Policy Brief

Determinants of Vulnerability to Climate-Induced Water Stress in CAREC

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October 2020

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This policy brief is one of the outputs of the Institute's recently completed research project titled "Climate Insurance, Infrastructure and Governance in CAREC" and the namesake virtual workshop delivered in collaboration with the Asian Development Bank Institute (ADBI) and the Xinjiang Institute of Ecology and Geography of the Chinese Academy of Sciences (XIEG) on 18-19 June 2020.

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Abbreviations

ADB	Asian Development Bank
CAREC	Central Asia Regional Economic Cooperation
CMIP5	Coupled Model Intercomparison Project 5
FAO	Food and Agriculture Organization (of the United Nations)
GDP	Gross Domestic Product
GNI	Gross National Income
RCP	Representative Concentration Pathways
WRI	World Resources Institute
WB	World Bank

Summary

Many parts of the CAREC region exhibit much higher rates of temperature rise and substantial changes in precipitation patterns compared with global averages. It is projected that climate change will exacerbate the water supply-demand imbalance which already prevails across large parts of the region due to high water withdrawals. Increasing water scarcity will particularly affect the water-dependent sectors, such as the irrigated agriculture. High dependence of the economies on water resources and excessive water withdrawals explain high sensitivity of several CAREC countries to climate-induced alterations of future water supply. In addition, low levels of economic development and insufficient government effectiveness contribute to low capacity to adapt to rising water scarcity. The mismatch between the scale of expected climate impacts and the capacity to cope with them predisposes the high vulnerability of the region to climate-induced water stress.[1]

1. Multifaceted climate impacts on water resources in CAREC

The CAREC region[2] experienced larger increase in mean annual temperature over the last century than the global average. The strong warming trend has already contributed to extensive alterations in seasonal and spatial patterns of precipitation, which are even more evident in the mountainous areas that serve as the water towers of the region through water provision from snow and glacier melt.[3] Climate and hydrological projections suggest that further temperature increases and changes in precipitation in the region will likely cause significant changes in river run-off (*Figure 1*). It is expected that rivers in the southern part of the region will likely observe a reduction in annual run-off[4] and under the high emissions scenario the decrease in annual discharge of the region's largest rivers may constitute up to 25-30%.[5] Some basins in the region may see a slight increase in annual discharge by the mid-century, mainly due to more intense glacial melt under the increasing temperatures, though after the "peak melt" by the end of the century the discharge will decrease.[6] Hence, while accelerated glacier melt currently stalls for some time, the impact on water resources are likely to deteriorate substantially in the medium to long run.

[1] In 2019, the CAREC Institute, in cooperation with the Innovations and Scientific Research Cluster, conducted a research project on the theme "Climate Insurance, Infrastructure and Governance in the CAREC region". The key aim of the project was to provide an overview of the current status of climate change in 11 CAREC countries through the prism of water, energy and food nexus, economic and financial aspect, and governance. This policy brief is prepared based on the findings of this project. The full report of the project can be viewed at: https://www.carecinstitute.org/wp-content/uploads/2020/05/CI-climate-research-report-29-May-2020.pdf

[2] The Central Asia Regional Economic Cooperation (CAREC) Program is a partnership of 11 countries and development partners working together to promote development through cooperation. Its member countries consist of Afghanistan, Azerbaijan, Georgia, Kazakhstan, Kyrgyz Republic, Mongolia, Pakistan, People`s Republic of China (PRC), Tajikistan, Turkmenistan, Uzbekistan.

[3] Xianyong Meng et al., "Simulation and Spatiotemporal Pattern of Air Temperature and Precipitation in Eastern Central Asia Using RegCM," *Scientific Reports* 8, no. 1 (2018): 1–10, https://doi.org/10.1038/s41598-018-21997-4; Alireza Shahabfar, Abduwasit Ghulam, and Christopher Conrad, "Understanding Hydrological Repartitioning and Shifts in Drought Regimes in Central and South-West Asia Using Modis Derived Perpendicular Drought Index and TRMM Data," *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* 7, no. 3 (2014): 1053–63, https://doi.org/10.1109/JSTARS.2013.2284006.

[4] NC, "The Third National Communication of the Republic of Uzbekistan under the UN Framework Convention on Climate Change," 2016.

[5] Mikko Punkari et al., "Climate Change and Sustainable Water Management in Central Asia," *ADB Central and West Asia Working Papers*, no. 5 (2014).

[6] NC, "Seventh National Communication and Third Biennial Report of the Republic of Kazakhstan to the United Nations Framework Convention on Climate Change," 2017; G. Hock, R. et al., "High Mountain Areas," in *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*, 2019.

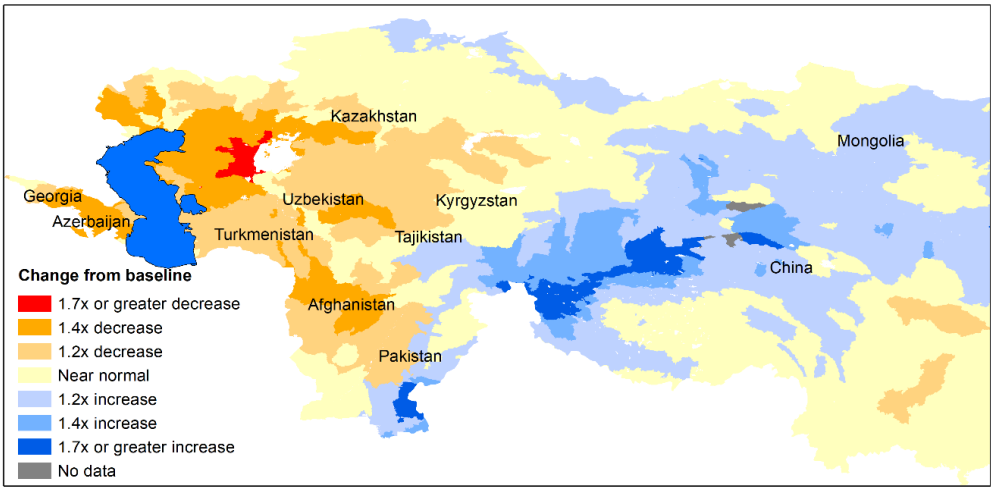

Figure 1. Projected changes in water supply in the CAREC region by 2040 under RCP 8.5 scenario (Source: based on CMIP5 projections, adapted from WRI Aqueduct 3.0)

Furthermore, most rivers in the CAREC region will see seasonal shifts, with peak discharges shifting to earlier months[7]. The shifts in seasonal monthly discharges may increase the probability of early spring floods, which already occur at higher frequency and magnitude in mountainous parts of the region[8,9]. At the same time, reduced run-off during the summer months coupled with higher evapotranspiration rates due to higher temperatures will reduce the availability of water for irrigated agriculture in the endorheic basins that dominate the southern plains of Central Asia, particularly in Turkmenistan, Uzbekistan, northern Afghanistan, Pakistan, and southern Kazakhstan.

All countries in the CAREC region will see alterations in their water resource under climate change, which will induce changes in the annual and seasonal runoff volume and patterns. Many parts of the CAREC region should stay prepared to expected reductions in water availability, particularly in semi-arid and arid regions.

[7] I Didovets et al., "Changes in Water Availability under Climate Warming in Eight River Catchments of Central Asian Region," *Manuscript Submitted for Publication*, 2020.
[8] Nicolas Ahouissoussi, James E Neumann, and Jitendra P Srivastava, *Building Resilience to Climate Change in South Caucasus Agriculture*, *Building Resilience to Climate Change in South Caucasus Agriculture*, 2014, https://doi.org/10.1596/978-1-4648-0214-0.
[9] NC, "Third National Communication of the Republic of Tajikistan under the United Nations Framework Convention on Climate Change The Third National Communication of the Republic of Tajikistan under the UN Framework Convention on Climate Change," 2014.

2. Climate change to hit water-dependent agricultural sectors

While the projected temperature rise will prolong the growing season, it will also result in more frequent and intense heat stress for the crops. Coupled with the changing precipitation patterns, this will lead to higher incidence of drought conditions in large parts of the CAREC region.

Most types of agricultural activities in the CAREC region will be therefore at the frontline of expected climate impacts. Climate change will not only reduce water availability in the region, as explained earlier, but simultaneously increase crop water demand due to higher evapotranspiration rates. Because of reduced streamflow and higher demand for irrigation water, the water stress will likely intensify across arid and semi-arid parts of the region with serious implications for irrigated crop production[10]. Some assessments imply a significant fall in yields in major crops under reduced water availability for irrigated agriculture[11].

The sensitivity of water availability in some CAREC countries to climate change is reasoned by domination of the irrigated agriculture among key economic activities. Sector diversification and promotion of efficient irrigation activities can enhance climate resilience

Climate change will not only intensify the intersectoral competition over water resources within countries but also between CAREC countries. A substantial share of available renewable water resources in large parts of the CAREC region are of transboundary nature, with multiple large river basins being shared by several countries. Moreover, the countries that withdraw the largest shares of their available renewable water resources are dependent on water resources originating outside their territory (i.e., have a high-water dependency ratio). More than 75% of renewable water resources of Turkmenistan, Uzbekistan, Pakistan, and Azerbaijan originate from neighboring countries. Given the high interannual fluctuations in river streamflow, the lack of effective transboundary water agreements and management mechanisms may potentially emerge as an additional driver aggravating their exposure to possible water stress.

The transboundary river systems, which dominate much of the CAREC region, exert dependency of the downstream countries on streamflow from the upstream countries. Transboundary cooperation will become increasingly important to overcome water stress.

[10] A Lobanova et al., "Assessment of Agricultural Production Vulnerability to Climate Change in Three Pilot Location in the Aral Sea Basin. Manuscript Submitted for Publication," *Manuscript Submitted for Publication*, 2020.

[11] William R. Sutton, Jitendra P. Srivastava, and James E. Neumann, *Looking Beyond the Horizon: How Climate Change Impacts and Adaptation Responses Will Reshape Agriculture in Eastern Europe and Central Asia. Directions in Development.* (Washington, DC: World Bank, 2013).

3. Improving water use efficiency proves crucial

One unique characteristic of the CAREC region is that it comprises the most water intensive countries in the world in terms of water withdrawals per capita and unit of produced GDP (*Figure 2*). The degree of impact of climate challenges on water resources in the region is subject to the level and nature of country dependence on water resources for pursuing economic activities. Such dependence may emerge in several forms that reflect a level of water use intensity in CAREC countries.

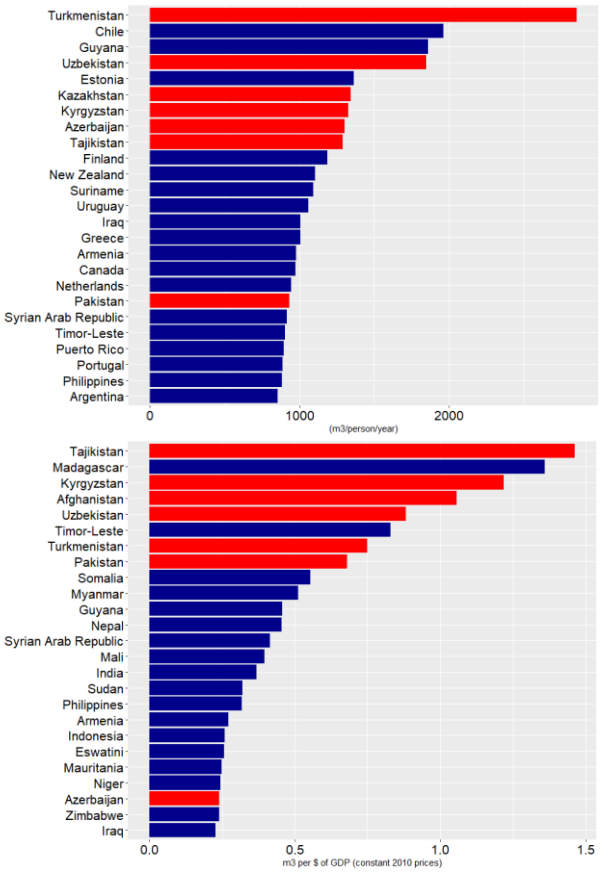

Figure 2. Top 25 countries with respect to water withdrawal per capita (left) and per unit of GDP (right). (Data source: FAO AQUASTAT database)

In addition, several CAREC countries exhibit extremely high ratio of water *withdrawal as a proportion of availability of water*, that is, the share of total renewable water resources withdrawn on an annual basis. Water withdrawals in Turkmenistan, Uzbekistan, and Pakistan are at the availability threshold because of the dry-climatic conditions and high shares of irrigated agriculture. The water withdrawal ratios are moderate in Tajikistan, Afghanistan, and Azerbaijan, but tend to increase during the past two decades.

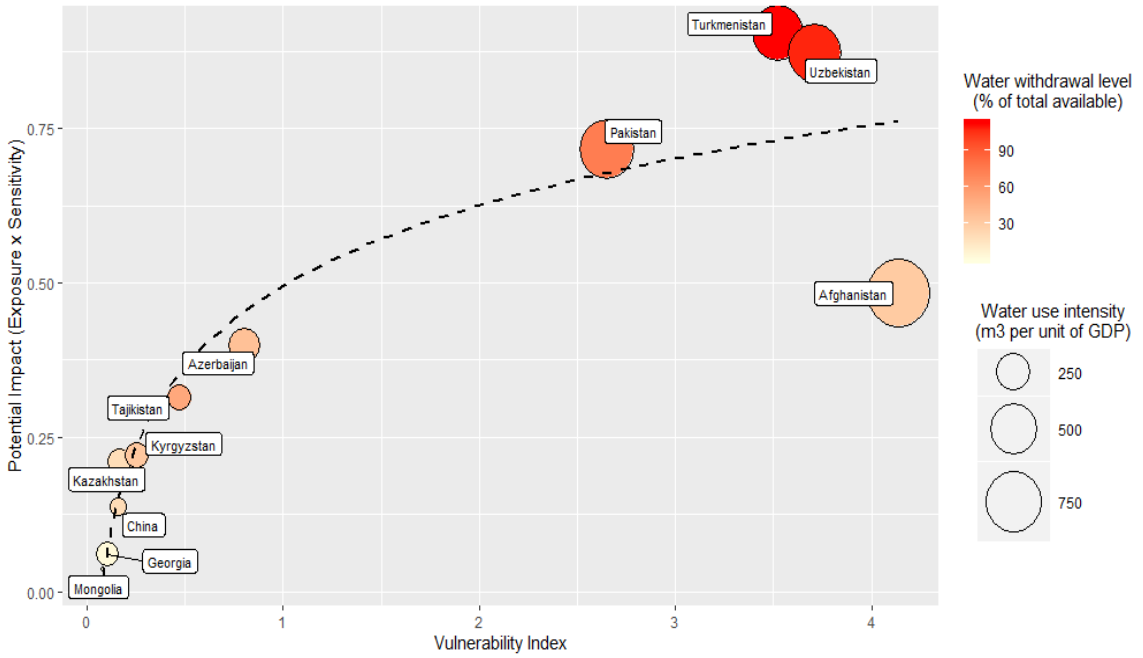

Figure 3. Relationship of the estimated vulnerability of the CAREC region countries to climate induced water stress with baseline water intensity. (Source: CAREC Institute," Climate Vulnerability, Infrastructure, Finance and Governance in CAREC Region', 2020)

The high dependence on water resources is the main reason behind the high susceptibility of some CAREC countries to climate change impacts. This dependence roots in low economic productivity of water use. Improving water use efficiency should therefore be key goal for reducing sensitivity and thus enhancing climate resilience to the anticipated water stress

CAREC countries also show substantial variability in terms of their *water footprint*, calculated as the amount of water used to produce goods and services. This indicator measures the dependence of the national economy on water resources and can be viewed as an estimate of water use efficiency on a national scale. The water footprint allows tracking performance of the countries in strengthening their resilience to water scarcity. At present, Pakistan, Uzbekistan, and Turkmenistan consume [12] on average about 600 m^3 of water per US$ 1,000 of GDP, whereas in the case of Afghanistan this number surpasses 900 m^3.

The sensitivity of Mongolia, Georgia, the People's Republic of China (PRC), Kazakhstan, and Kyrgyzstan to climate change impacts on water availability is comparably much lower than in other CAREC countries (*Figure 3*). Being endowed with abundant internal water resources, these countries exhibit relatively lower water use intensities and a smaller share of irrigated agriculture.

[12] FAO, "AQUASTAT Database," 2019, http://www.fao.org/aquastat/en/.

4. Economic growth and efficient policies as prerequisites for resilience

CAREC countries show varying degrees of adaptive capacity, when it is defined as the combination of adequate physical infrastructure, economic power, and efficiency of the relevant institutional framework. The exposure and sensitivity of countries to the impacts of climate change need to be juxtaposed with the adaptive capacity of the countries to alleviate those challenges. Such a comparison shows[13] that CAREC countries experiencing higher exposure and sensitivity of their water resources to climate change tend to have lower adaptive capacities to cope with those challenges (*Figure 4*).

As the vulnerability of countries to climate change is linked to the level of their economic development, developing countries tend to be more vulnerable to negative climate change impacts compared to developed countries. According to the World Bank classification,[14] more than half of CAREC countries predominantly fall into the low and lower-middle-income groups, based on the level of GNI per capita. As both the impacts of climate change and adaptation to these impacts amount to substantial costs, lower-income CAREC countries carry a sizeable economic burden. This is particularly relevant for Afghanistan and Tajikistan, which are among the low-income countries.

Since the adaptive capacities of the CAREC countries are restrained by their economic performance, development finance will remain important for strengthening climate resilience towards exacerbating water stress. Moreover, successful adaptation implies that the CAREC countries should improve their capacities to design and implement effective policies.

An enabling institutional framework also facilitates to prepare for and adapt to climate change. The ability of the countries to provide public services, and to design and implement sound policies, also known as *government effectiveness*, is considered as a precondition for better development outcomes[15]. However, most CAREC countries suffer from low government effectiveness, which likely limits their adaptive capacities.

[13] CAREC Institute, "Climate Vulnerability, Infrastructure, Finance and Governance in CAREC Region," 2020, https://www.carecinstitute.org/publications/climate-vulnerability-infrastructure-finance-and-governance-in-carec/.
[14] World Bank, "New Country Classifications by Income Level: 2019-2020," 2019.
[15] Nick Brooks, 'A Conceptual Framework Vulnerability , Risk and Adaptation : A Conceptual Framework', no. November (2003);

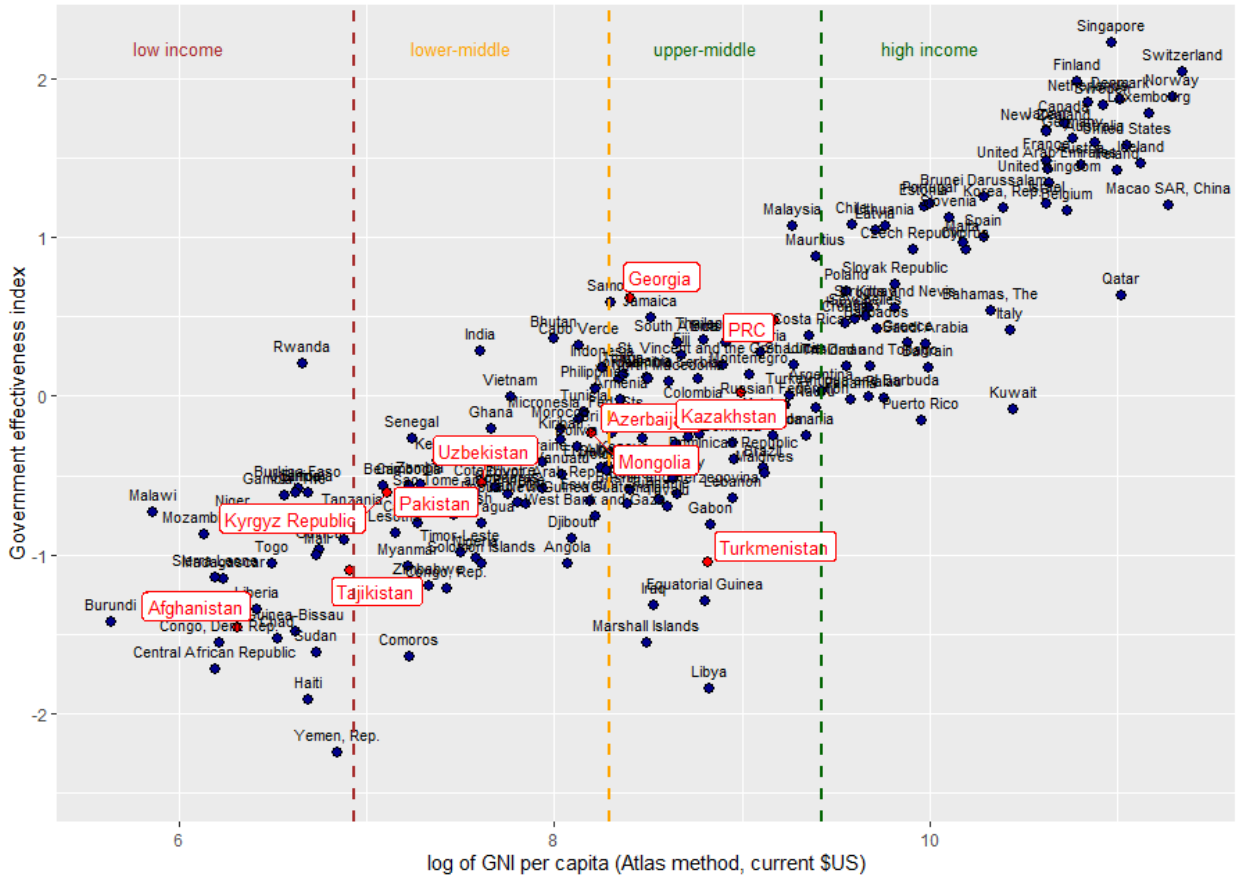

Figure 4. Performance of the CAREC countries in terms of government effectiveness and gross national income (GNI) per capita. (Data source: World Bank, World Development Indicators. 2020)

5. Vulnerability as a mismatch between challenges and adaptive capacities

To make a cross-country assessment of the present vulnerability among CAREC countries to expected changes in water balance, authors considered both climate impacts and non-climate factors that characterize resilience of the sector or its performance in terms of water use. Such a comparison across the CAREC region[16] reveals that some countries in the region may suffer from those impacts by a far larger extent (*Figure 5*). The largest discrepancies between adaptive capacity and potential impacts of climate change prevail in Afghanistan, Pakistan, Turkmenistan, and Uzbekistan.

[16] CAREC Institute, "Climate Vulnerability, Infrastructure, Finance and Governance in CAREC Region," 2020, https://www.carecinstitute.org/publications/climate-vulnerability-infrastructure-finance-and-governance-in-carec/.

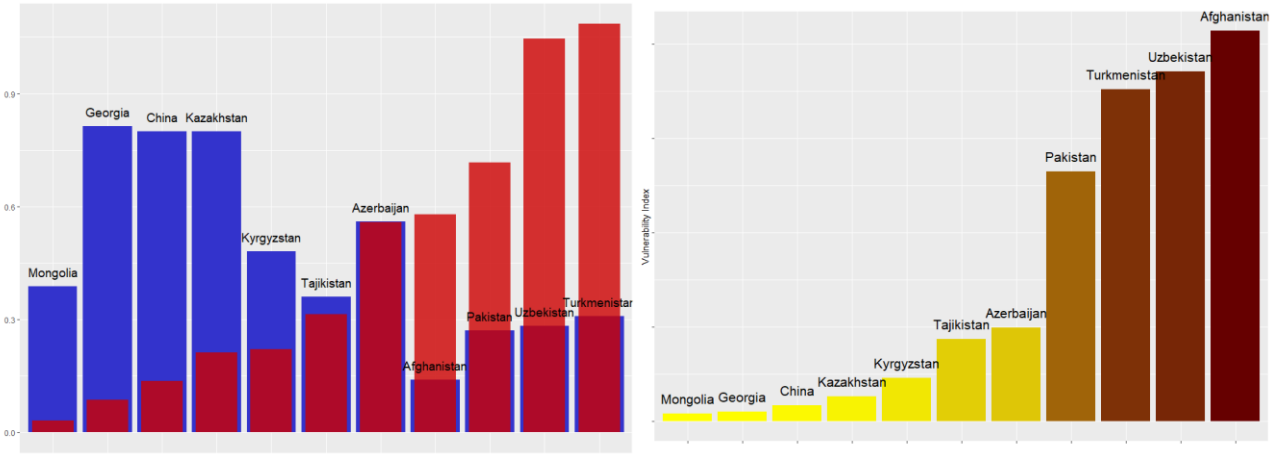

Figure 5. Left: Potential impacts on water resource availability (red) and adaptive capacity (blue). Right: Comparative vulnerability to expected change in water availability by 2040 under RCP 4.5 scenario17. (Source: CAREC Institute," Climate Vulnerability, Infrastructure, Finance and Governance in CAREC Region', 2020)

In Afghanistan, Pakistan, Turkmenistan, and Uzbekistan, the main cause of high vulnerability is determined by a much dramatic scale of decrease in water availability, which is multiplied by substantial dependence of their economies on water resources. In the case of Afghanistan, it is the low adaptive capacity of the country that defines its high vulnerability, even if potential climate impacts are relatively moderate. In Georgia, on the contrary, high adaptive capacity and low sensitivity result in less vulnerability, even if Georgia's exposure to adverse climate impacts is comparably large.

[17] Detailed information on the methodology is provided in Chapter V of the CAREC Institute Report: 'Climate Vulnerability, Infrastructure, Finance and Governance in CAREC Region', 2020, https://www.carecinstitute.org/publications/climate-vulnerability-infrastructure-finance-and-governance-in-carec/.

6. Policy Recommendations

Climate change impacts on water resources is obviously a big concern for the whole region. Ensuring continuous resilience of CAREC countries to climate induced water stress will require complementary actions by the countries. Below are a few suggestions for consideration:

a. Climate change will continue affecting all countries' water resources and causing changes in the annual and seasonal runoff volume and patterns. These changes in water availability will mostly affect semi-arid and arid regions that require particular attention by governments of Afghanistan, Azerbaijan, Pakistan, Turkmenistan, Uzbekistan, Kazakhstan, and Georgia. This necessitates concrete analysis of the sector and identification of ways to safeguard food security which is essential for economic and social stability of CAREC countries.

b. Excessively high dependence on water resources is the main reason for high susceptibility of Afghanistan, Pakistan, Turkmenistan, and Uzbekistan to climate change impacts. This dependence is also rooted in low economic productivity of water use in these CAREC countries. Hence, CAREC countries should continue improving water use efficiency as a major measure for reducing sensitivity and thereby enhancing climate resilience to the anticipated water stress. Crop diversification and promotion of efficient irrigation activities can be initial steps to enhance climate resilience.

c. The transboundary river systems, which dominate much of the CAREC region, exert dependency of the downstream countries on streamflow from the upstream countries. Transboundary cooperation will become increasingly important to overcome water stress in the region. Through the reenforced regional cooperation, CAREC countries may reduce climate sensitivity and lower economic and other risks associated with increased climate impact.

d. Since the adaptive capacities of CAREC countries at present time are largely restrained by the state of their economic performance, the development finance will be needed to strengthen their climate resilience towards exacerbating water stress. Yet, the resource mobilization alone will likely not be sufficient for successful adaptation. CAREC countries should continue making efforts to improve their capacities to design and implement effective policies.

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