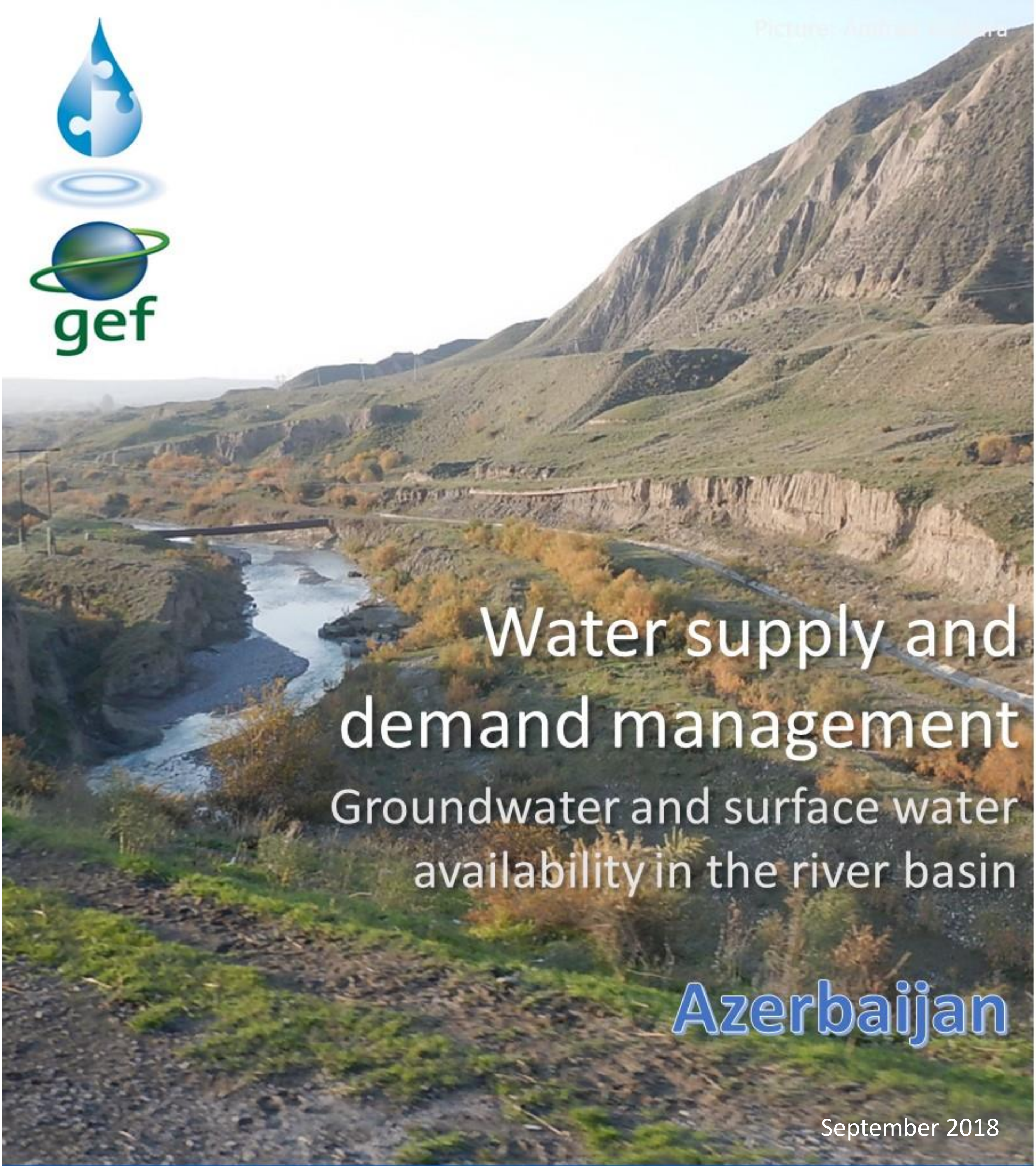

# Water supply and demand management

## Groundwater and surface water availability in the river basin

## Azerbaijan

September 2018

United Nations Development Program

Advancing Integrated Water Resource Management (IWRM) across the Kura river basin through implementation of the transboundary agreed actions and national plans

# National Assessment report: Groundwater and Surface Water Availability in the River Basin

# Part II: Azerbaijan

## Document Information

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## List of Abbreviations and Acronyms

| | |
|---|---|
| BCM | Billion Cubic Meter |
| CC | Climate Change |
| EIB | European Investment Bank |
| FAO | Food and Agricultural Organisation |
| GCM | Global Circulation Models |
| GNEWSRC | Georgia National Energy and Water Supply Regulatory Commission |
| GWP | Georgian Water and Power Company |
| HPP | Hydro Power Plant |
| IEV | Intrinsic Ecological Value |
| JSC | Joint Stock Company |
| LTD | Limited Company |
| MCM | Million Cubic Meter |
| MEA | Ministry of Environment Protection and Agriculture |
| MPD | Minimal permissible discharges |
| UNDP | United Nations Development Program |
| UWSCG | United Water Supply Company of Georgia |
| WWTP | Wastewater treatment plant |

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# Water availability in the Kura River Basin

# 1 THE KURA RIVER BASIN

The Kura/Aras River Basin stretches over five countries, namely Armenia, Azerbaijan, Georgia, Iran and Turkey, and covers an area of 186 600 km². Azerbaijan with an area of 86 600 km² and Georgia (69 700 km²) cover together 88% of the Kura River Basin ( (FAO, Aquastat, 2018).

The Kura River, originating in Turkey, forms the main river basin in the South Caucasus with approximately 1500 km length. After 150 km the Kura River reaches the border of Georgia. While flowing east, the river follows the large valley between the Greater Caucasus and Lesser Caucasus mountains. It drains most of the southern Caucasus and the mountain ranges of the extreme northern Middle East.

The largest tributary is the Aras River which has its origin also in Turkey. Along its course to the Kura River, the Aras River constitutes the border between Turkey and Armenia, Armenia and Iran and Iran and Azerbaijan.

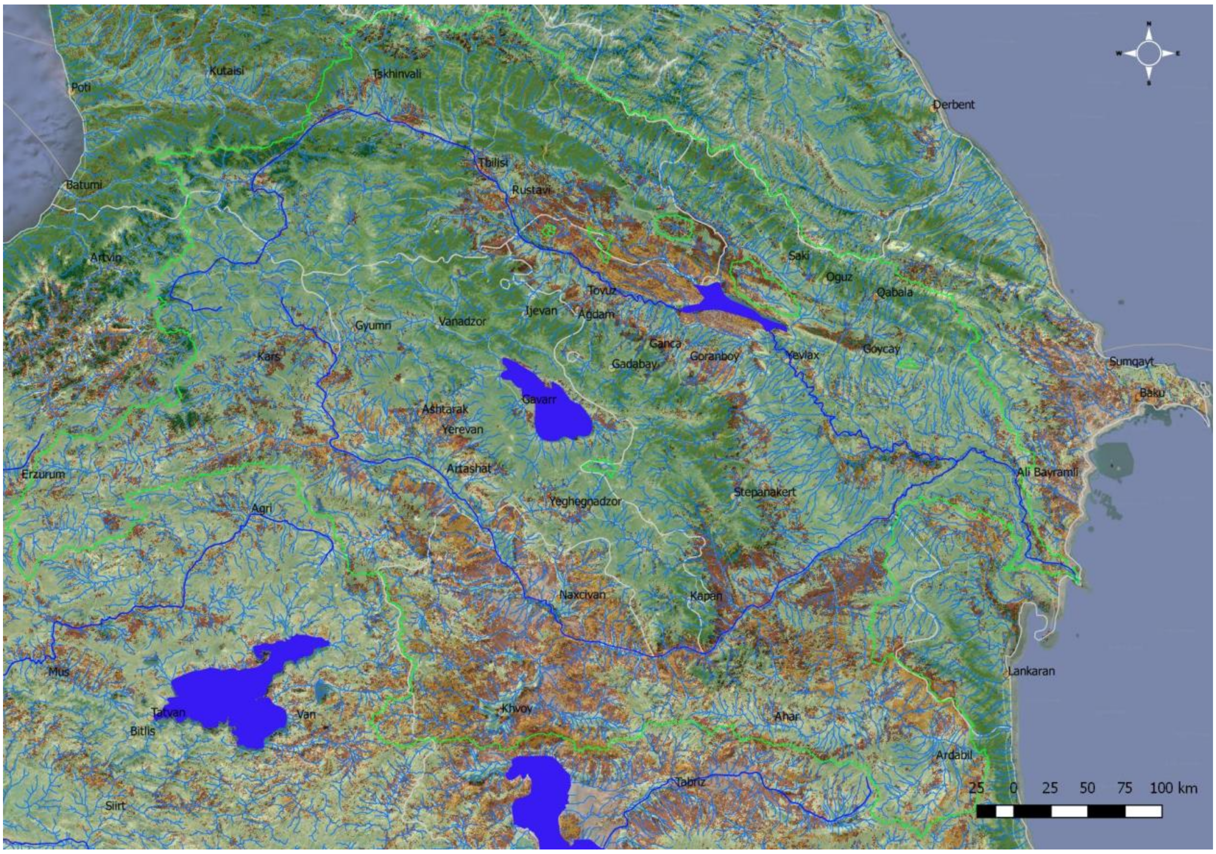



Figure 1: Overview of the Kura River Basin

The Kura River Basin is the main transboundary water system in the geopolitically challenging region of the South Caucasus. The participating countries of Azerbaijan and Georgia have undergone significant political and economic transition and are now developing rapidly across a wide range of water dependent sectors (UNDP, 2017).

The UNDP GEF Kura *Project Advancing Integrated Water Resource Management (IWRM) across the Kura river basin through implementation of the transboundary agreed actions and national plans* is implementing a Strategic Action Program for the Kura River Basin in partnership with the Governments of Georgia and Azerbaijan.

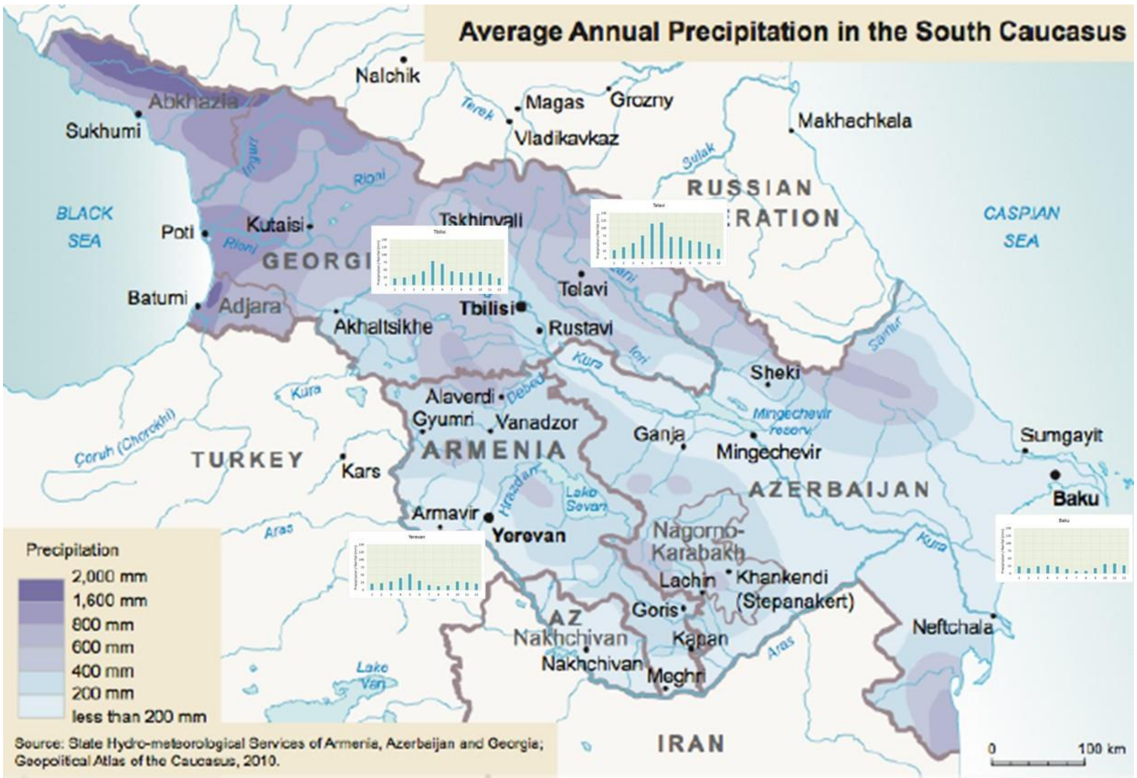



Figure 2: Precipitation in the Kura River Basin, modified from (Hannan, Leummens, & Matthews, 2013), precipitation from climate-data.org

Precipitation in the basin ranges from less than 200 mm up to more than 1600 mm. The distribution is illustrated for Baku, Tbilisi, Yerevan and Telavi.

The runoff in Azerbaijan follows more or less the elevation. The highest yield of runoff occurs in the mountains, while the Kura and Aras lowlands are regions with considerable abstraction and losses.

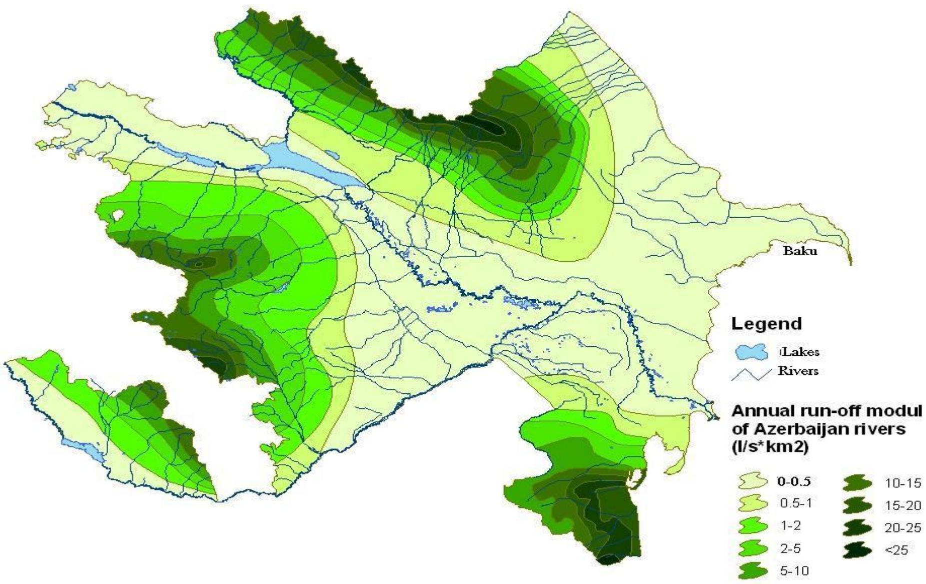



Figure 3: Runoff map of Azerbaijan taken from (Verdiyev, 2018)

The runoff distribution in Georgia was taken from (Beldring, 2017). The figure shows the big differences of the major basins. The western part of Georgia draining into the Black Sea has considerably higher precipitation and runoff compared to the eastern part draining into the Caspian Sea.

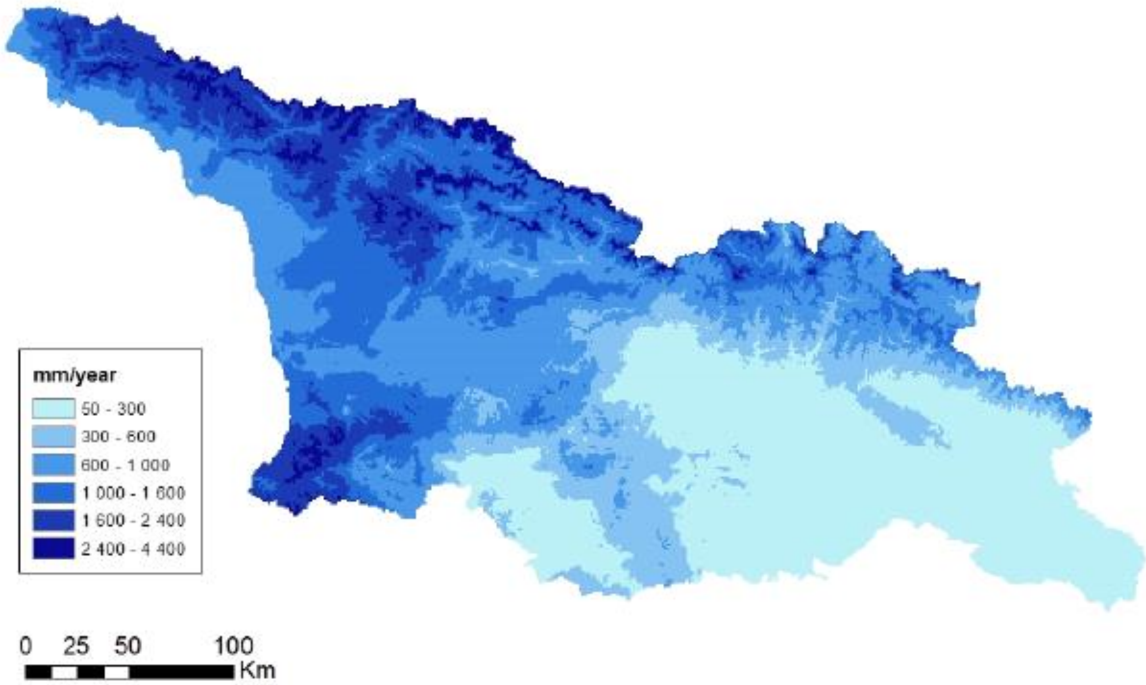



Figure 4: Runoff map of Georgia taken from (Beldring, 2017)

The assessment of available water resources is considerably hampered by substantial gaps regarding data and reliability of data. Figures concerning surface and groundwater resources in Georgia and Azerbaijan result in different water balances depending on the sources used. The sources were National Statistics of Georgia (GEOSTAT, 2017), FAO Aquastat, UNICEF Washdata.org, (Hannan, Leummens, & Matthews, 2013), (Vogel, 2017) and internal reports of the Kura II Project provided by national consultants from Georgia and Azerbaijan. Which data source is used for preparing tables or figures is indicated.

In order to produce a consistent water balance for the Kura River Basin, only data from the Second Assessment of transboundary rivers, lakes and groundwaters (UNECE, 2011) were finally applied to generate Figure 5. This represents the best estimate about the flow network of the Kura-Aras River Basin based on massive effort supported by all governments involved in the Kura River Basin.

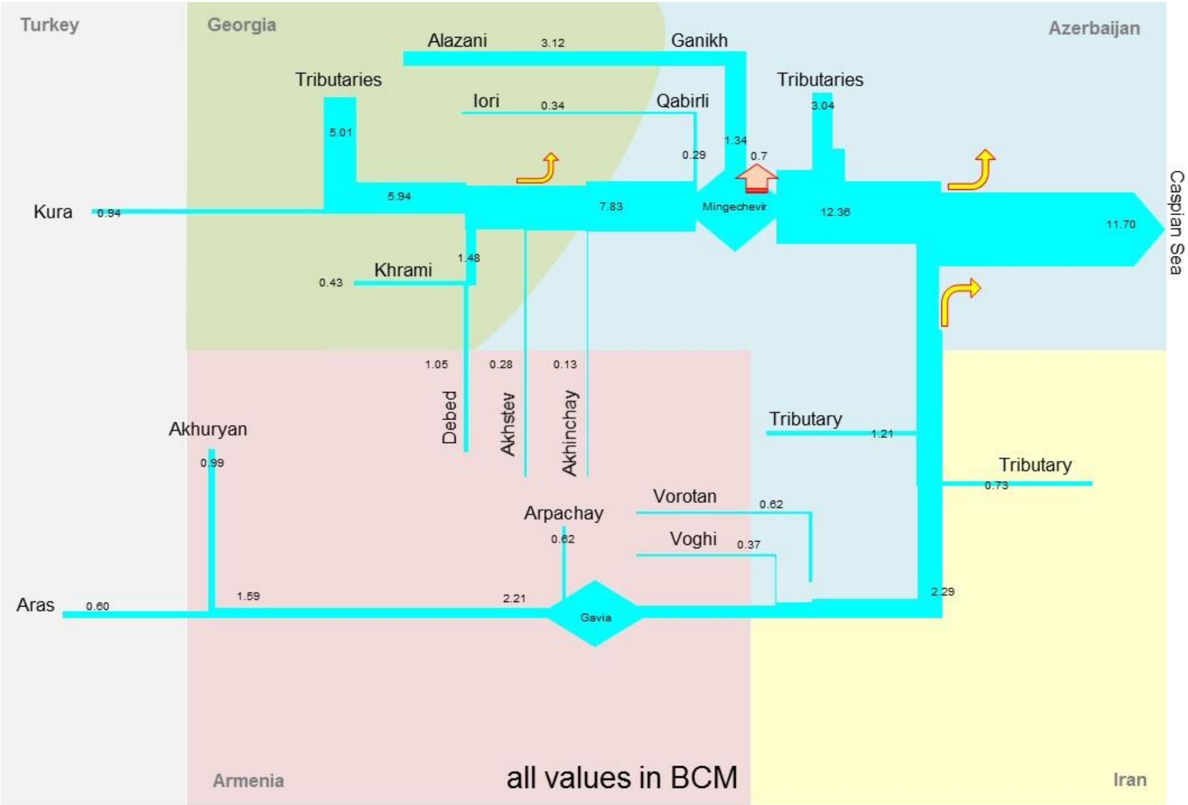



Figure 5: Surface water flow chart of Kura-Aras River Basin (source: (UNECE, 2011)

Figure 5 is schematic flow network of the Kura and Aras River with the contribution of major tributaries. All data refer to long-term average conditions.

# 2 CURRENT SITUATION (BASELINE)

UNECE has compiled data about renewable water resources in the Kura Basin given as follows.

Table 1: Renewable water resources per capita in the Kura River Basin (UNECE, 2011)

| Country | Renewable surface water resources (km3/year) | Renewable groundwater resources (km3/year) | Total renewable water resources (km3/year) | Renewable water resources per capita (m3/capita/year) | Period of observations used for estimating water resources |
|---|---|---|---|---|---|
| Azerbaijan | 8.704 | 5.2 | 13.9 | 1.913 | 1953-2008 |
| Georgia | 6.438 | 1.923 | 8.362 | 3.144 | 1935-1990 |

The figures correspond well with the flow chart in Figure 5.

Concerning water availability, it is meaningful to assess long-term trends and distribution patterns of streamflow. An aggregated analysis capturing surface and groundwater is possible by assessing streamflow along different points along the Kura River. The underlying assumption is that streamflow includes renewable base flow from groundwater aquifers. The further downstream the observation point is the more groundwater aquifers contribute to the streamflow. Another aspect why the analysis focuses on streamflow is the fact that groundwater data are scarce and do not allow an equally profound analysis compared to surface water.

The following analysis was conducted based on annual streamflow data from 1975 to 2010 and monthly distribution patterns at different locations along the Kura River taken from (Hannan, Leummens, & Matthews, 2013). Since repetitive monthly pattern are used the inner-annual distribution might divert from reality but is still within an acceptable confidence interval.

The current situation is referred to as baseline.

The points for the analysis are illustrated in Figure 6.

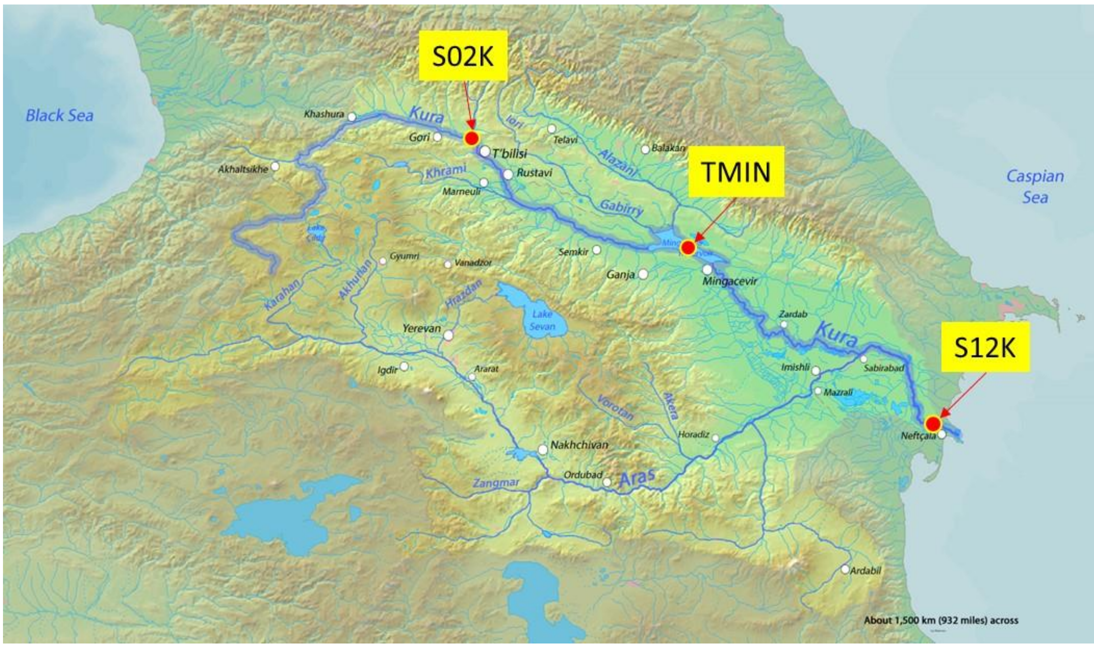
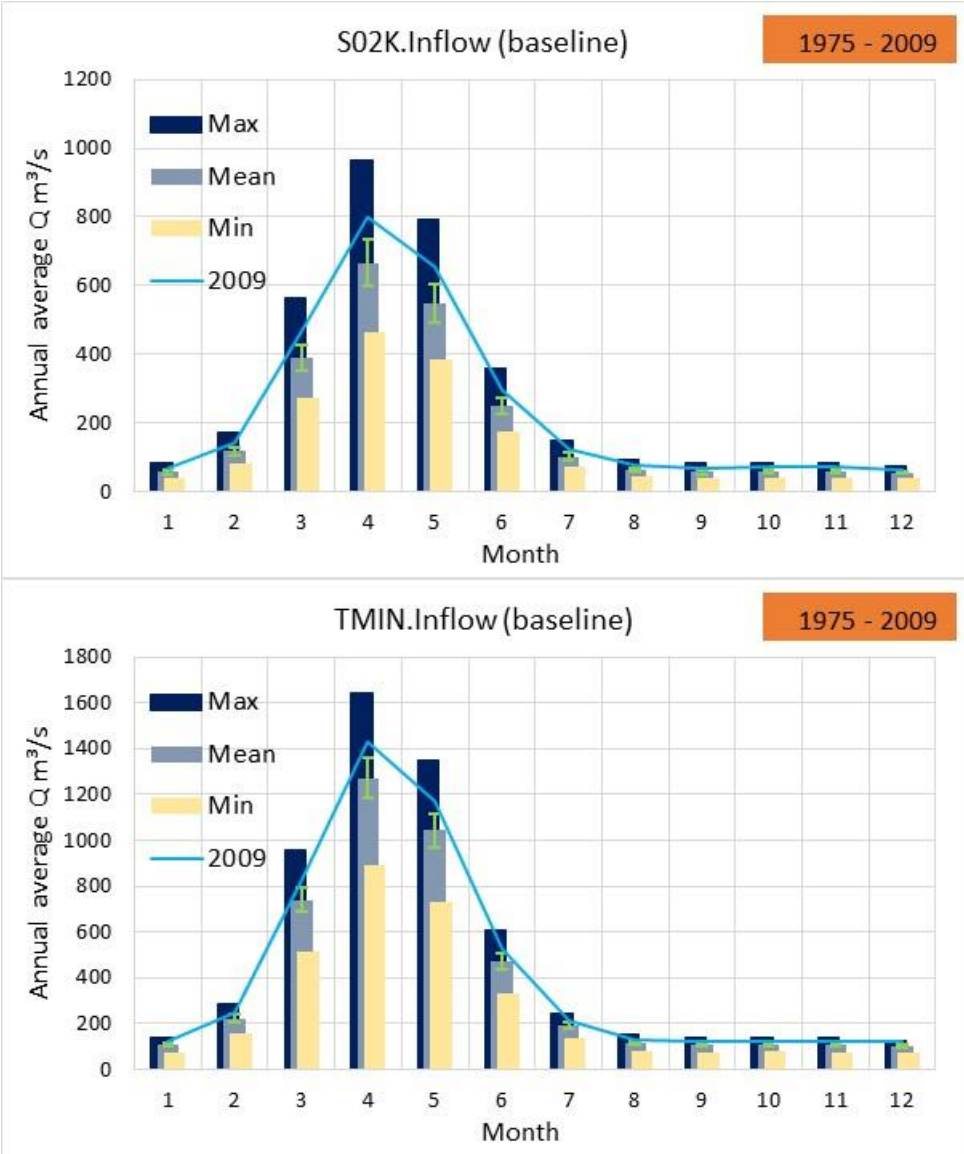



Figure 6: Selected points for the analysis along the Kura River

Three points were selected. S02K represents the upper part and receives flow from the sub-catchments in the northern Caucasus Mountains and upstream the confluence with the Khrami River. TMIN is the total inflow into the Mingechevir reservoir the catchments of the Khrami, Debed, Akhstev, Akhincay, Iori/Qabirli and Ganikh/Alazani rivers. S12K is the mouth of the Kura River and represents the flow which discharges into the Caspian Sea.

The monthly distribution with long-term mean, min and max values is given in Figure 7.



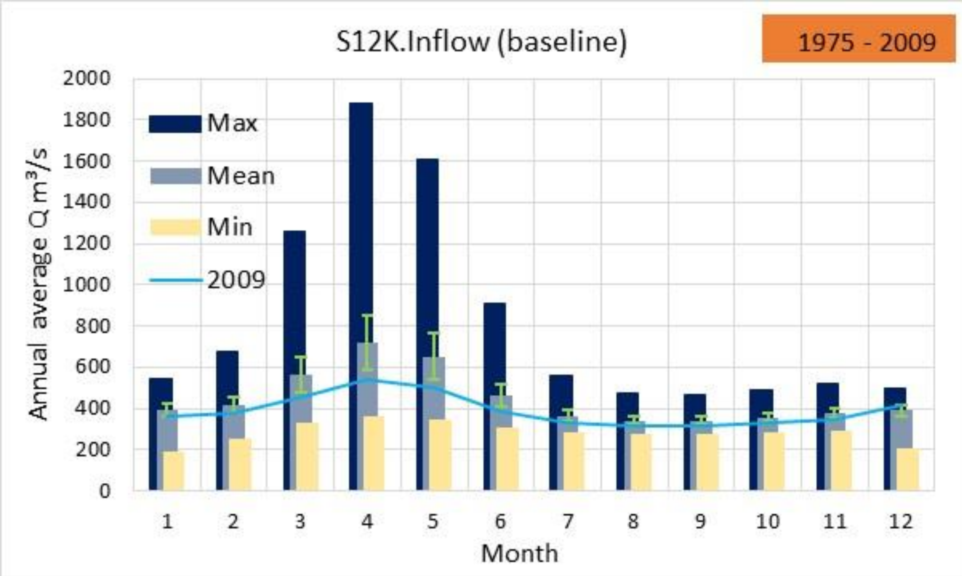
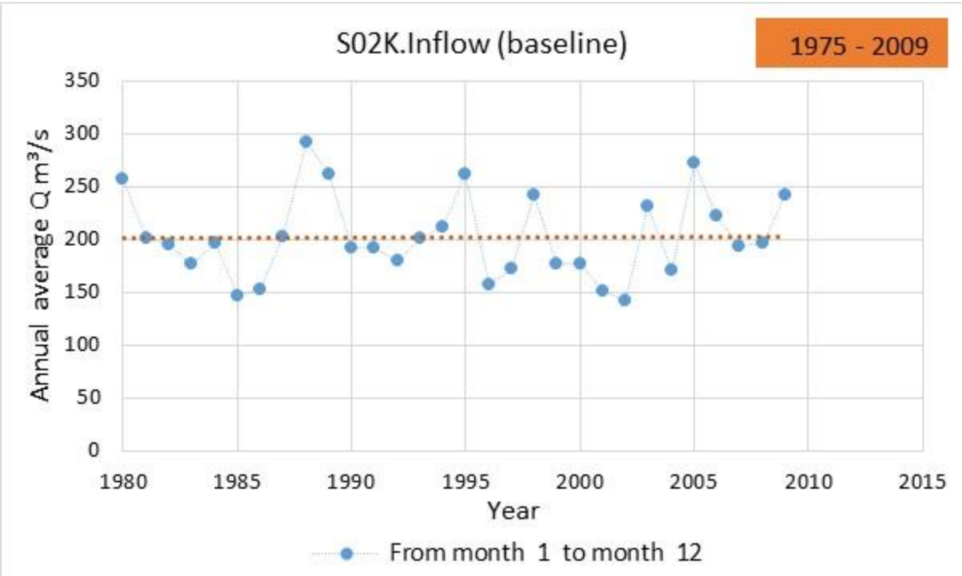



Figure 7: Long-term mean, min and max monthly discharge illustrated with the year 2009

The effect of the Mingechevir reservoir is clearly visible, smoothing downstream mean and min values. However, max values still occur during high flow conditions.

A trend analysis explains what the future would be like if past conditions were to continue and extrapolation was possible.



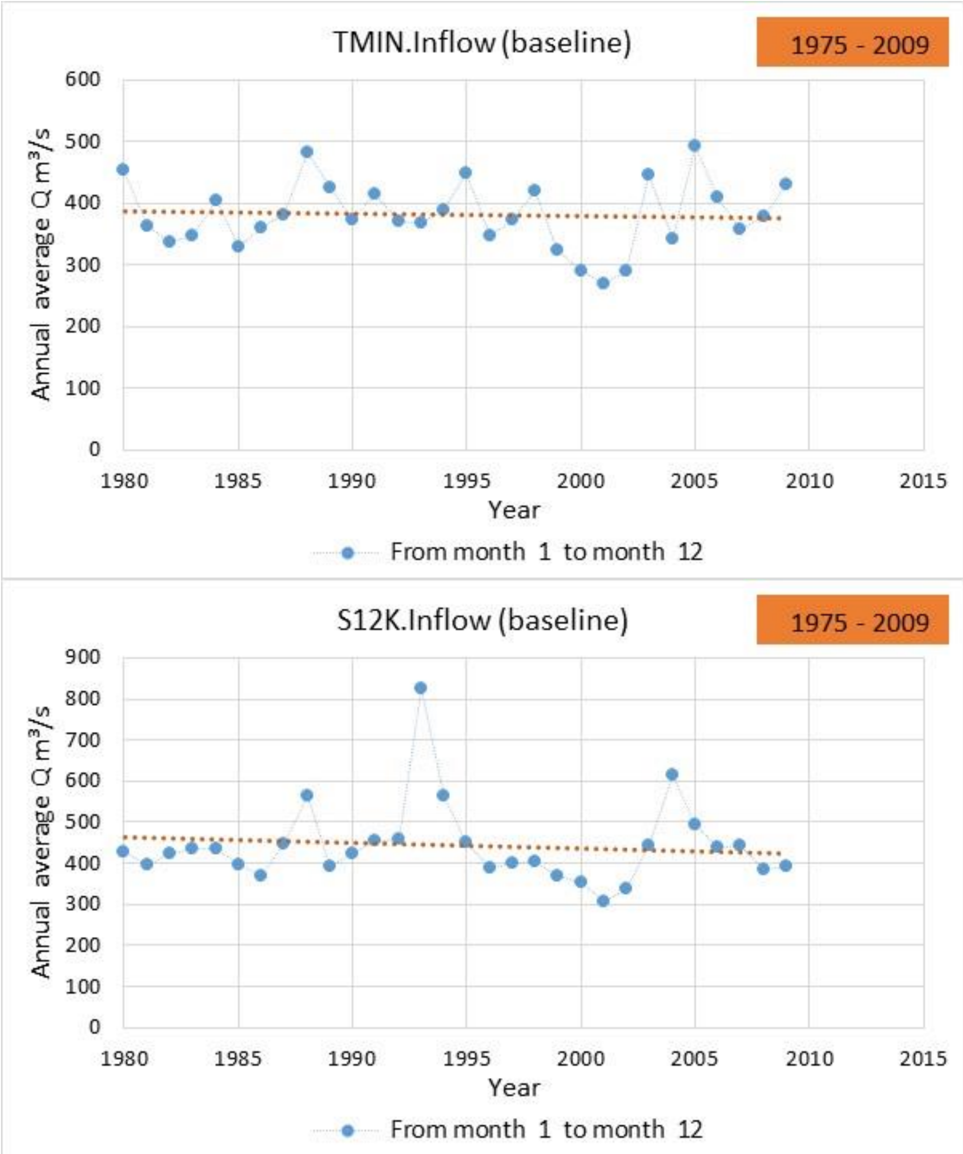



Figure 8: Trend analysis for annual streamflow 1975 – 2010

There is no trend visible in the upper part of the Kura River while a trend seems to exist at the confluence. Such a trend is among others also mentioned in (Verdiyev, 2017b). Analysing the anomaly or derivation from the long-term average shows that the trend mainly stems from exceptionally dry years end of the 90s and the beginning of this century.

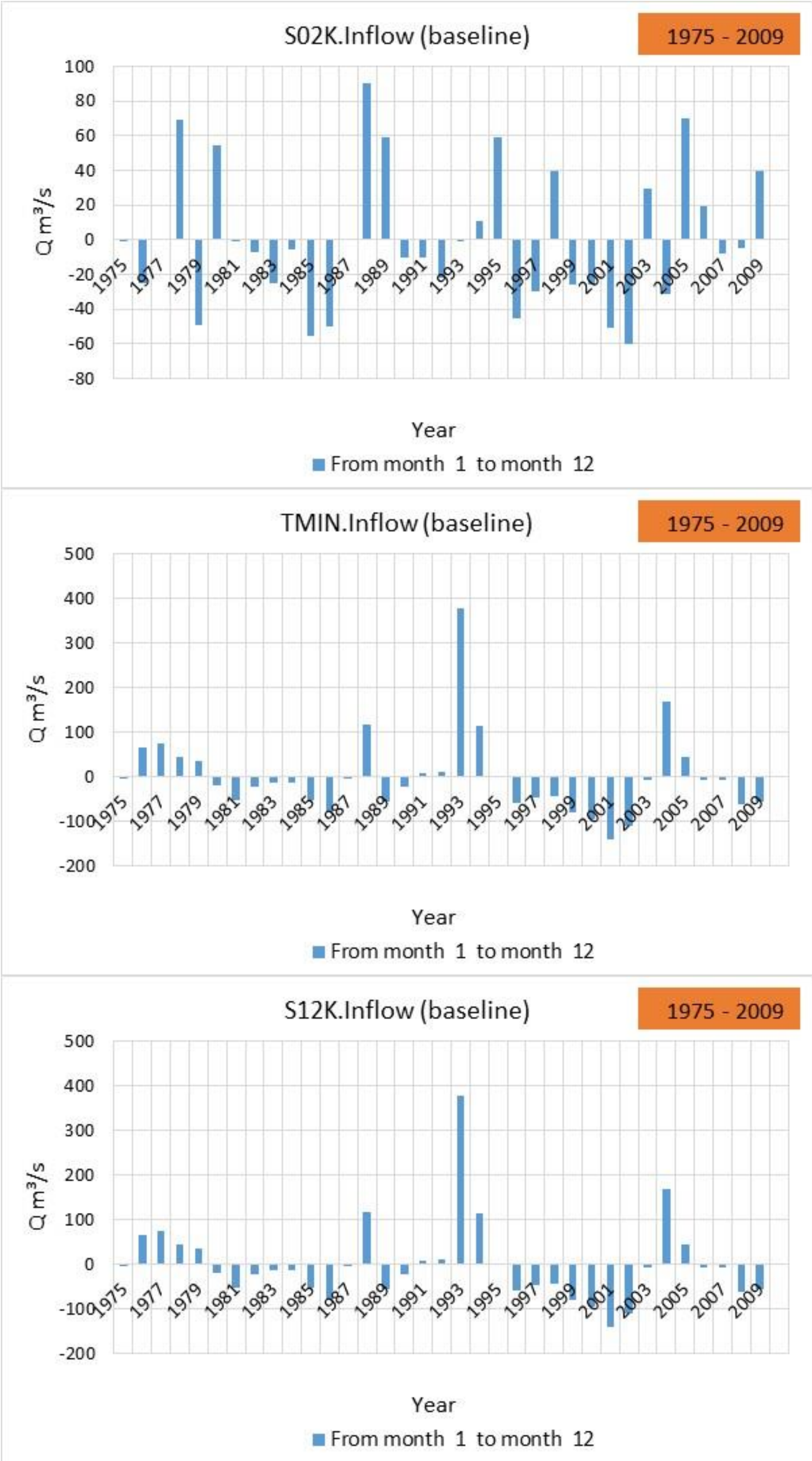



Figure 9: Anomaly of annual streamflow 1975 – 2010

# 3 CLIMATE CHANGE IMPACTS ON WATER AVAILABILITY

The Regional Climate Change Impacts Study for the South Caucasus Region ( (UNDP, 2011) was conducted in 2011 and assessed the Kura River Basin according to likely effects of climate change. A team of international and national experts from Armenia, Georgia and Azerbaijan supported by relevant Ministries of each country worked together on behalf of UNDP and assessed the effect of climate change on available water resources. 65 meteorological stations were analysed, results of different emission scenarios from global circulation models (GCM) were obtained, downscaled and analysed.

The report highlights that climate change is already occurring in the South Caucasus. On the country-average scale, Armenia, Azerbaijan and Georgia all show statistically increasing trends in mean annual temperature, mean daily minimum temperature and mean daily maximum temperature over the last century. The evidence for trends in annual precipitation is less convincing, although there are stations in Armenia and Azerbaijan that have experienced precipitation declines. In Georgia, there are no decreasing trends in annual precipitation, but two stations in the southwestern part of the country show increasing trends in precipitation. Almost all the meteorological stations have recorded increases in the duration of warm spells – either consecutive days above 25 ºC or consecutive nights higher than 20 ºC. There is no strong evidence that the maximum duration between rainy days is changing in the South Caucasus (cited from (UNDP, 2011)).

Evaluating results of emission scenarios, all GCM are in accord that the mean annual temperature will increase significantly by the end of the century (A2 emission scenario): 1.8 ºC-5.2 ºC and 3.5 ºC-4.9 ºC, in western and eastern Georgia, respectively; 4 ºC - 5.1 ºC in Armenia; and 3 ºC-6 ºC in Azerbaijan. However, results for precipitation are less homogeneous. One GCM shows an increase of precipitation while all other models applied for the region revealed a decline in precipitation for all three countries: 20 – 31% in Armenia, 5- 23% in Azerbaijan, and 0 – 24% in Georgia by the end of the century (A2 emissions scenario). In view of already occurring dryer conditions, there is more evidence that the South Caucasus will continue to become drier this century rather than becoming wetter.

What this means for water availability was further analysed in (UNDP, 2011). Three transboundary river basins in the South Caucasus were assessed: Alazani (Ganikh), Khrami-Debed and the Aghstev River Basins. Due to projected declining precipitation and increasing temperatures, by the end of the century, streamflow is projected to decline dramatically: 26 - 35%, 45 – 65%, and 59 – 72% in the Alazani (Ganikh), Khrami-Debed and Aghstev Basins, respectively. If this becomes reality within the next 30 to 70 years, there is a dramatic change of the water resources in the countries.

In the light of this assessment, one scenario was developed and evaluated, a 25% reduction of streamflow equally distributed over the Kura River Basin.

Although a 25% reduction is the lowest impact according to (UNDP, 2011), the effect is huge and disproportional. It is obvious that any scenario with a higher reduction of streamflow would result in even worse conditions.

Uncontrolled streamflow will drop dramatically and it is questionable if low flow conditions remain at the level indicated. As the reduction of streamflow refers to annual conditions, the inner-annual distribution is unclear and uncertain. A very likely assumption is that wet month become wetter and dry month become dryer as this can be observed at many locations (Lohr, Froehlich, & Richter, 2018). It was decided not to add an additional assumption about inner-annual distribution as no data or sufficient background was available for verification.


Figure 10: Comparison of baseline and CC scenario A (long-term mean, min and max)

The figures seem to reveal that floods are not a problem anymore. This is wrong as monthly means simply level out effects of extreme but short flood events. In other words, preparedness for drought and flood will still be necessary and most likely with wise to allow for higher intensities.

The situation occurs less drastically downstream the Mingechevir reservoir. The answer is that the relatively consistent streamflow level at point S12K is achieved at the expense of the reservoir level.

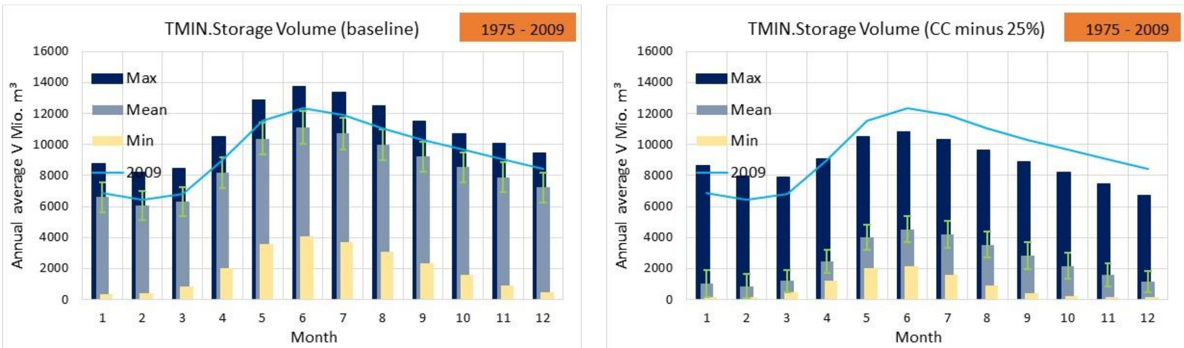



Figure 11: Comparison of baseline and CC scenario A (storage volume – Mingechevir reservoir)

The decrease of the storage volume means a reduction of security of supply. What can be derived from the results is that a reduction of streamflow of 25% percent results in a reduction of roughly 50% of the storage content to maintain downstream requirements.


Figure 12: Comparison of trends for annual streamflow (baseline – CC)

Apart from the fact that streamflow drops by 25%, it is interesting that the trend exacerbates downstream the reservoir. The reason is that the reservoir more frequently reaches its minimum operating level and cannot fulfil the required low flow augmentation.

# 4 FUTURE DEVELOPMENTS IN THE COUNTRY

## 4.1 Population and water statistics

The State Statistical Committee of the Republic of Azerbaijan makes their records accessible through a website (Azerbaijan, 2018). All population related information was taken from there.

The State Statistical Committee of the Republic of Azerbaijan has published the census on population from 1897 to 2018 (Azerbaijan, 2018). The current growth rate is about 1% with a declining trend. The rural population diminished slightly in favour of a larger number of urban population. Since almost 50 years migration into urban areas at a low level is apparent according to the figures.

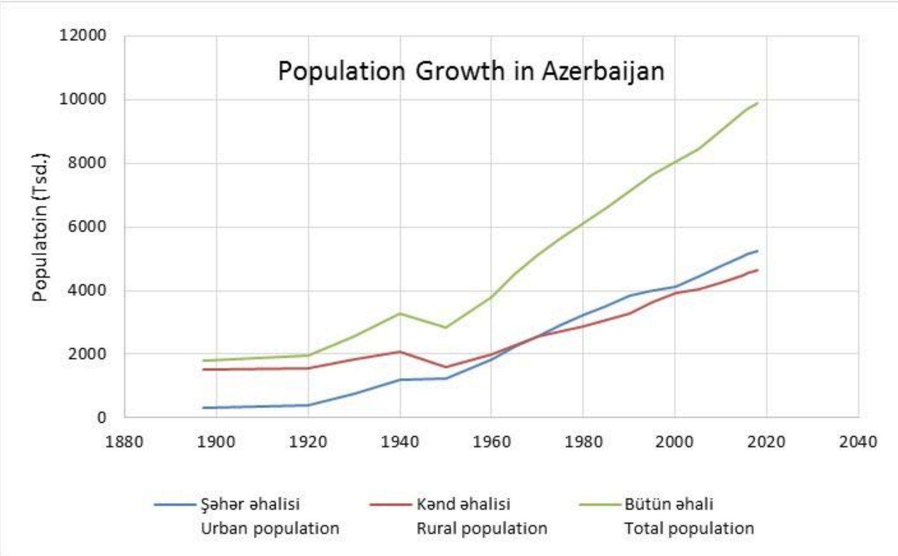



Figure 13: Population in Azerbaijan 1897 to 2018 (Azerbaijan, 2018)

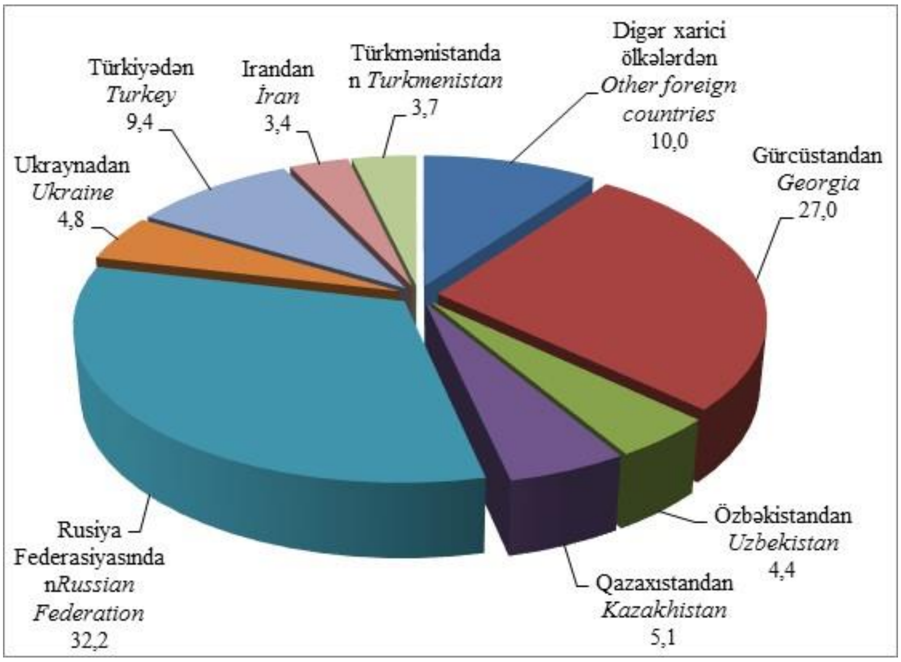



Figure 14: Migration into Azerbaijan (Azerbaijan, 2018)

The countries Georgia and Azerbaijan are not only linked through natural resources like the Kura River but also by migration. Georgia ranks second in the list of countries from where people migrate to Azerbaijan with a long-term perspective.

The water consumption from 1990 to 2017 is shown in Figure 15. While domestic and industrial needs remain nearly constant, the agricultural sector shows an increasing trend.

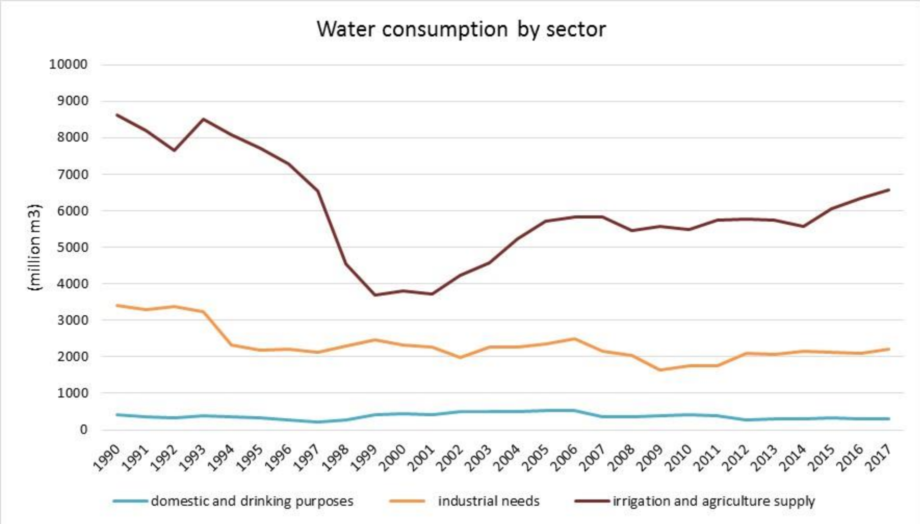



Figure 15: Water consumption in Azerbaijan by sectors (Azerbaijan, 2018)

Given the statistical figures and combining them with population, the water consumption in 2017, which is the latest year published, amounts to 81 (l/day/capita) for drinking water, 1835 (l/day/capita) for irrigation and total consumption 2550 (l/day/capita) on average.

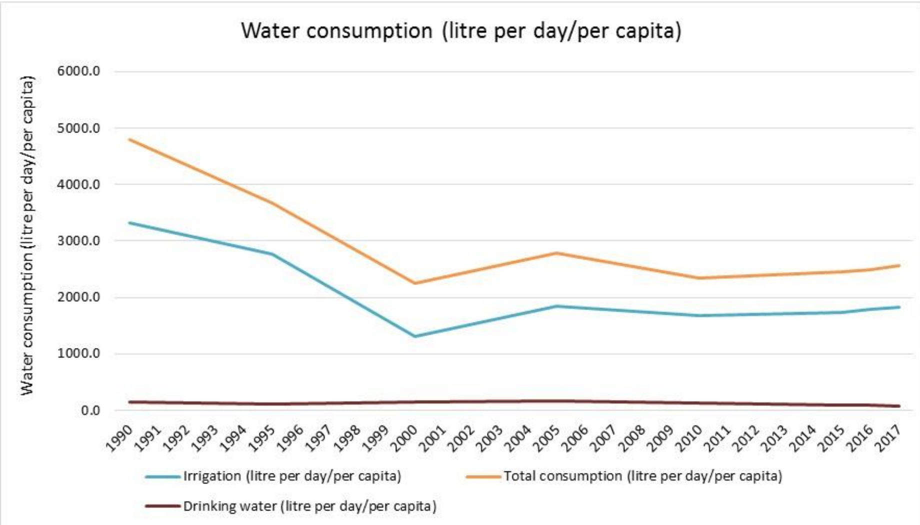



Figure 16: Water consumption litre per day and per capita with figures from (Azerbaijan, 2018)

The total amount of water abstracted runs up to 12 BCM/year most of which is withdrawn from the Kura River.

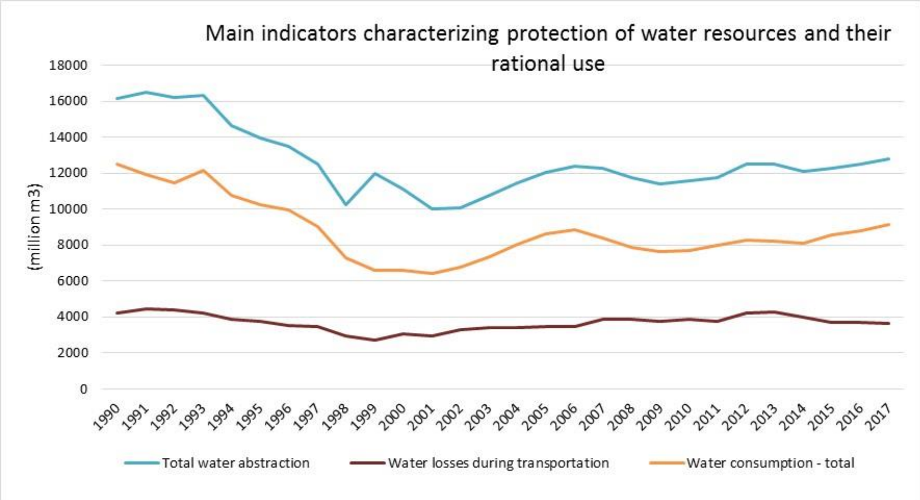



Figure 17: Water abstraction, water consumption and losses (Azerbaijan, 2018)

## 4.2 Agriculture

Agriculture in Azerbaijan relies on irrigation since the area where agriculture is present is arid.

The area under cultivation in the country is large and space for new development is limited. Therefore, development in the agricultural sectors in Azerbaijan will concentrate on improving and enhancing existing sites rather than developing new irrigable land. This means that the focus will be on the enhancement of existing sites, irrigation efficiency and improved operation of water infrastructure to reduce water consumption. The country seems to have good preconditions to follow this path given the fact that Azerbaijan is forced to use the very limited water resources in an efficient way to cope successfully with the future.

The figures from (UNDP, 2011) provide a valuable source of information on future crop water and irrigation requirements, although the assessment have been made for sites in Georgia. If results from the analysis in Georgia are transferred to Azerbaijan, it can be assumed that due to the more arid climate conditions the increase of crop water requirements will exceed those in Georgia. As a result, the expected increase of 20 to 40% in crop water requirements is regarded as a lower bound for Azerbaijan.

The increase in water requirements is a consequence of decreasing precipitation and increasing temperatures with higher evapotranspiration. Even maintaining existing irrigation facilities will require significantly more water in the future. A shift to drought-tolerant crops, efficient use of modern irrigation techniques, nature-based erosion protection measures to keep soil fertility as high as possible are proposed in (UNDP, 2011).

## 4.3 Industry

Industrial sector in Azerbaijan is largely dominated by the exploitation of natural resources like gas and oil and linked industries. These sectors are probably not much affected by water resources. This might change when it comes to processing of agricultural products. Sugar companies, to mention one branch, needs water and produces large amounts of waste water so that they are affected in two ways: water withdrawal and enough water to dissolve discharge waste water.

## 4.4 Mining

Certain activities related to mining need water, be it as direct consumers of water for production processes or be it to have sufficient streamflow to limit concentrations of toxic and/or unwanted substances when waste water is discharged into rivers. The problem of emitting waste water and keeping a good standard of water quality has increasingly become an issue in Europe and in other parts of the world. The level mining companies are affected depends on how water quality standards are enforced and environmental laws are mandatory. The EU WFD, for example, owns high water quality standards and if and when Azerbaijan is to adopt the EU WFD, mining companies or more generally, all emitters of waste water, are advised to pre-empt restrictions by foresighted investments in advanced water treatment technology.

## 4.5 Hydropower and Energy generation

A reduced availability of flow has detrimental effects on hydropower generation. A 25% drop of streamflow will reduce the operating time of turbines disproportionally as a 25% reduction is beyond the assumptions used when turbines were designed, so that minimum operating levels will often be undershot. Developments of hydropower dams in the country, if any, should take likely changes in streamflow regimes into account by a flexible design and flexible turbines with a flat efficiency curve and a wide range between the maximum capacity and minimum flow.

Conventional power plants relying on water for their cooling system or if they release water with high temperatures into rivers will face more production stops compared to the past.

## 4.6 Summary

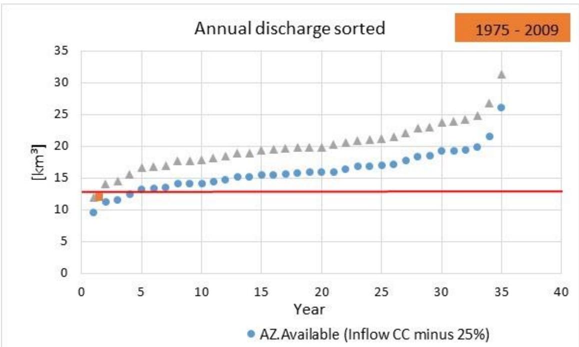
The most important issue of the future in view of water resources will be to what extent the gap between water requirements and water availability opens and how adaptations measures are able to cope with adverse climate conditions.

Climate change will certainly exacerbate drought conditions and will lead to an increase of crop water requirements. Both points are detrimental to the security of water supply.

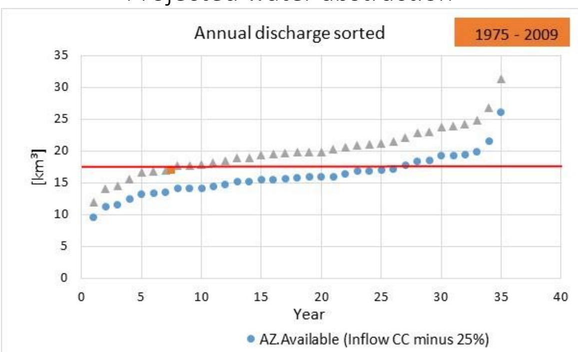
The results taken from (UNDP, 2011) in combination with the simplified hydrological modelling approach and future projections about water abstraction, indicate that with baseline conditions, annual water availability in Azerbaijan falls short of the annual average abstraction of 12 BCM in less than two years out of 35. With the climate change scenario and unchanged abstraction, the shortages increase to 5 years out of 35.

In case the projection is used, calculated with a linear trend since 2010, baseline climate conditions show an increase of shortages from less than 2 to 7 years out of 35 years. With both, projection and climate change conditions, only 9 years out of 35 reach or exceed the required water abstraction. In other words, enough water will be available only every 4th year.

Current water abstraction



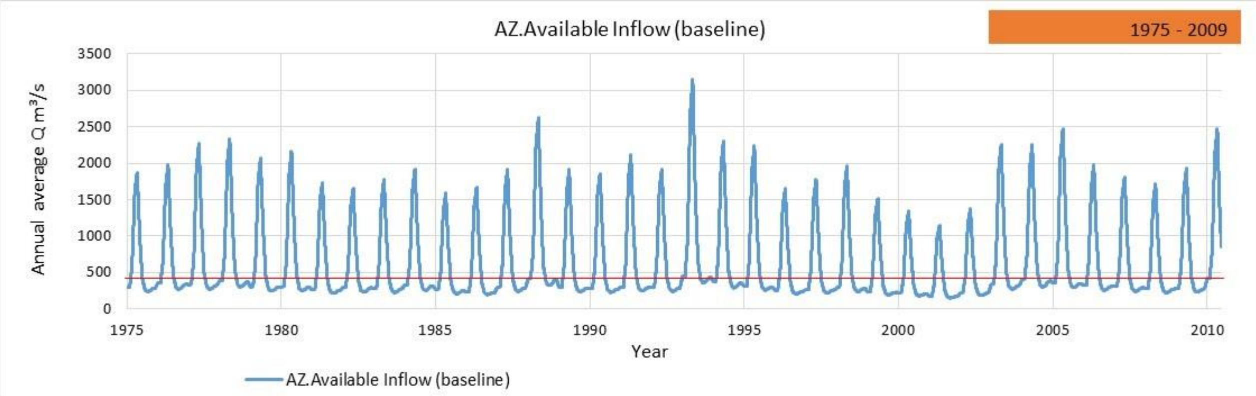

Projected water abstraction




Gray = baseline; blue = CC

Figure 18: Water shortages under baseline and climate change conditions in Azerbaijan

It is obvious that additional water storage is needed. The hydrograph indicates that year by year the low flow period must be bridged with water from reservoirs.



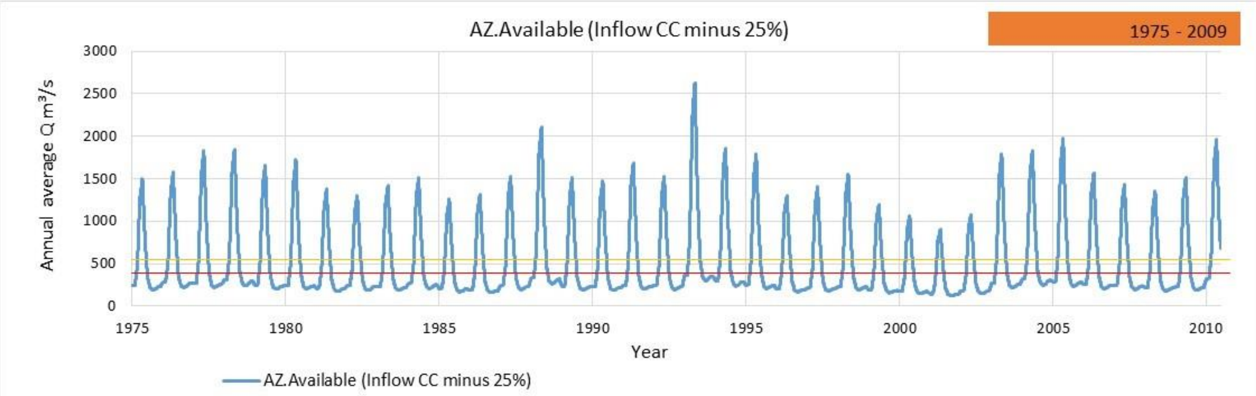




Figure 19: Hydrograph with baseline and climate change conditions in Azerbaijan

The red colour indicates the current level of water abstraction and orange is the projected level.

New reservoirs would form large water surface areas. This would give rise to huge losses due to evaporation. Therefore, good reservoir sites or even underground reservoirs along with desalination could be possible solutions.

Undoubtedly, every effort to increase water use efficiency, even though not economically viable at the moment, will pay off in the long run.

Summarizing the results, the climate change assessment conducted on behalf of UNDP in 2011 ( (UNDP, 2011) and hydrological modelling performed for this report, reveal a likely 25% reduction of streamflow, which can lead to a 50% drop of storage volume in reservoirs as exemplarily demonstrated for the Mingechevir reservoir. The drop is caused due to the attempt to keep downstream requirement at the current level.

As a result, the security of supply will drop and reservoir operation might become more challenging. The need for seasonal forecasts will rise. Integrated planning and strong collaboration between different sectors will be a must.

Furthermore, a reduction of streamflow will certainly decrease the quality of surface water if the current standard of waste water treatment in still in place in the future.

Reduced streamflow will lead to more groundwater abstraction, most likely beyond the annual recharge level, which will be reduced as well.

As such, water use efficiency will become one pillar for development or – if not in place – a major obstacle for development. Consequently, water use efficiency should be promoted and enforced at all levels.