in the countries suggest that part of the unmet power demand could be satisfied without increasing capacity and affecting water allocation for irrigation. Indeed, power losses amounted to around a quarter of power generated in Kyrgyzstan and Tajikistan in recent years. A project addressing power losses and assessing its benefits in terms of lower water and energy consumption may be an interesting starting point. Information on the demonstrated benefits could in turn inform discussion among upstream and downstream countries on how to share costs of and benefits from the regional nexus approaches among them.

Box 5. Co-operation in Chu-Talas basin between Kyrgyzstan and Kazakhstan with co-financing by Kazakhstan

Kazakhstan and Kyrgyzstan share the transboundary rivers Chu and Talas, whose water is used for irrigation in both countries and offers opportunities for the generation of hydropower. All facilities to regulate the rivers, such as canals, dams, and water reservoirs are located in Kyrgyzstan. As such, Kazakhstan depends on the operation and proper maintenance of these facilities.

Kazakhstan and Kyrgyzstan have a decade long history of co-operation in these basins. In January 2000, they signed an agreement on sharing the operation and maintenance costs of the facilities which would be shared on a pro rata basis according to the water volume received. In 2006, the Chu-Talas Commission was established to focus on (a) approval of water resources allocation (b) determination of measures to maintain water facilities; and (c) approval of a financing plan for the above measures. In 2008-2011, the OCSE – UNECE project "Developing co-operation on the Chu and Talas Rivers" (Chu-Talas II) focused on enhancing understanding on water resources, improving access to information, and involving new stakeholders in the river management process. More recently, the "Enhancing climate resilience and adaptive capacity in the transboundary Chu-Talas basin (2015-2018)" project focused on climate change adaptation in the basin. The project considers that glaciers in the basin may be fully exhausted by 2100. This project led to identification of pilot adaptation projects, such as restoration of floodplain forest and training courses on water efficiency measures for irrigation, that were implemented in partnership with local NGOs, such as Kyrgyz Association of Forest and Land users and Ecological Movement "BIOM".

Source: (UNECE, 2021[86])

Promoting intra-regional trade of resources would also help manage the energy-water-land use nexus and foster economic development. Overall, the solution to nexus regional issues in Central Asia entails a better intra-regional distribution of resources that are scarce in certain countries and abundant in others. As such, more integrated and sustainable regional trade can help to ensure that these resources are more efficiently allocated. It should also be noted that economic co-operation can decrease the risk of political instability, thus increasing the attractiveness of the region to foreign investors (Libert, 2018[87]). The International Transport Forum (ITF) (ITF, 2019[88]) notes intra-regional trade accounts only for around 5% of total trade of Central Asian governments (here defined as Kazakhstan, Kyrgyzstan, Mongolia, Tajikistan and Uzbekistan) due to a number of barriers, including limited harmonisation of rules and standards, different formal procedures for entering and crossing each country, and substantial border-crossing time.

Lowering barriers to trading in agri-food products could promote a resource efficient production, specialisation and exchange within the region, if inputs such as water and electricity are correctly priced. Increased production and trade of crops in places where there are comparative advantage may lead to water savings, as highlighted in a meeting of the UN Special Programme for the Economies of Central Asia (SPECA). Countries in the region can consider minimising production of irrigated crops that may be produced on rain fed land (Libert, 2018[87]). At the same time, the efficiency benefits of food trade would need to be evaluated in the light of countries concerns over food self-sufficiency. Importantly, the development of a regional market of agricultural products may positively influence economic growth (UNECE, 2017[73]) and contribute to modernising this sector (UNECE, n.d. in (JRC, 2018[40])). For instance, Cantos et al. (2005 in (ITF, 2019[88])) showed that the agriculture sector has the higher elasticity to road infrastructure (0.124), followed by industry (0.067) and services (0.013).

A number of technical barriers need to be addressed to accelerate regional agri-food trade. They include lack of adequate facilities and inter-agency co-ordination at border control, weak standard-setting and enforcement procedures (e.g. quality control, food safety and quality assurance), weak national laboratory testing and conformity assessment capacity in several Central Asian countries (UNECE, 2017[73]). In addition, while expenditure on road and rail is now in line with international standards at 1% of GDP, local and regional roads are in poor condition. Ensuring the connectivity of local business to key transport corridors would be crucial to spread their benefits to rural areas (ITF, 2019[88]). Further, some countries in the region have or are developing long-term strategies for the agro-industry (e.g. The Kazak "Concept of the national project for the development of the agro-industrial complex for 2022-2026"[12]). It may be useful to evaluate to what extent these strategies are complementary and build on the competitive advantage of each country.

Re-enabling power trade is likely to be highly beneficial given the asymmetry of energy mixes in Central Asia*.* On the one hand, fossil fuel rich countries face the challenge of reducing emissions of GHGs and air pollutants. On the other hand, hydropower rich countries face the challenge of ensuring sufficient power generation to meet the winter peak demand. The creation of an integrated power market would help to address some of the challenges by trading electricity. It could also promote non-hydro renewables, since an interconnected grid allows easier balancing of electricity deficits and surpluses, which can mitigate challenges associated with relatively intermittent production of renewable energy (UNECE, 2017[73]). For instance, the winter wind power resources in Kyrgyzstan and Tajikistan, whose potential is considerable, could help reduce hydropower use in the countries and alleviate the risks of water deficit for irrigation in summer months (Libert, 2018[87]). Furthermore, developing connections to sell electricity could make the summer discharge operations more attractive for upstream countries and benefit the irrigation demands of downstream states (UNECE, 2017[73]).

Several on-going projects to rehabilitate inter-connectors across countries are an important step forward to re-establishing power trade. An appropriate governance aligned to the desired level of power system integration however needs to be determined and put in place. The IEA has recently reviewed international experience with cross-border integration, and identifies three critical areas of collaboration for effective integration: system operations, long-term planning, and regional institutions (IEA, 2021[89]) (See Box 6). In this context, the recently launched ADB project on "Fostering Expanded Regional Electricity and Gas Interconnection and Trade under the CAREC Energy Strategy 2030" is particularly relevant (ADB, 2020[90]). The Central Asia Regional Electricity Market Project (CAREM), which aims to provide technical assistance and capacity building for the creation of sustainable Regional Electricity Market, has recently been working on the market design for a possible Central Asia Regional Electricity Market (USAID, 2021[91]).

[12] https://legalacts.egov.kz/npa/view?id=8566310 in Russian

Box 6. Challenges and benefits of power system integration

The integration of power system across boundaries is usually motivated by economic, security and environmental benefits. From an economic perspective, connecting power systems allows to develop economies of scale on both the supply and demand sides, thus lower investment and operating costs of the power systems in question. Interconnection also allows to diversify power sources, thus increasing the reliability of supply (and demand). Finally, larger power systems are able to integrate higher shares of variable renewables since larger geographic areas can naturally balance variation in availability of renewable power sources (e.g. sun shines with different intensity across large regions), thus increasing the sustainability of the system.

A key challenge is how to share investment and operational costs (e.g. cross-border transmission infrastructure). In addition, mechanisms to evaluate and coordinate the evolution of domestic policies may be needed since these may have cross-border implications (e.g. decision to increase sensibly the share of variable energy sources). Furthermore, while power systems integration is possible without sacrificing national autonomy, some balance between national and regional priorities is needed to achieve the full benefits of integration.

Source: (IEA, 2021[89])

Box 7. Studies on benefits of increased cross power trading in the region

Mercados (2010[47]) estimated that the joint operation of CAPS networks would result in USD 1.6 billion saving in the first three years of operation (2010-2012) due to optimal dispatch and more efficient operation of power plant.

Mercados 2016 focuses on power trade benefits from (i) fuel savings only at historic energy prices, (ii) both fuel savings and economic value of avoiding unserved energy at historic fuel prices, and (iii) fuel savings and the economic value of avoiding unserved energy at “market” fuel prices. The benefits of fuel savings for the 2010-2014 period are estimated at USD 1.5 billion. Overall benefits range would range between USD 5.2 and USD 6.4 billion when benefits from avoiding unserved power demand are included (Mercados, 2016 in (World Bank, 2016[67])).

More recently, the World Bank has estimated that Central Asia countries can reduce operating expenses by as much as USD 6.4 billion in the next 10 years (World Bank, 2020[83])

Investment in the modernisation of the transboundary and national water infrastructure needs to continue and scale up. Investing in the modernisation of both national and transboundary water infrastructure can decrease water losses that are around 40% on average in the region. Reducing these losses could significantly contribute to the sustainable use of water resources across the nexus, when an appropriate cap on water abstraction is put in place. A larger deployment of supervisory control and data acquisition (SCADA) and other technical applications to improve water provision could improve precision of water supply from 10% to 2% (UNECE, 2017[73]) (see also Box 8). Additional efforts may be directed to increasing water supply through the use of desalination plants and adoption of rainwater tanks to complement the national infrastructure but their environmental implications need to be carefully evaluated (see Box 9)

Box 8. Automation of Water Distribution Systems in the Syr Darya Basin

Supervisory control and data acquisition (or SCADA) systems for automated control and monitoring have been deployed in the Syr Darya Basin in a number of regions, such as Uchkurgan hydro scheme (with SDC support, 2001-2002), Kuyganiar hydroscheme (with SDC support, 2004), Upper Chirchik hydro scheme (with USAID support, 2003), Naryn-Karadarya hydro scheme. As a result, the accuracy of flow regulation and maintenance increased and measurement errors decreased from 5-10% to 2-3%.

A larger application of SCADA system, or other compatible systems, in the Syr Darya basin including its small and medium reaches would increase transparency of water distribution, eliminate flow discrepancies in national data that results in errors in measuring transboundary rivers water balance and, consequently, increase trust between the riparian countries. There remain however some challenges in the upscaling of automated monitoring systems, including how to determine the location of measurement devices to be installed.

Source: SIC - ICWC data, 2021

Box 9. Adopting the energy-water-land use nexus approach can highlight hidden negative impacts of policy choices: Synergies between water desalination plants and renewables in Mauritius

As an example from the outside of Central Asia, a nexus assessment conducted in Mauritius provides some valuable lessons. The sugar business has been an important contributor to the economy of Mauritius and a key source of export and foreign exchange earnings. When the exports lost preferential access to the EU market, the government wanted to investigate whether to promote the development local biofuel industry. The expected benefits of biofuel included higher energy independence due to lower reliance on oil imports and reduction of GHG emissions.

A nexus based impact assessment allowed to highlight some of the potential pitfalls of such policy. More precisely, the islands were increasing the use of irrigation to compensate water shortages due to lower rainfall. This water was from desalination plants with a high-embedded energy and this higher demand could have led to increased water demand for thermal power plants cooling and thus additional water withdrawals. Furthermore, if the increase in electricity demand had been met with coal-fired power generation, then the GHG benefits of the policy would also been eroded.

The assessment concluded that wind and solar plants would have provided several benefits. First, they are typically less water-intensive than fossil fuel generation. Secondly, water desalination facilities may be treated as an interruptible load and be shut down when wind and solar power generation is not available, thus facilitating the integration of renewables in the grid.

Source: (UN DESA, 2014[72]; Howells et al., 2013[92])

Larger adoption of non-hydropower renewables and energy efficiency technologies can reduce pressures on a number of dimensions of water, energy and land resource management. For instance, solar and wind power can help to reduce pressure on water supply as water needs of solar and wind power plants during power generation are significantly lower than conventional thermoelectric generation. Furthermore, as highlighted by the experience in some OECD countries, renewables and energy efficiency investment could be used to reduce cash-constrained water utilities' energy expenditures that often account for the largest share of a water utility's operating budget (Atkinson, n.d.; ESMAP, 2012 in (IRENA, 2015[93]). (IEA, 2016[18])). For instance, some utilities are leveraging solar technologies to meet the electricity demand of water pumping in some location. Bioenergy feedstock may also help to better balance the domestic energy mix, while at the same time their unintended consequences on water and land use need to be carefully evaluated (IRENA, 2015[93]) .

The deployment of off-grid and small-scale renewable energy solution can increase energy and water access especially in remote areas. Examples include renewable energy-based pumping and water treatment technologies) (UNECE, 2020[94]). Importantly, possible risks for continuity of supply (e.g. limited distribution networks for spare parts for early adopters) need to be carefully evaluated. The continuing decreasing costs of solar and wind panels would facilitate the adoption of such technologies. In the last decade, costs have declined by 82% for PV and by 40% for concentrating solar power (CSP) and onshore wind. The IRENA (2020[95]) finds that more than half of the renewable capacity added in 2019 achieved lower electricity costs than new coal, and that cost reduction trends should accelerate thanks to a wider adoption of auctions for power capacity installation across the globe (IRENA, 2020[95]). In this context, it should be noted that UNECE modelling finds that larger uptake of non-hydro renewable energy technologies in the Syr Darya Basin would allow lowering hydropower contribution to national energy mix by 25% by 2030 compared to business as usual scenario, thus decreasing the need for additional hydropower capacity (UNECE, 2017[73]).

5 Conclusions and next steps

This section summarises key findings from the analysis provided in this document. Based on the findings, it proposes policy recommendations that the governments in Central Asia and their stakeholders could consider when they design, develop and implement energy, water and land use projects and move towards the nexus approach.

Key findings

Energy, water and land management have been key factors of interstate relations in the region since independence in the early 1990s. The unbalanced endowments of energy, water, and land resources generates strong interdependences, tensions and divergent interests between the upstream and downstream countries in Central Asia. The consequences of both climate change and climate change mitigation and adaptation policies have potential to heighten tensions within the region in the future. Higher temperature, which may increase between 1° and 3°C by 2030-50, will affect water availability and demand, agricultural productivity, and power demand and production systems.

Kazakhstan, Turkmenistan and Uzbekistan have access to domestic fossil fuel resources and are richer in agricultural land per capita, but are highly dependent on transboundary water from Kyrgyzstan and Tajikistan. The high degree of heterogeneity among the countries in terms of water, energy and land resources necessitates strengthened mechanisms to share resources to mutual benefits and to increase both national and regional security.

At the same time, these countries face a number of common challenges. National economies are typically not diversified and therefore vulnerable to external shocks. In addition, high energy and water losses characterise distribution networks across the region. Low water efficiency and poor access to sanitation (especially in rural areas) are additional shared challenges.

A diverse set of barriers to sustainable management of water, energy and land resources exist in Central Asia. Examples include, fragmented responsibilities within the governments for managing those resources, incoherent national strategies, lack of reliable and accessible data, outdated infrastructure and regulatory systems, including technical regulations and tariff systems. Compounded by pressures from future population growth, side effects of economic diversification and water withdrawals by neighbouring countries, these barriers will limit the pursuit of long-term national and regional water, energy and food security. Enhanced regional co-operation among Central Asian countries is required to address these challenges in the face of climate change. For a country in the region, neighbouring countries can provide solutions for its domestic problems through the energy-water-land use nexus approaches.

The nexus approach can help to address these challenges while promoting both national and regional security. The adoption of a nexus approach can help to increase alignment across energy, water and land policies both at the regional and national levels. This would have two main benefits. First, the nexus approach could help countries reduce risks of unintended negative consequences of policies addressing one dimension of the nexus (e.g. energy) on the other two dimensions (e.g. water and land). Secondly, it can facilitate negotiations between states to ensure appropriate sharing of benefits from any bilateral or regional agreements around the three nexus dimensions. Robust analysis of economic, social and political implications of nexus focussed interventions is crucial for identifying opportunities and realising these benefits.

Further evidence is needed especially on the economic and financial benefits of regional co-operation, which could inform the development of financial mechanisms and instruments to support the nexus implementation. Available studies highlight the large economic benefits of co-operation along one specific nexus dimensions (e.g. energy or water) while only few scientific papers model simultaneous co-operation along the three nexus dimensions in the region. A stronger and more comprehensive evidence on the economic and financial benefits of the nexus approach is needed to make the “business case” for stronger co-operation at the inter-sectoral or inter-state level.

The initial evidence collected on nexus challenges and opportunities was discussed at Regional Expert Workshop: “Benefits of regional cooperation on the energy-water-land nexus transformation in Central Asia” in June 2021. The discussion held suggested that policy reforms could usefully target a number of enablers of regional co-operation. Capacity building for data collection and sharing, including long-term climate data, emerge as key building blocks to manage the nexus at both the national and regional level. Methodologies to collect such data and information should also be jointly developed and agreed upon among relevant stakeholders. Clear and flexible legal and economic frameworks should also be developed by building on lessons learned from previous efforts to establish water-energy exchange mechanisms in the region. In addition, there has been increasing interest in adopting technologies and business models that can contribute to climate and environmental objectives in the countries. A greater uptake of such technologies and business models can help to reduce the barriers to regional co-operation by unlocking efficiency gains that can ease pressure on available resources.

Policy recommendations

Develop and communicate evidence that supports the “business case” for adopting nexus approaches

A lack of co-operation on water, energy and food security is leading to economic and environmental inefficiencies. More evidence on the “business case” for co-operation at the inter-sectoral or inter-state level must be generated and supported by economic and financial analysis. It is also important to make targeted efforts to communicate the evidence to policy makers and private-sector entities so as to ensure that the developed evidence is actually used in policy processes and businesses. Both development and communication of evidence on the business case for co-operation on the nexus would provide a basis for further enhancing political support, practical mechanisms and frameworks, and the enabling environment for collaboration.

Analyse national and regional priorities and develop coherent policy frameworks to optimise current and future resource management and security

Resources in Central Asia are considered sufficient to meet the current demand of the region. However resource distribution is imbalanced spatially and temporally, which creates challenges to achieving resource security in the region. Co-operation, coordination and coherent policy making and planning are key to meeting these challenges. The region faces dynamic challenges and resource imbalances and the pressures of today will not be the same pressures tomorrow. This includes pressures from climate change, population growth, economic diversification and changing water demand from neighbouring countries outside of the region.

Promote inter-sectoral and cross-regional approaches for sustainable water, energy and land resource management to facilitate economic co-operation, benefits sharing and incentive frameworks

Co-operation at the inter-sectoral and regional levels is on-going but should be increased. Main barriers to co-operation include insufficient managerial or political support, lack of economic and financial support mechanisms, insufficient data and information and challenges from complex or fragmented institutional arrangements. Opportunities for increasing economic co-operation and sharing of benefits and creating incentive frameworks for co-operation on these matters must be explored.

Foster exchange of region's past experience of co-operation on energy, water and land-use issues, learn lessons, and reflect the challenges of today in the improvement of the current regional and national policy frameworks

Opportunities exist for embedding the nexus approach into national, regional and transboundary policies. These opportunities include improved planning processes, development of flexible legal frameworks and economic mechanisms including compensation schemes and taking stock of lessons learned from previous efforts to establish water-energy exchange frameworks. Lessons can be learned from the development and implementation of previous regional agreements with a focus on the need for co-operation to fulfil international obligations.

Promote regional capacity building to share development of energy, water and land-use security priorities and support the benefits of adoption and implementation of the nexus approach

Further investments in basic enablers for implementation of the nexus approaches remains critical. These enablers include enhanced capacity both at the institutional and individual levels to collect and share weather and climate data and information, including long-term climate forecast. It is also important to put a clear institutional arrangement in place within relevant government bodies to conduct risk assessments on climate, energy, water and land use related issues informed by best available data and information. The need to inform and empower local actors also highlights the importance of ensuring that education systems provide the right skills to developing workforce in the region. The scope of enhanced capacity development mechanisms and education systems would include, for instance, water allocation, financial compensation and conflict settlement, building on expertise and practice that currently exist. They are related to previous challenges with adherence to regional agreements on water-energy exchange, and Integrated Water Resources Management principles.

Enhance the use of investment decision support tools that explicitly consider benefits and trade-offs of the nexus approach

Opportunities exist to enhance the adoption of "green economy" approaches; this could include a larger adoption of water efficient technologies that would be essential to optimise regional water resources in the context of increased pressure and climate change. National investment programmes are often characterised by a multi-sectoral approach. Governments should also ensure that the broader policy framework is conducive to investments in green technologies in support of sustainable use of water, energy and land.

"Operationalisation" of the nexus through the use of relevant economic and financial evidence, weather and climate data and information, and decision support tools should aim to help Central Asian governments and the private sector make decisions that are aligned with the countries' objectives on sustainable development. This approach would also help the countries realise the synergetic effects of coherent planning to achieve long-term energy, water and food security for the citizens of Central Asia.

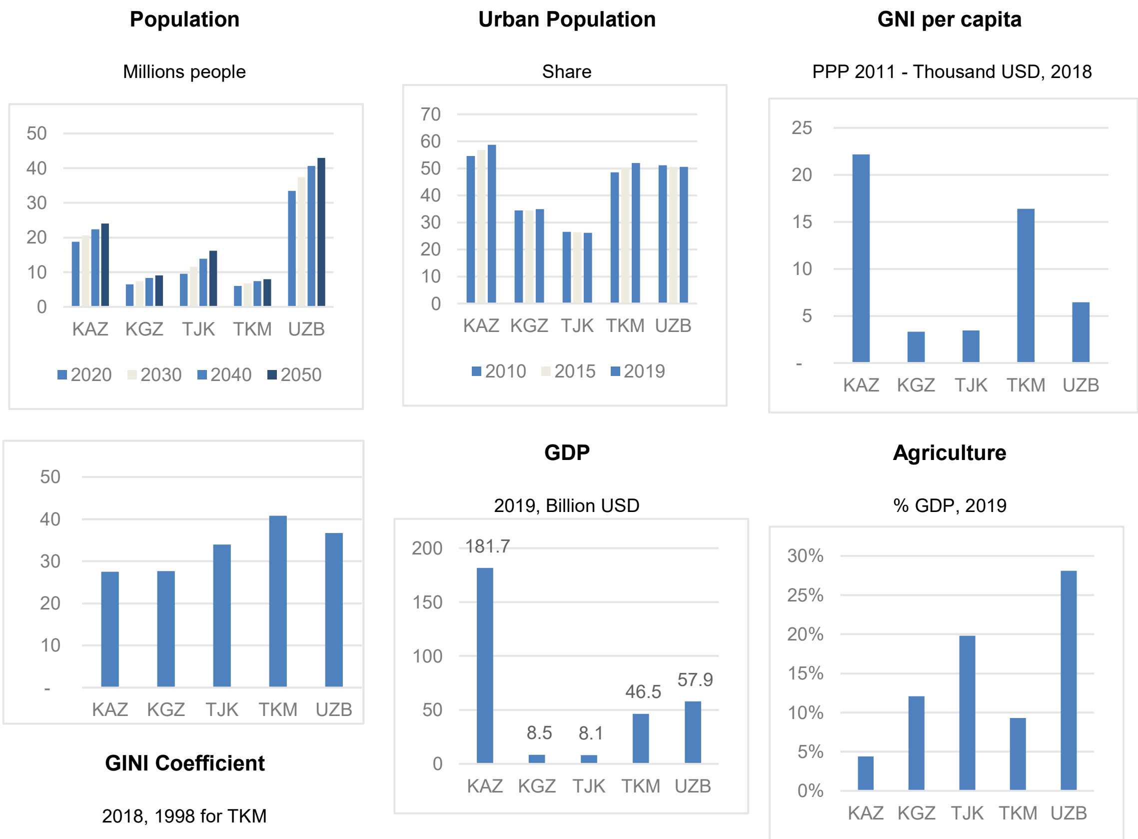
Annex 1. Cross country comparisons and Country Studies

Indicators towards the monitoring of energy, water and food security in Central Asia

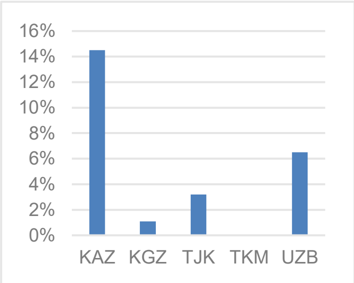
This chapter outlines different kinds of data to illustrate the large heterogeneity of Central Asian countries and their complementarity in terms of energy, land and water resources. As shown in Figure 10, Kazakhstan, Turkmenistan and Uzbekistan, are economically stronger than Kyrgyzstan and Tajikistan in terms of both size of economies and income per capita. All the five countries expect a continued population growth over the next decades.

Fossil fuel resources have significantly contributed to the economies of Kazakhstan, Turkmenistan and to a lesser extent Uzbekistan. This wealth of fossil resources however creates also challenges: the mining and quarrying sector accounts for a large share of national GDP for them, thus exposing these undiversified economies to the risk posed by fluctuation in global fuel demand and global efforts for achieving the climate change mitigation goals under the Paris Agreement.

Figure 10. Macroeconomic indicators

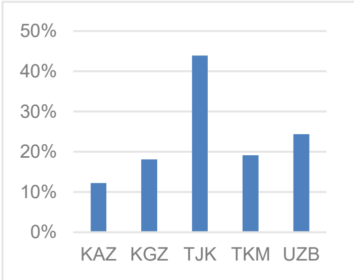


Mining & quarrying



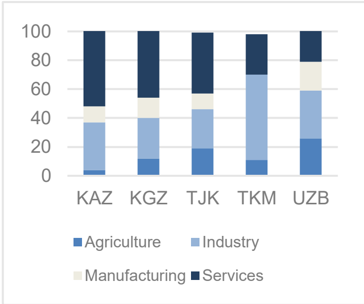
% GDP, 2019

Employment in agriculture



% active pop, 2019

Sectors, value added (% of GDP)

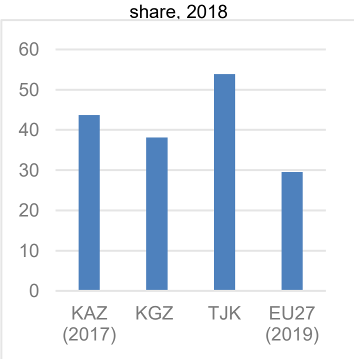


2019, 2010 for TKM

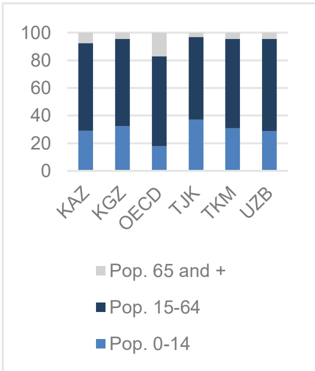
Source: GNI per capita and GINI Coefficient – hdr.undp.org. Sector value added to GDP – World Bank data. All other data from National Statistic Offices as provided by SIC-ICWC.

Female employment. agric.

share, 2018



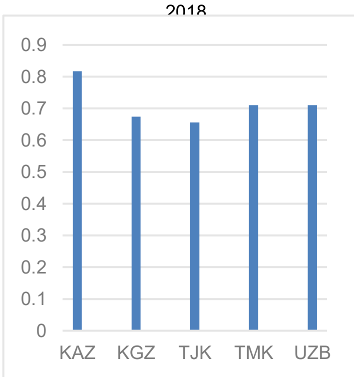
Pop. age distribution



share, 2019

Human Devel. Index (HDI)

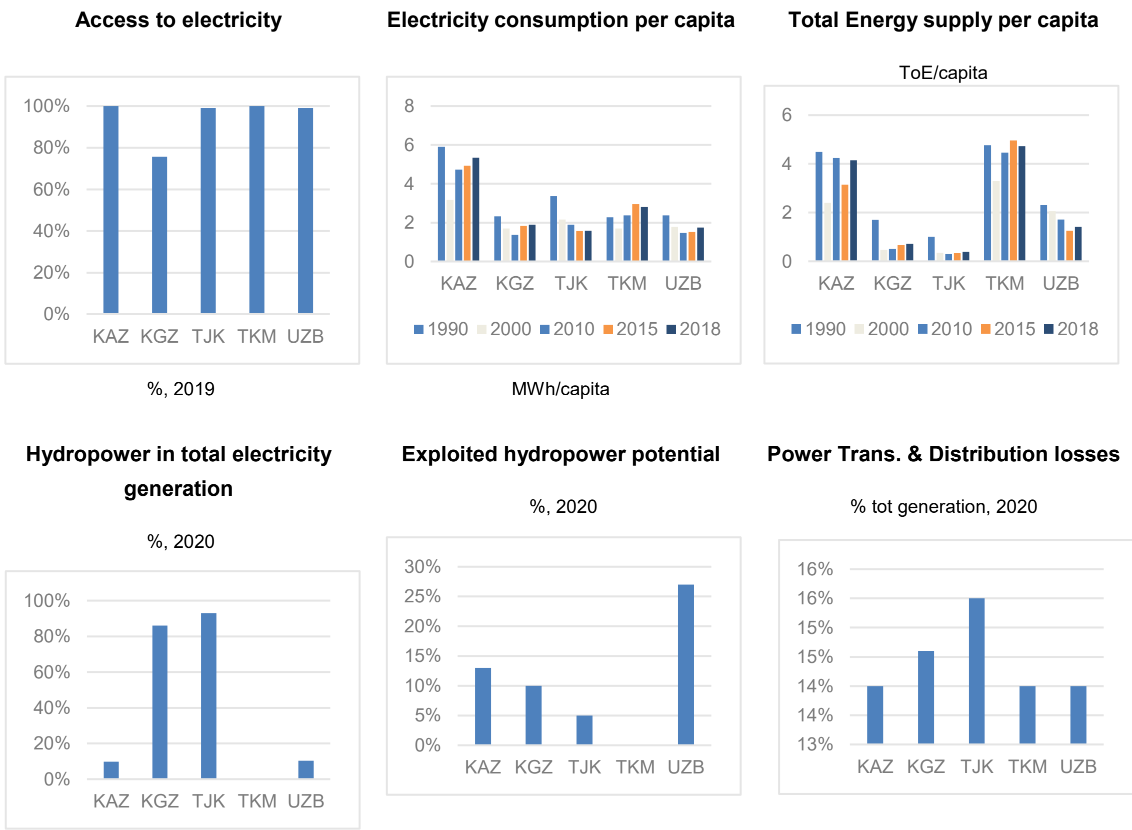
2018



Source: Population age – World Bank data. Female employment in Agriculture – FAO data. HDI - hdr.undp.org

Energy related indicators in Figure 11 show that electricity consumption has increased significantly over the past decade in all Central Asian countries, while relatively good levels of electricity access have been observed except in Kyrgyzstan. Hydropower is playing a particularly important role in electricity generation in Kyrgyzstan and Tajikistan, while there is considerable potential of further exploitation of hydropower energy across the region. On the other hand, energy losses in distribution networks are high in Central Asian countries, ranging from 13% to 16%. Power trade in the region varied considerably across the years but was never entirely interrupted. The existing infrastructure can be the platform for a more integrated power market.

Figure 11. Energy indicators



Note: * Sector & of GDP: missing data for TKM on Mining & quarrying.
Source: SIC ICWC data (2021).

Export and import of electricity between the countries of the region

mln.kW*h

	Year 1995	Central Asia Power Systems – Import						
		Kazakhstan	**Kyrgyzstan**	**Tajikistan**	**Turkmenistan**	**Uzbekistan**	**Afghanistan**	**Sum:**
Export	**Kazakhstan**					7,2		**7,2**
Export	**Kyrgyzstan**	786,6		69,1		928,7		**1784,4**
Export	**Tajikistan**	309,4			31,8	296,1		**637,3**
Export	**Turkmenistan**	1682,3		101,3				**1783,6**
Export	**Uzbekistan**	432,2	412,5	1128,6	315,7			**2289,0**
	Sum:	**3210,5**	**412,5**	**1299**	**347,5**	**1232**	**0**	**6501,5**

1995

Export and import of electricity between the countries of the region.

mln.kW*h

	Year 2005	Central Asia Power Systems – Import						
		Kazakhstan	**Kyrgyzstan**	**Tajikistan**	**Turkmanistan**	**Uzbekistan**	**Afghanistan**	**Sum:**
Export	**Kazakhstan**							**0,0**
	Kyrgyzstan	2668,1		230,1				**2898,2**
	Tajikistan	68,5	3,5			683,5		**755,5**
	Turkmanistan							**0,0**
	Uzbekistan			814,9	0,4			**815,3**
	Sum:	**2736,6**	**3,5**	**1045**	**0,4**	**683,5**	**0**	**4469,0**

2005

Export and import of electricity between the countries of the region

mln.kW*h

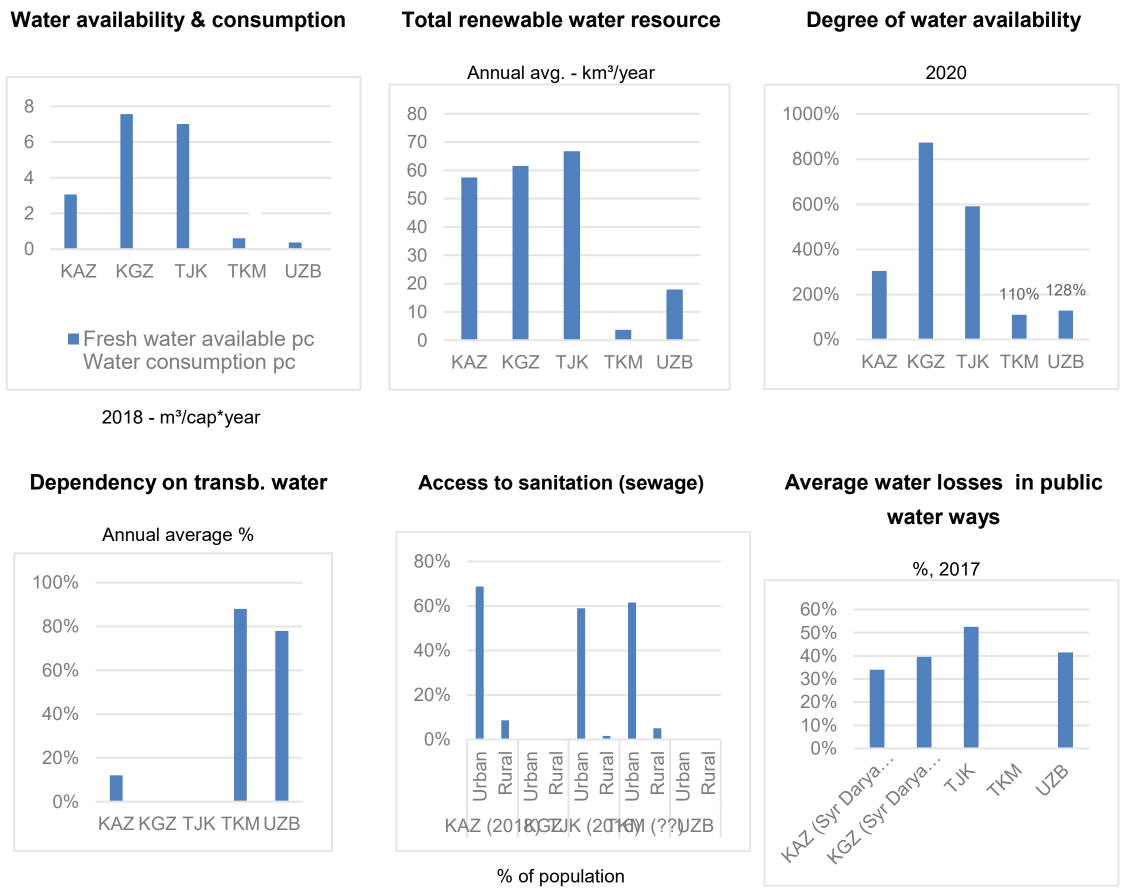
	Year 2019	Central Asia Power Systems – Import						
		Kazakhstan	**Kyrgyzstan**	**Tajikistan**	**Turkmanistan**	**Uzbekistan**	**Afghanistan**	**Sum:**
Export	**Kazakhstan**		273	13,4		966,6		**1253,0**
	Kyrgyzstan	277,2		35,4		4,3		**316,9**
	Tajikistan	13,4	27,1			1425,1		**1465,6**
	Turkmanistan					1115		**1115,0**
	Uzbekistan		4,1				2023	**2027,1**
	Sum:	**290,6**	**304,2**	**48,8**	**0,0**	**3511**	**2023**	**6177,6**

2019

Note: The tables above show the relationship and changes between import and export of electricity within Central Asia in 1995, 2005 and 2019.
Source: Provided by SIC-ICWC (2021)

Water related indicators in Figure 12 also illustrate that Kazakhstan, Turkmenistan and Uzbekistan as downstream countries have much lower degrees of water availability than upstream countries (Kyrgyzstan and Tajikistan). Water supply-demand gaps are particularly severe in Turkmenistan and Uzbekistan. They are dependent upon transboundary water from these two upstream countries to meet their water demand. Furthermore, significant water losses in transmission of water (e.g. irrigation canals) put significant stress on water supplies. Rural areas in the region markedly lag behind urban areas in ensuring access to water sanitation facilities. Degrees of access to water supply also markedly vary, from nearly 100% in urban areas of Kazakhstan, 60% in Tajikistan, Turkmenistan, Uzbekistan and rural areas of Kazakhstan, to about 40% in Kyrgyzstan.

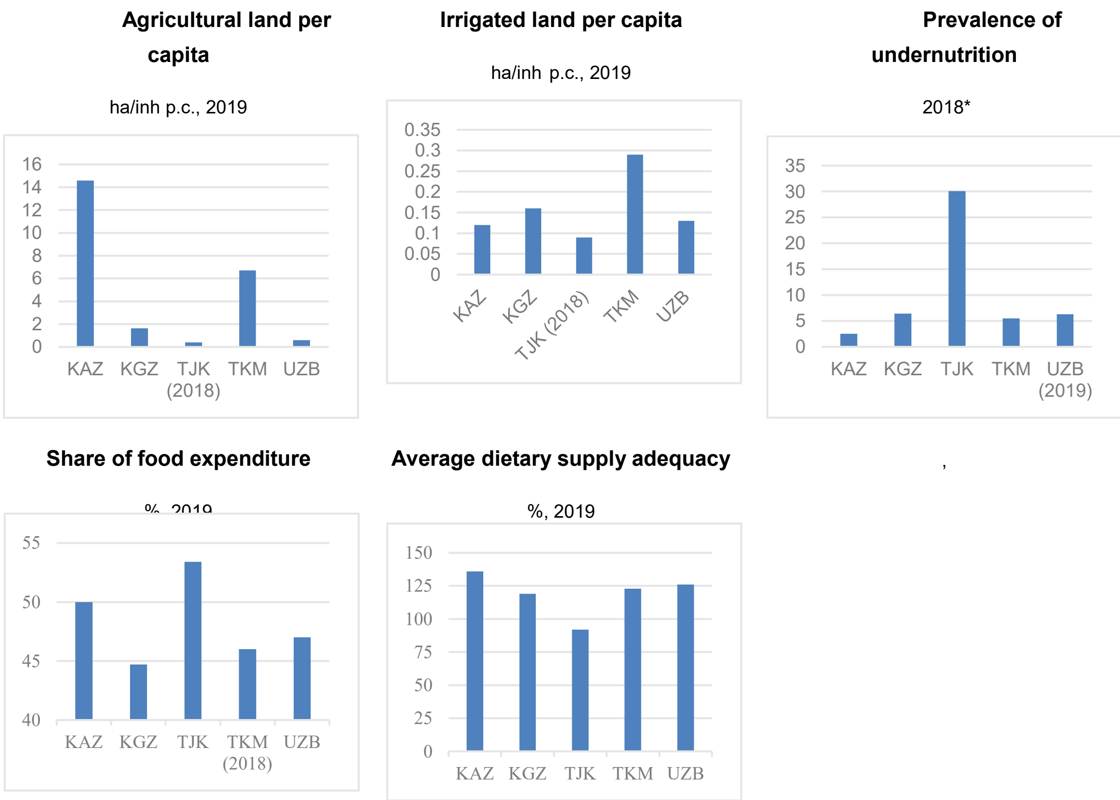
Figure 12. Water indicators



Note: Dependency on transboundary water is computed as the difference between "Actual water withdrawal" "Internal surface water" over by "Actual water withdrawal"
Source: IBNET for ratio of utilities revenues and costs (accessed May 2021), SIC-ICWC data for other indicators (2021)

Land related indicators in Figure 13 show varying levels of land availability especially for agriculture and situations on food security in Central Asia. Some downstream countries like Kazakhstan and Turkmenistan have significantly higher agricultural land per capita, while Turkmenistan also has the highest level of irrigated land per capita. As discussed above, these countries are also dependant on transboundary water resources from the upstream countries. Addressing food insecurity is an imminent need for many Central Asian countries, particularly Tajikistan. The country sees a high prevalence of undernutrition, share of food expenditure and inadequacy in average dietary supply.

Figure 13. Land and food indicators



Note: * Expresses the probability that a randomly selected individual from the population consumes an amount of calories that is insufficient to cover their energy requirement for an active and healthy life (FAO). ..
Source: SIC-ICWC (2021)

Kazakhstan

Key messages

As the largest country by area in Central Asia, Kazakhstan is characterised by regional disparities in terms of resource availability. The country has significant fossil fuel deposits and renewable energy potential13, yet some western regions are not connected to the national power grid. Food security is high but the quality of agricultural land is deteriorating. The central and southern regions (except for mountainous areas) are arid zones. The central and northern regions experience regular flooding. Since seven out of the eight river basins are transboundary (44% of total water is formed outside the republican boundaries), domestic water security can be guaranteed only by a sustainable nexus management at the regional level and in partnership with neighbouring countries.

Key data and information

The economy contracted by 2.8 per cent due to lower commodity prices, a cut in oil production, and Covid-19 containment measures in 2020[14] (EBRD, 2020[96]). Between 2017 and 2019, the annual GDP growth rates were consistently high (around 4.1 to 4.5 %). The National Development Plan was adopted based on the previous Strategic Development Plan 2025 with adjustment needed to reflect COVID-19 challenges and opportunities.

Upgrading the power network and improving tariffs design will be instrumental to meet the ambitious renewable energy and climate targets. Kazakhstan has pledged to reach carbon neutrality by 2060, suggesting key milestones such as need to phase out coal, increase gasification as a transit technology and rapidly increase renewable energy and energy efficiency. Just transition issues are very important for maing such a transformative change happen.The country, which has significant fossil and renewable energy resources, plans to have energy sources alternative to coal and oil that should account for not less than 50% of the power mix by 2050 and to reduce greenhouse gas emissions by 15% by 2030[15]. The percentage of electricity produced from renewable energy in total production, including large hydropower plants, was 10.4% in 2019 (Bureau of National Statistics, 2020 and SIC - ICWC Inputs, 2021), and total installed capacity of renewables amounted to 1,050.1 MW (283,8 MW of wind, 541.7 MW of solar, 222.2 MW of small hydropower plants and 2.42 MW of bioenergy power plants).

However, a number of challenges need to be addressed to achieve the ambitious targets on renewable energy development. First, the power grid is fragmented liming the ability to integrate more variable energy sources. For instance, parts of the power system in the western regions are not connected to the national grid, like the Uralsk power plant that is connected with Russian Federation's power grid. Furthermore, low energy tariffs undermine the financial stability of the sector. Currently, households pay nearly six times less for electricity than the EU-28 average (EBRD, 2020[96]). The country is reported to be introducing pilot reforms to bring tariffs to cost recovery level for heating and water, and considering to abolish cross-subsidisation (EBRD, 2020[96]).

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[13] Kazakhstan has significant reserves of coal, oil, gas and uranium and huge renewable energy resources. The cumulative RES potential for power generation is 1,885 billion kWh. The total installed generating capacity of power stations is 22 936 MW. The power consumption per capita is 5 797 kWh (2020).

[14] Year-on-year in the first three quarters of 2020.

[15] Targets set by the 2013 "Concept of transition to green economy in the Republic of Kazakhstan", as reported in SIC inputs, 2021.

Land degradation is posing a serious threat to the agricultural sector. The agricultural sector, which employs 18 % of the working age population and contributes to 4.5% of GDP (IMF, 2020[97]). The sector is considered as a potential key driver of economic diversification, as highlighted in National project for the development of the agro-industrial complex of the Republic of Kazakhstan for 2021 – 2025 (Government of Kazakhstan, 2021[98]). This is due to the large arable land availability (second highest per capita in the world) and the country proximity to two large markets (China and Russia). However, salinisation, water-logging, deterioration of irrigation and drainage systems are decreasing available irrigated land. In 2018, the irrigated land was 25% smaller than 1991 level (2 091.9 thousand ha were irrigated in 1991 as opposed to 1 420 thousand ha in 2018). In this context, the current Plan of Irrigation Development sets the target of almost doubling the quantity of irrigated land by reclaiming 600 thousand ha of withdrawn land and developing new 1.5 million ha by 2028. The costs of such investments are large and amount to 117.8 billion tenge (or USD 275 million) for the reclamation of 256 thousand ha, and at 1 126.9 billion tenge (or USD 2 600 million) for the irrigation of 1.67 million ha.

The key barriers to modernisation of the agriculture sector include infrastructure gaps, poor access to technology and financing. Further to the need for general structural reforms to agricultural lands, some local experts mention that the merging of small agricultural producers may help to increase crop rotation on cultivated land and ease the adoption of advanced technology. Such aggregation can lead to higher profitability and financial sustainability. However, it should be noted that the structure of farms varies across regions with smaller farms in the south and larger but heavily indebted farms in north Kazakhstan (IMF, 2020[97]).

Water supply is high on average but some areas suffer from water scarcity while others regularly affected by flooding. Examples include the Western Kazakhstan province along the Small and Big Uzen' rivers, and Palassovskaya irrigation system along the Saratov canal. Furthermore, population growth coupled with pollution including from wastewater discharges, industrial activity such as oil and gas and mining in the north and east of the country and upstream drainage water discharges are creating an increasing pressure on water resources. In addition, floods are common in certain areas. The inefficient runoff regulation (given the lack of accurate water forecasts and limited coordination) in the Tobyl and Syr Darya basins poses a threat of flooding cities and villages. Similarly, annual flooding in the Yertis floodplain poses a severe problem. Water related natural hazards have already caused significant economic losses. According to the Kazakh Ministry of Emergencies, over the period from 2007 to 2012, 260 cases of spring floods were recorded. Over 14 500 buildings and structures were flooded or damaged and about 36 000 people were impacted.

Internal reforms and international co-operation are crucial to secure water resources. As the country is highly dependent on transboundary water resources (44% of total water is formed outside the republican boundaries), domestic water security can be guaranteed only by a sustainable nexus management at the regional level. Currently, irregular water supply to the Aral Sea region and Ili-Balkhash lake systems are impacting biodiversity and ecosystems. An "integrated system of water management" is still under development in Kazakhstan as is the case in other countries in the region. Ensuring the coherence between deferent legal frameworks (e.g. environmental protection, economy and finance, construction, education, science, international relations, national security) is a key challenge.

Existing government coordination mechanisms may support an integrated nexus management and financing. The Coordinating Council for the SDGs, which is chaired by the Deputy Prime Minister, is an example of an existing horizontal coordination tool. The working groups of the Council monitor five key areas of the Sustainable Development Goals in all their dimensions (environmental, social, and economic). Furthermore, another Council for transition to green economy was established by the President of Kazakhstan (established by the Presidential Decree No. 823 of 26 May 2014). Given their cross-sectoral mandate, these bodies may help to build the capacity for integrated resource management required by the energy water land use nexus approach.

Kyrgyzstan

Key messages

With 75% of its land being mountainous, Kyrgyzstan has abundant water resources and hydropower accounts for nearly 90% of electricity generation. However, the mountainous terrain is expensive to convert to agricultural use and the country sees an increasing reliance on food imports in the context of rapid population growth. While water quality and availability are high, pressures from ageing infrastructure, mining and agricultural activities are increasing. Coal reserves in the Sulyukta region and large hydropower potential remain untapped with seasonal imports of oil and gas to meet winter power peak demand. The developing industrial sector is highly energy intensive due to low technology and below cost recovery electricity tariffs.

Key data and information

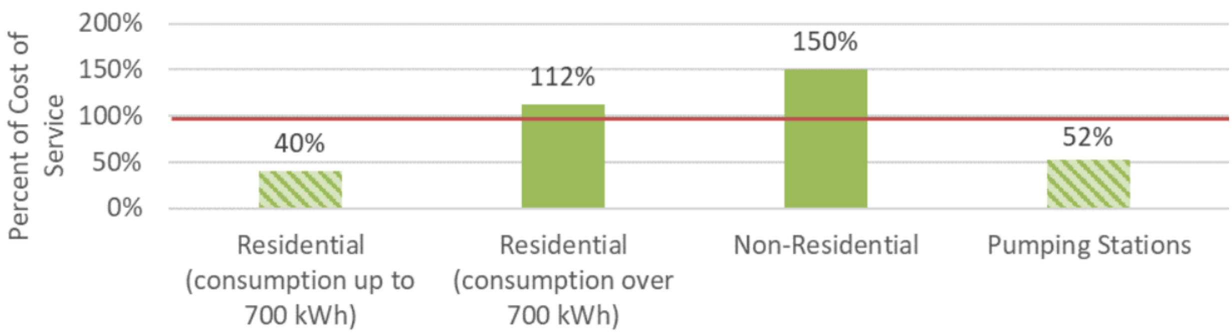
Real GDP contracted by 6.0% in the first three quarters of 2020. Main reasons for this include the decline in remittances from Russia (by 7 % in the first eight months of 2020), and contraction of the services and construction sectors. An economic stimulus package has been introduced to respond to the crisis but the large informal economy, which accounted for 23% of GDP in 2018, complicates the targeting of support measures (EBRD, 2020[99]).

While the country's domestic energy demand has been growing (EBRD, 2020[99]), **the productivity of the power sector is decreasing due to ageing infrastructure**. Around 45% of available capacity is beyond the useful life of 25 years, including the Toktogul hydropower plant[16] and Bishkek CHP plant (IMF, 2019[100]). The low energy efficiency seen in Kyrgyzstan and the high transmission losses (15% of total energy generation) add pressures to the system. In 2020, Kyrgyzstan imported electricity due to a shortage of water in the Toktogul reservoir. Although the country has a large untapped hydro potential, it is planning future imports of 1 billion kWh of electricity from Kazakhstan, Tajikistan and Turkmenistan (EBRD, 2020[99]). Kyrgyzstan also has coal reserves in Sulyukta region, yet extracting and using them would also have negative implication for the country's climate action.

In addition, companies in the energy sector are heavily indebted. Overall, the energy sector companies' cumulative debts reached KGS 110 billion as of May 2020 (USD 1.5 billion or 19% of GDP) (EBRD, 2020[99]). The below cost recovery tariffs charged to residential consumers and to the power used in pumping stations contribute to indebtedness and undermine capacity to maintain and upgrade the network. For instance, residential electricity tariffs are below cost recovery (and below the price required to cover the costs of imported electricity according – see Figure 14). This cross-sectoral tariff subsidisation hinders incentives to save power among households and, jointly with the frequent electrical outages, undermines competiveness of the private sector.

[16] The Toktogul hydroelectric power plant is undergoing a staged rehabilitation program financed by Asian Development Bank and Eurasian Development Bank. The project is articulated in three phases, and each phase is independent of the others. The first ongoing phase covers the replacement of secondary electrical and mechanical equipment. The second phase, which is expected to be completed in 2021, focus on the rehabilitation of two turbine and generator units. The third phase will cover the replacement of other two turbine-generator units. Upon completion of the three phases, the capacity of Toktogul HPP is to be increased by more than 200 MW (SIC inputs, 20121. ADB, 2021).

Figure 14. Actual Electricity Tariffs as a Percentage of the Cost of Service



Source: (World Bank, 2018[101])

The expected seasonal low water level from 2019 to 2025 may increase the tension on domestic energy sources and the regional water-energy nexus. Given the expected unfavourable natural conditions, reforms aiming at improving energy efficiency and increasing energy supply (either through domestic generation or imports) are crucial. According to some estimates, energy efficient measures can help to save around 35–40% of the total energy consumption. Furthermore, diversifying the power mix by increasing power imports or developing new power generation plants (including hydro), or both, may help to decrease pressures on existing reservoirs. For instance, the development of Kambarata-1 and Kambarata-2 cascades may allow operating the Toktogul hydro scheme in irrigation mode (as it was the case at Soviet times, when it was initially planned and built), thus helping to meet the water demand of Kazakhstan and Uzbekistan. The governments of Kyrgyzstan and Uzbekistan developed a roadmap for the construction of Kambarata-1, and have recently agreed on a protocol on a mutual supply of electricity (the Kambarata-2 has been already commissioned) (Khasanov, 2021[102]).

Several transboundary agreements exist for the operation of reservoirs located in the Kyrgyz territory. For instance, Kazakhstan and Kyrgyzstan have a long history of co-operation in the Chu Talas river basin, where the operation and maintenance costs of the facilities are shared on a pro rata according to the water volume received. A 2017 agreement between Kyrgyzstan and Uzbekistan envisaged a similar arrangement for the Orto-Tokoy (Kasansai) reservoir, with Uzbekistan to compensate Kyrgyzstan for some operation costs (SIC - ICWC Inputs, 2021).

Some existing domestic mechanisms have the potential to ensure coordination of nexus policies. For instance, the Coordination Committee on Climate Change (CCCC) reviews and discusses national commitments and reports under the auspices of the United Nations Framework Convention for Climate Change (UNFCCC). As NDCs require cross-sectoral consensus and inputs, the CCCC is likely to have experience in coordinating policies across multiple sectors. An inter-ministerial National Water Council (NWC), which was formally established in 2005 and convened for the first time in 2013, is also in place (*SIC - ICWC inputs*).

Low agricultural productivity and projected population growth undermines food security. The productivity of irrigated land is estimated at only USD 1 678 per hectare against the regional average of USD 2 480 per hectare. At the same time, 50% of the Kyrgyz land is used in agriculture but only 10% is irrigated. As the population of Kyrgyzstan is forecast to be 7.24 million in 2025 and 10.2 million in 2050, pressure on domestic land is expected to increase.

Over the last 15 years irrigated area has decreased by 54 600 ha, with the most of the area transformed into non-irrigated land. Notwithstanding this decrease, the volume of agrarian production has remained stable or only slightly decreased. The value of agrarian production and crop production moved, respectively, from USD 747 million and USD 391.4 million in 2005 to USD 1 612 and USD 737 million in 2019. According to some experts, the small size of agricultural farms, which lack technical capabilities and access to funding for maintenance and rehabilitation works, has resulted in high energy intensity, low water efficiency, low economies of scale, and deterioration of on-farm water irrigation networks.

Tajikistan

Key messages

As 93% of its land is mountainous or highland terrain, Tajikistan has significant water resources and hydropower potential. With limited productive arable land and a reliance on food imports, the high forecast population growth (69% to 2050) poses additional pressures on food security in the country. Power generation and demand are highly concentrated: hydropower accounts for 93% of the power generation mix and one large industrial consumer, an aluminium smelter, uses about 43% of total power supply. Although Tajikistan has significant untapped hydropower resources, the country suffers from power outages in winter. Large power losses in transmission and distribution (i.e. around 17%) accentuate the mismatch between supply and demand. The country is particularly vulnerable to climate change due to changes to water flow regimes and because three-quarters of the population live in areas that are prone to natural disaster.

Key data and information

Despite the pandemic, the Tajik economy grew by 3.5 % cent in the first half of 2020 thanks to a strong performance of the agriculture and industry sectors. The most negatively affected sectors include hospitality, freight transportation and retail trade. The decline in remittances from Russia (around 15% less) and a dismal export performance (with the exception of gold that is a typical countercyclical commodity), posed an additional drag on the economy (EBRD, 2020[103]).

Winter power demand peak is often not met, resulting in power outages. Hydropower, accounts for 93% of power generation mix even if only 3-5% of the total domestic hydropower potential is exploited. Notwithstanding the large untapped reserves, which are estimated to exceed by three times the electricity consumption in the whole Central Asian region, the country struggle to meet the electric heating demand peak during winter. The electricity deficit is estimated at 3 billion kWh, and it is met through import of gas and coal.

Reducing power losses, inefficiency and energy intensity may help to increase energy security. Energy intensity in Tajikistan is 25% higher than the OECD average, thus underling the importance of a cross-sectoral approach to reduce pressure on the energy dimension of the nexus. There are 15% losses during electricity generation and transmission and 30% losses during distribution and through inefficient consumption. Energy demand is forecasted to increase due to expected population and economic growth.

A number of reforms have been introduced in the energy sector in recent years. In 2019, an independent Electricity Sector Regulation Department was created, and the national utility company Barki Tojik will be split into two companies (Shabakahoi Intiqoli Barq OJSC (transmitting electric networks) and Shabakahoi Taqsimoti Barq OJSC (electrical distribution network)) once the appointment of new management and the establishment of separate balance sheets is completed (EBRD, 2020[103]). Power tariffs are proposed by the Antimonopoly Service and approved by the Government. These are currently subsidised for households, large industrial consumers (e.g. the Tajik Aluminum Plant, which accounted for 43% of total energy consumption in 2019 (World Bank, 2020[104])), and agricultural use (especially for irrigation through pumping stations).

Water and energy use are deeply interlinked in the country given its under-diversified power mix. In this context, some mechanisms exist to promote synergies between water and energy policies, such as the Water-Energy Council (WEC) which is in charge of coordination of Ministries and Agencies working on water and energy issues (UNECE, 2017[73])https://unece.org/sites/default/files/2020-12/Syr-Daria-FINAL-WEB-.pdf. Furthermore, a recent project implemented by CAREC focused on the update of the “methodological guidelines for the development of rules of water reservoirs exploitation” with the objective of aligning them with the energy-water-land use nexus approach. The revised methodological guidelines were submitted to the national entities for approval (CAREC, 2019[105]). The country is also in the process of establishing River Basin Authorities. In 2021, five river basin organizations were established under the Ministry of Energy and Water Resources of the Republic of Tajikistan and Basin Dialogues on Integrated Water Resources Management have been created in the Syrdarya, Zarafshon, Pyanj and Kofarnikhon basin areas (SIC - ICWC inputs, 2021. (CAWater-info, n.d.[106])).

The country is particularly vulnerable to the impacts of climate change. Tajikistan is the most vulnerable country to climate change in Central Asia (ADB, n.d.[107]). Changes in water regimes (e.g. peak seasonal runoff is expected to shift from early spring to late winter) can have significant consequences for rural livelihoods and food security. Floods and droughts are also projected to increase in both frequency and severity (Liu, Liu and Gao, 2020[12]). This is particularly concerning as three-quarters of Tajikistan's population live in rural areas that are prone to earthquakes, avalanches, mudflows, landslides, and flash floods (ADB, n.d.[107]). According to ADB data in 2020, entitled Disaster Risk Management in Tajikistan, the total damage from disasters amounted to USD 48 592 800 in 2014 and may increase 2.7 times by 2030 (SIC - ICWC inputs, 2021).

With limited productive arable land and an ageing water infrastructure, the high projected population growth poses additional pressures on the agricultural sector. Only 26% of the land is suitable for agriculture (cropland and pasture) and irrigation is often costly to develop due to the frequent high slope (over USD 4 500/ha compared to average cost of developing new irrigated lands of USD 2 500/ha in Central Asia on average). In 2020, the energy inputs in pumping stations amounted to 1 393 billion kWh (or 10% of domestic demand), and the water lift was 5.265 billion m^3. Furthermore, half of the existing irrigation and drainage systems (e.g. water lift, vertical drainage wells and related energy facilities) are considered to be deteriorated. The multi-pumping stations that were built more than 40 years ago, the lack of coating in over two-thirds of irrigation canals, and an estimated 33.5% of drainage systems out of service are of particular concern. Furthermore, agriculture is poorly mechanised linked to the prevalence of a number of small agricultural firms that face financing barriers. This is also compounded by challenges related to training farmers and equipping them with information and technologies in support of the overall productivity of the agriculture sector.

Several areas experience salinisation and waterlogging of irrigated land. Land erosion is observed at higher slopes and irrigated area per capita is declining[17]. These challenges have probably also contributed to reverse some of the agricultural productivity observed in the last decade.

[17] Irrigated land per person decreased from 0.12 ha in 2000 to 0.081 ha in 2020 (SIC inputs, 2021).

Turkmenistan

Key messages

Turkmenistan is a lowland country dependent on water reserves formed outside its borders, in particular, the Amu Darya River. With rich fossil fuel reserves, the opportunities for energy exchange within the region and with neighbours are high. Expansion of current agricultural land is a challenge due to the large desert areas (i.e. 80% of the land is classified as desert) and pressures on water reserves. Water desalination capacity has been recently added, and the use of groundwater reserves is being considered. Measures to promote the deployment of renewable energy sources, which currently have a very limited role in the country energy mix, are being introduced.

Key data and information

Albeit being affected by a drop in gas exports, Turkmenistan's economy continued to grow in 2020 (5.8% year-on-year in the first three quarters). The drop in gas exports was mainly due to a significant decrease in natural gas demand from China. (EBRD, 2020[108]).

The country has abundant domestic energy sources. With some of the largest natural gas resources in the world, virtually all Turkmen power plants are natural gas powered[18] and until 1 November 2017 all citizens received free electricity up to a certain level of consumption. Currently, the population pays 2.5 Manat (USD 0.7) per 100 kWh. The country also has large potential for solar and wind power (in the north and west of the country).

According to local experts, the restoration of operation of the Turkmen power grid in parallel with the Central Asian unified energy system has potential to improve reliability within the region. The Turkmen energy system, which has excessive capacity, can export electricity to Central and South Asian countries, thus possibly helping to address energy shortages in other countries. All electric stations run on Turkmen natural gas from nearby gas fields, and have reserve capacities from 15 to 50%, depending on season and export. The Turkmen energy system has already built the 500-kV line from Atamurat substation to the Afghan city of Andkhoy. In turn, Afghanistan is building a 220-kV transmission line from Andkhoy to Pul-e-Khumri.

Turkmenistan, in co-operation with development partners, has implemented several projects aimed at reducing greenhouse gas emissions, and improving energy efficiency. These include the "Energy Efficiency and Renewable Energy for Sustainable Water Management in Turkmenistan" project which is being implemented from 2015 to 2022 (with the support of USD 6 185 000 from GEF and USD 100 000 from UNDP). There has also been another joint UNDP and GEF project entitled "Improving Energy Efficiency in Residential Buildings in Turkmenistan". The budget of the latter is USD 46 million, including contributions from national governments. Furthermore, the law on renewable energy was adopted in 2021 (CIS Legislation, 2021[109]). This new law includes green tariffs and other advanced approaches and principles on preferences/privileges to support the development of renewables, elaborates legal, institutional, financial and other terms for renewable energy producers (and services) in Turkmenistan, and outlines procedures of interaction with the state energy agency.

Longer land leases have been introduced to promote sustainable land use. More efficient use of irrigated land is encouraged by long lease of land to farm. This includes land from the newly formed Special Land Fund comprised of arable land of daykhan associations for a term up to 99 years provided that not less than 70% of the so called "State Order crops" are grown there. State Crops are crops that the government annually identifies as national priorities and support their production by providing fertilizers, crop protecting agents and irrigation water. This approach can have possible downsides across all

[18] The total installed capacity of 12 state power plants of Turkmenistan is about 5.2 thousand MW.

elements of the nexus that require detailed analysis. Long-term commitments can lead to rigidity in producers, a lack of innovation and a decoupling of production practises from market demands (Henderson and Lankoski, 2019[110]).

However, water scarcity and soil salinity represent remains a growing threat to food security. About 1 million ha of irrigated land is subject to salinization. Marginal land area (i.e. withdrawn from production) is increasing largely due to unsustainable agricultural practices. The prevalent irrigation technique is surface irrigation, though drip irrigation has been developed in sub-mountain regions of Kopetdag for the last 15 years. Infrastructure problems are widespread, with reservoirs and canals generally requiring rehabilitation to improve efficiency.

Climate change can exacerbate issues in access to water and sanitation. At present, coverage by drinking water networks is low (63% of the population has access to adequate water supply) and timed/scheduled supplies are prominent. Water supply and sanitation services are only available in large towns and cities, and the underlying infrastructure is aged. Climate change could decrease water quantity in the Amu Darya River by 10-15% by 2050 and runoff in the Murghab, the Tejen, and the Atrek rivers (Government of Turkmenistan, 2015[111]). OECD/SIC ICWC (2020) shows that enhanced flow regulation along the Vakhsh and the Panj rivers could decrease water flow to Turkmenistan. In addition, increased water withdrawal by upstream countries (e.g. Afghanistan) and reduced runoff in available transboundary water sources is already reducing river water availability in all major water bodies of Turkmenistan. Rural communities are particularly exposed to the low access to water supply and sanitation infrastructure.

Energy costs affect agricultural productivity in certain regions. Monthly limits for electricity consumption by pumping stations and water consumption for firms in the agro-sector are in place. However, high-energy costs in some zones that use pumping irrigation has led to less than optional energy consumption and irrigation. This significantly affects irrigated agricultural production, including food crop harvests. In addition, significant wear and tear affects the nation’s pumping system, requiring more energy resources and inputs for its maintenance that ultimately affect generated revenues.

Hectare-based, rather than consumption-based, payments for water use also contribute to inefficient water use in irrigated agriculture. The transfer from such a system to the payment on the basis of amounts of water actually consumed will contribute to ensuring optimal water use by firms. In this context, in the recent years the country has been replacing (almost) free use of domestic and drinking water by paid metered use.

The country is planning to build more desalination plants. As of 2016, there were two seawater desalination plants in the Balkan province of the country. Development of another two desalination plants (in Kiyanly and Ekerem), including an energy system to be comprised of a gas-turbine station and a solar plant, were completed in 2020. These are aimed to address the shortage of drinking and irrigation water in the western part of the country (*State News Agency, 2017*). Expanding the use of groundwater, which currently accounts for only 2.5% of water supply, and increasing the recovery of drainage water also have potential to bridge gaps in supply and demand of water. Renewable energy powered water pumps can also help to increase access to water especially where there are sufficient groundwater resources (see Box 10).

Box 10. Example on solar water pumps for sardobs in Turkmenistan

Sardobs are traditional wells that are built on pastures in the desert zone of Turkmenistan, and are usually publically owned and leased for free to the cattle farmers. Built from loam and later on bricks, sardobs collect the underground or rainy water in a wells that can be up to 5 meters deep. Long dry periods led to a decay of sardobs and pushed shepherds to have their livestock graze on pastures closer to villages, thus increasing desertification of these areas.

Solar water pumps have been used to restore the sardos in the Esenaman land plot, a remoted dessert area that belongs to the “Garalgum” livestock farm. The Nexus Regional Dialogues Programme in Central Asia, funded by the European Union and the German Federal Ministry of Economic Co-operation and Development piloted the restoration of two old sardobs and the installation of solar panels and pumping stations in this region. As a result, local farmers have been able to use sardobs areas to graze their livestock with important benefits across the energy-water-land use nexus. Reduced risk of overgrazing would allow ecosystems in previously used pastures to restore, while water and energy supply have increased.

Sources: (CAREC, 2019[105])

Mechanisms of inter-sectoral planning are limitedly used but several good examples exist. For instance, several sectors were involved in the planning and development of the Dostluk Reservoir Construction Project, which was a joint Turkmenistan – Iran project. The joint operation of the large Tuyamuyun reservoir on the Amu Darya River together with Uzbekistan is another positive example of good international co-operation. An Inter-sectoral commission for environmental conservation was established by a Presidential Decree on October 2020 (“Neutral Turkmenistan”, 24 October 2020).

Uzbekistan

Key messages

The agricultural sector, which accounted for 28% of GDP in 2019, is central to the national economy. With the majority of Uzbekistan's water supply formed outside of its borders, agreements on water allocation with upstream neighbours are critical. Given the significant natural gas reserves, an emerging renewables sector and plans for the region's next nuclear plant, Uzbekistan is rich in energy reserves, yet imports hydropower energy from its neighbours to support water availability in the growing seasons. The mining and quarrying sector accounts for 7% of the country GDP and energy exports (e.g. natural gas) account for a fifth of the country total (World Bank, 2019[112]). Pumped irrigation and a degrading land bank contribute to the low yields and profitability typically seen in the agricultural sector.

Key data and information

Uzbekistan's economy, which is considered more diversified than other countries in the region, grew moderately in 2020 (0.4% year-on year in the first three quarters of 2020). Over the period between 2016 and 2017, the country recorded stable annual GDP growth rates raining from 4.5% (2017) to 6.1% (2016) (EBRD, 2020[113]). The industrial sector (mining, manufacturing and construction) accounts for 33% of GDP compared to 27% on average across CA countries. The large gold exports, which account for more than half than total exports, provided a natural hedge during the turbulent COVID-19 times (EBRD, 2020[113]).

The agricultural sector accounts for 28% of the national GDP (2019) but is affected by land salinization. About 1.92 million ha (47%) of the total irrigated area (4.2 million ha) is subjected to salinisation, of which 580 thousand ha are strongly and medium saline. Moreover, about 600 000 ha of irrigated land had to be abandoned over the period from 2000 to 2010 due to acute water shortage in 2000/2001 and 2008/2009. The Strategy for Water Resources Management and Irrigation Sector Development, adopted in February 2021, aims at decreasing moderately and highly saline land from 1 926 thousand ha to 1 888 thousand ha and, rehabilitate of 232 thousand ha of irrigated land areas that have been abandoned.

Another challenge is the high energy intensity of the agricultural sector. About half of the total irrigated area (or 2.2 million ha) are irrigated by pumped groundwater, which consume 7.5 billion kWh a year (or 0.01% of total power demand). The Ministry of Water Management provides public finance to the operation and maintenance of 1 687 pump stations, including 5 284 pump units at total annual capacity of 23.5 billion m^3 of water.

Uzbekistan has adopted the Strategy on the Transition to a Green Economy for the period 2019-2030. The main goals of the strategy is to achieve environmentally and socially sustainable economic development. Main tasks include increasing energy efficiency and rational use of natural resources, integration of "green" criteria into public investments and spending, supporting pilot projects and slikk development in support of green economy transition. Mitigation of environmental impacts on the Aral Sea region is also highlighted.

The 2019 "Agriculture Development Strategy for 2020-30" sets an ambitious agenda to modernise the agricultural sector. Key priorities include the diversification of agricultural production, phasing out state control of production, and liberalisation of the sector by removing export barriers and mandatory production quotas for cotton and wheat. In addition, the plan targets the creation of agribusiness clusters for the cotton, wheat, horticulture and livestock sectors with the aim of attracting private capital and increasing access to export markets. The EBRD (2020[113]) reports that the sector's development will be accompanied by measures to ensure environmental protection and efficient use of resources. Given the large reliance on water pumps, the modernisation of this sector can help to increase the sustainability of the power sector (see Box 11.)

Box 11. The energy and cost efficiencies of automated systems for monitoring electricity consumption

Pumping stations supply water to over 50% of irrigated lands of Uzbekistan. The high obsolesce rate and, technological issues contribute to high energy intensity of this sector.

Following the request of the Ministry of the Water Resources, a technical assessment and sectoral management of pumping stations (1 700) and the pumping units (more than 5 000) was conducted. In addition to underlining the ageing of several units, the analysis also showed that almost 70% of employees' time was spent in manually collecting and analysing consumption data. In this context, the pilot project concluded that the installation of an Automated System for Monitoring Electricity Consumption would result in cost saving of around USD 1 million and annual energy savings of 0.5% (40 million kW). The project proposal has been submitted to the Government and potential investors (CAREC, 2019[105]).

The ageing infrastructure and growing power demand creates challenges for the electricity sector. Per capita energy consumption is estimated at 1 903 kWh and is well below peer countries in the region (e.g. per capita consumption amounts to 6257 kWh in Russia, 5133 kWh in Kazakhstan and 2637 kWh in Turkey). Power outages are relatively common, and the state's regulations[19] indicate which consumers should be taken off the grid in case of power shortages. The National Energy Concept 2020-2030 projects domestic consumption to almost double by 2030 and to reach 120.8 billion kWh.

The government is planning to introduce a number of reforms in the electricity sector. The 2020 "Concept for Provision of Electric Energy to Uzbekistan in 2020-30" envisages the creation of a wholesale electricity market by 2023, an independent energy regulator by 2021, and a review of electricity tariffs. New targets for solar, hydro, wind and nuclear power generation are also being set in light of the growing demand (EBRD, 2020[113]). Hydropower, which accounts for 10% of total power generation in 2020 (IRENA, 2021[114]), is expected to more than double by 2030 by increasing total capacity of HPPs to 3 785 MW. Renewable energy sources beyond hydroelectric, which currently account for less than 1% in the power mix (IRENA, 2021[114]), are expected to increase to 3% by 2030. Additionally, transmission and distribution losses should be reduced, respectively, from 2.72% to 2.35% and from 12.47% to 6.5% by 2030. The country also is investigating the possibility of bringing online the region's first nuclear power plant. The Law on the Use of Renewable Energy Sources, adopted in 2019, also defines regulations related to the generation of electricity from renewable energy sources and the production of the equipment that generate such energy.

Uzbekistan's water security is likely to deteriorate in the coming years. Some zones regularly experience water scarcity, especially in the Amu Darya delta. Available water supply varies widely at the peak of the growing season. Population growth, growing water demands of riparian countries, negative impacts of climate change, and pollution are expected to increase water stress. Available water supply could decrease to 85% of water demand in normal years and 70% in dry years by 2030. Furthermore, as

[19] The special Resolution of the Cabinet of Ministers (No. 22 of 12 January 2018) "On additional measures for better use of electric power and natural gas" regulates power restrictions in case of shortage of fuel or hydro-resources in the power grid

85% of national water resources are formed beyond the national boundaries, international co-operation will be crucial to ensure long-term water security.

Importantly, the country imports energy with the double objective of meeting internal demand and contributing to regulating water releases. Uzbekistan imports electricity from Kyrgyzstan and Tajikistan to reduce idle discharges from hydropower plants and boost Uzbekistan’s water supply in the growing season. In 2020, Uzbekistan produced 66.4 billion kWh, exported 2.7 billion kWh, and imported 5.3 billion kWh of electric power but figures vary over the years according to water needs and other criteria.

Annex 2. Discussion questions for the expert workshop

This annex provides policy questions that were prepared for a workshop entitled: "Benefits of regional cooperation on the energy-water-land nexus transformation in Central Asia" held on 8 June 2021. The workshop gathered over 80 participants with an interest in the energy, water, and land-use nexus including experts from all five Central Asian countries. The summary record of the expert workshop can be found on the OECD website.

Draft questions for discussion 1:

- What is your perspective of the current practice with combined water and energy planning at a national level?
- To what extent are energy generation and use plans, and water use plans harmonized in your countries considering annual and seasonal dimensions? How does that transpose to the regional level?
- Who are the key actors involved in supervision of this harmonization at the national level, and how are plans monitored? How is this done at the national and sub-national level?
- Which actors are involved in monitoring of fulfilment of mutual obligations on water supply (and at what frequency e.g. monthly, ten-day) to countries and water districts? How are they linked with electrical energy supplies?
- What lessons learned could you share with regard to good practice in this domain? Please provide any examples of co-operation between sectors for example, between hydro energy and irrigation? Are any considerations given to water related hazards and flooding or dam safety in these discussions?
- Moving forward, what do you think would be the priority issue within the water-energy-land nexus in Central Asia?

Draft question for discussion 2:

- What lessons learnt could you share with regard to good practice on international co-operation among CA countries? Please provide examples of co-operation between the sectors across countries, for example, between hydropower generation and irrigation?
- Do you think better dissemination of the lessons learnt and good practices regarding multilateral collaboration among CA countries can increase trust among CA countries? If so, how should such information be disseminated in your view?
- What are the main challenges to fulfilment of the 1998 Agreement and what can be done to make it operational?

- Should this collection of lessons learnt focus only on examples of coordination on nexus-related issues or examples could be wider in scope?

Draft question for discussion 3:

- What challenges exist concerning data availability and quality in your day-to-day activities?
- To what extent could better data sharing improve management of the nexus in your country, and within the region?
- What best practises exist in your country?
- To what extent have ongoing energy, water and land use sectoral initiatives contributed to improved data quality and availability? What key challenges remain?
- What are definitions, indicators and criteria of water, food and energy security officially adopted and/or used in your country?
- How can efforts to create a harmonised data system build on previous experiences, such as the SIC-ICWC unique Information System and data portals?

Draft question for discussion 4:

- To what extent could trade in agriculture products help to manage the regional nexus opportunities and challenges?
- What key barriers exist to trade in the agri-industrial products among CA countries?
- To what extent are national strategies for the development of the domestic agro-industries complementary and reflect regional nexus challenges? Could specialisation zones favouring climate and resource availability for certain crops support nexus challenges?
- What are the environmental and social effects of planned transport corridors that are particularly relevant for the agro-industrial sector at the local, national and regional levels?

Draft questions for discussion 5:

- To what extent could trade in energy and water help to manage the regional Nexus opportunities and challenges?
- Do you see opportunity for a regional Water and Energy strategy that considers combined energy and water strategic planning? Taking into consideration that in Central Asia, most water is used for irrigation, i.e. ultimately for agri-food production?
- What key barriers, including in infrastructure (e.g. interconnectors) and governance, exist to trade in these sectors among CA countries?
- What do you see as the main opportunities for a regional strategic plan and what could be the main barriers to its development?
- Would a regional energy/water consortium be an effective mechanism for implementation of the regional Water and Energy strategy? What would be the pros and cons of, and eventual political barriers to, its establishment?

Draft question for discussion 6:

- To what extent could larger use of renewable energy technologies help to reduce pressure on the water, energy and land systems in your country?
- What key barriers exist to trade in these sectors among CA countries?
- Would a rehabilitation of the national transmission and distribution grids to reduce losses help to manage the nexus in the region?

Draft question for discussion 7:

- What energy, water or land use activities in your domain lend themselves to application of a BAT approach?
- What benefits would the adoption of BATs –based permitting system in your country? What would be the key challenges?
- To what extent and how would a wider adoption of BATs help to address the regional nexus?

Draft question for discussion 9:

- Could the creation of a transboundary payment for (water) ecosystem services be envisaged in the regions?
- What are the opportunities towards a broader uptake of nature-based solutions? What are the key barriers for their larger uptake?

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