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Upstream – Downstream

Amu Darya, Syr Darya, Kyrgyzstan

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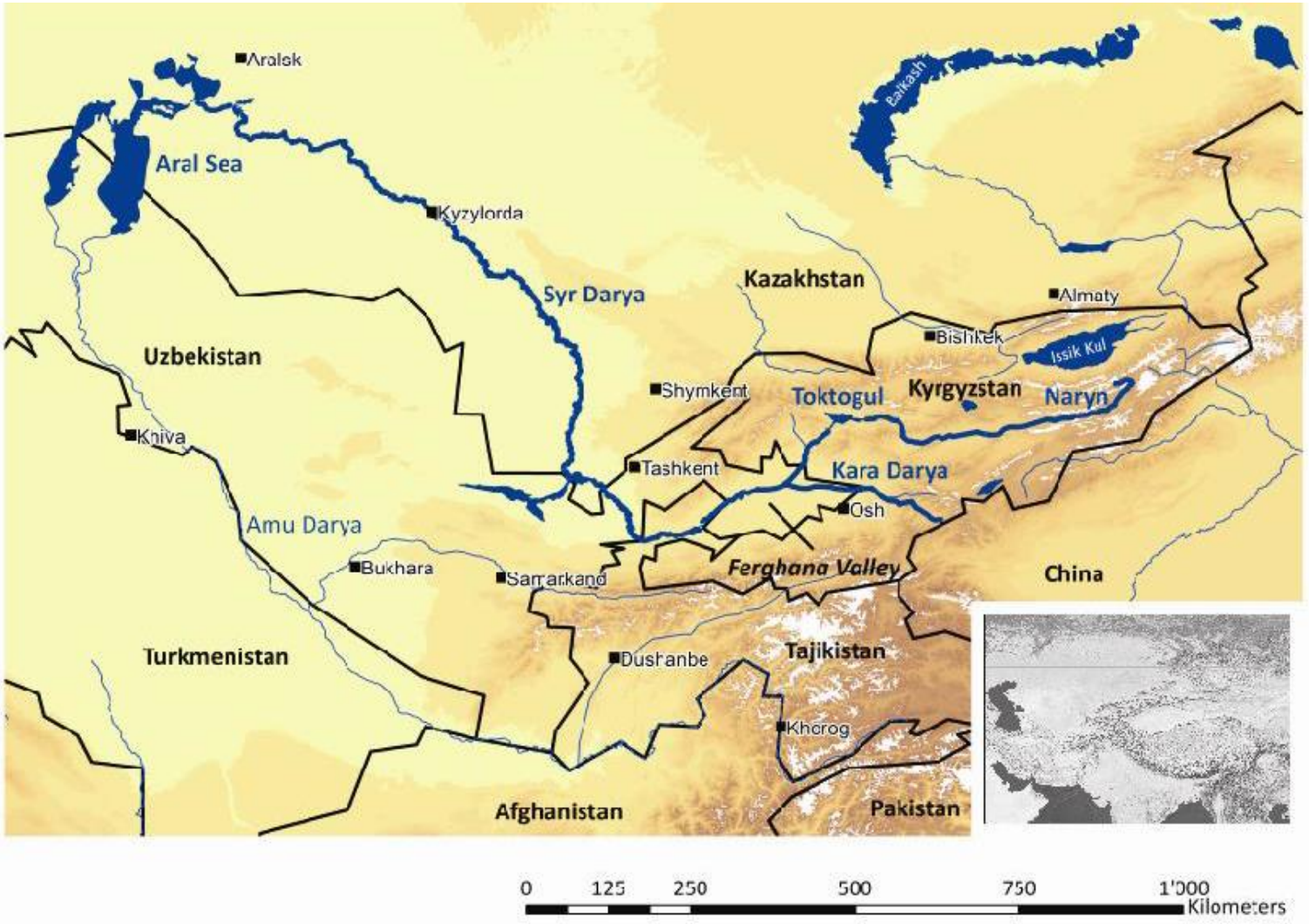
IHCAP – Indian Himalayas Climate Change Adaptation Programme
Capacity building programme “Cryosphere” Level-2 (February 2015)

Geographical overview

Topographic map of Central Asia

Geographical overview

Hydro-political map of Central Asia



Hydrological situation

Central Asia

- The post-Soviet states of ***Kazakhstan***, ***Kyrgyzstan***, ***Tajikistan***, ***Turkmenistan*** and ***Uzbekistan*** make up an area that is larger than ***4 Mio. km²*** and is home to ***~60 Mio. people***.
- **Syr Darya** and **Amu Darya** are the two main rivers of the region.

- The majority of ***water feeding*** of the two rivers is formed from ***glacier-*** and ***snowmelt*** in the high ***Pamir*** and ***Tien Shan ranges*** in Kyrgyzstan and Tajikistan.
- The **Syr Darya** river is formed by ***two tributaries*** originating in Kyrgyzstan, the ***Naryn River*** and the ***Kara Darya*** river.
- As it flows towards the Aral Sea, the **Syr Darya** river provides ***freshwater and water for irrigation*** to ***Uzbekistan, Tajikistan*** and ***Kazakhstan.***

Climatical situation

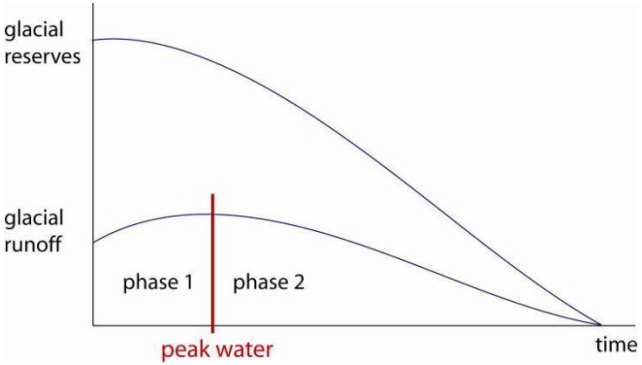
- Central Asia is characterised by a ***continental*** and ***semi-arid to arid climate*** with ***hot summers*** and ***cold winters***.
- ***Precipitation*** rates are ***low***, especially ***during summer***, when precipitation occurs almost exclusively in the mountainous regions.
- **Past decades**:
  - ⇨ ***temperatures*** have ***increased*** in all parts of Central Asia
  - ⇨ ***precipitation*** rates have ***increased at low altitudes*** and decreased at ***higher elevations***
  - ⇨ ***glaciers*** in the Tien Shan mountains have ***lost*** much of their ***volume***
- **Future**:
  - ⇨ continuous increase of temperature (2.6 - 4.4 °C by 2050)
  - ⇨ Precipitation is likely to increase in winter (4 -8 %) and decrease in summer (4 – 7%) by 2050
  - ⇨ probably more extreme events such as drought-prone summers and flooding in winter/spring
  - ⇨ earlier and more intense snowmelt; decrease in snow cover duration
- ⇨ even in the most glacier-friendly scenario, glaciers will lose up to two thirds (−60%) of their 1955 extent by the end of the 21st century

Ref: Sorg et al, 2014: The days of plenty might soon be over in Central Asia: Environmental Research Letters 10/2014

Buffering effect of glaciers

- In Central Asia, water supplies are critically dependent on glacier melt.
- The glaciers act to ***buffer periods of seasonally low flows***, since glacier melt is highest during summer when other sources of runoff are lowest.
- While glacier melt in these regions may contribute a relatively small part of the annual flow, it often contributes a substantial part of low flows, which typically occur during the time of year when water demand is highest.
- In the ***future***, however, this buffering of glaciers will likely undergo a substantial change and reduced glacier volume will eventually result in a ***decrease of glacier-fed summer runoff***.

- Water shortages during summer are thus likely to be caused by two exacerbating factors:
  - ⇨ less precipitation
  - ⇨ less glacial meltwater



Tipping point *(peak water) in glacial runoff*

(*Sorg, A., Mosello, B., Shalpykova, G., Allan, A., Hill, M., Stoffel, M.*)

Growing demand for water

- The Central Asian economies are dominated by ***irrigated agriculture*** practices and water consumption has been mounting to unsustainable levels.
- In order for the Soviet Union to become self-sufficient, priority for water allocation was given to the ***cotton*** production in the ***Uzbek*** Soviet Socialist Republic (SSR) and to ***rice*** production in the ***Kazakh*** SSR, with the ***Kyrgyz*** SSR designated as ***water supplier***.
- Major investments were made in the construction of dams, reservoirs, irrigation canals and other structures to promote and manage the ***transfer*** of ***water from its source in the Kyrgyz mountains to the main growing areas in the Uzbek and Kazakh*** SSRs.
- More than 90% of water in the region goes to irrigated agriculture.
- ***Uzbekistan***, for instance, is currently the ***second largest exporter of cotton*** in the world.
- The water consumption in the region increases also due to the current ***high population growth rate*** of between 2.5 and 3.4% per year.
- As ***living standards improve*** and demand for resources increases, ***pressures on scarce water resources heighten***.

Toktogul Reservoir

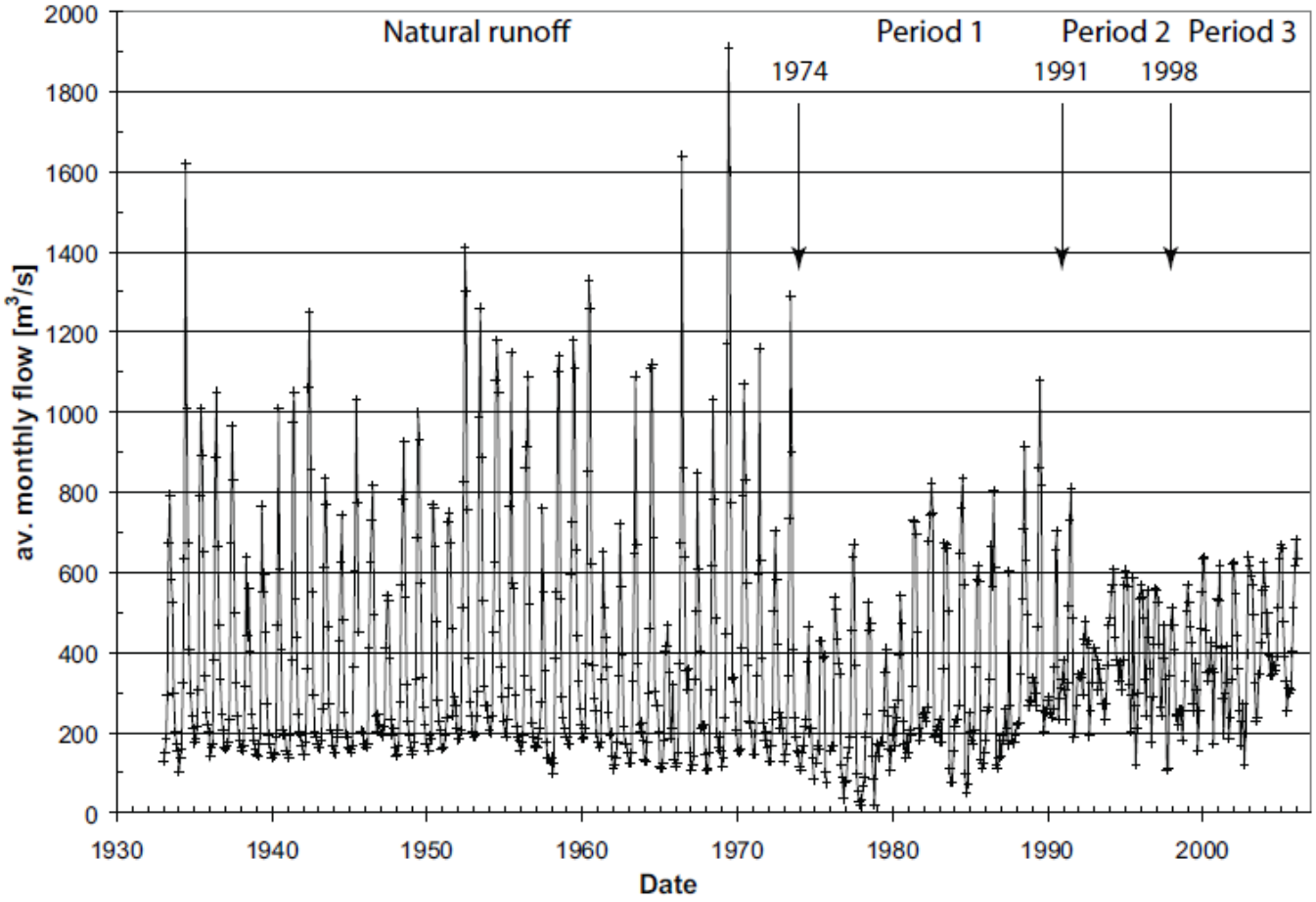
Naryn/Syr Darya Basin

- The runoff of the Naryn/Syr Darya is measured at the ***Uch Kurgan gauge station***.
- The ***Toktogul dam*** was commissioned 1974.
- The Toktogul dam is by far the ***largest storage facility*** in the Aral Sea basin, with a total storage volume of around 19.5 km^3.

T. Siegfried and T. Bernauer, 2007

Toktogul Reservoir

Mean monthly flow of the Naryn/Syr Darya River at the Uch Kurgan Gauge



Sources: Global Runoff Data Center (GRDC); and Andrey Yakovlev, Uzbek Hydrometeorological Service, Tashkent, Uzbekistan.

Toktogul Reservoir

International Water Management in the Naryn/Syr Darya Basin

The ***runoff variation*** of the past 80 years is characterized by ***four distinct periods***.

Natural runoff: 1933-1974:

- The ***runoff*** was ***natural*** and determined entirely by seasonal and climatic variability.
- A substantial change in flow patterns occurred with the commissioning of ***Toktogul dam*** (1974).

Period 1: 1974-1990:

- ***First river management period*** characterized by centralized management by the USSR of the Toktogul reservoir and the river basin as a whole.
- After the dam was commissioned, a general ***attenuation of peak*** downstream flows was observed
- Moreover, an overall ***decline of monthly flow variability*** occurred, especially in the summer months.
- The system was oriented primarily toward water provision for ***irrigated agriculture*** (particularly ***cotton*** production) in ***Uzbekista***n and ***Kazakhstan***.
- In the early 1980s, a ***water management organization*** for the Naryn/Syr Darya was set up in Tashkent, Uzbekistan. Its mandate was to operate and maintain all headwater structures with a discharge of more than 10 m^3/s.
- The electricity produced at Toktogul during that period went into the Central Asian Energy Pool (CAEP) and was thus shared among the riparian republics. In exchange, the ***neighboring republics supplied coal, oil, and natural gas to Kyrgyzstan*** in winter to cover increased Kyrgyz energy demand during the colder months.

Toktogul Reservoir

International Water Management in the Naryn/Syr Darya Basin

Period 2: 1991-1997:

- The ***second river management*** period commenced with the collapse of the Soviet Union in 1991.
- This event brought an end to centralized management of water resources and water-energy tradeoff arrangements.
- Syr Darya became an ***international river basin***.
- The newly independent states became involved in ***disputes over water allocation*** very quickly.
- Coal, oil, natural gas, and electricity supplies to Kyrgyzstan declined dramatically between 1991 and 1997.
- Since ***Kyrgyzstan has no fossil fuel sources of its own***, it cannot rely on domestic fossil fuel for electricity production and thermal energy.

- Kyrgyzstan switched the operation of the Toktogul reservoir ***from an irrigation to an electric power production mode***.
- Since the winter of 1993, water flows have ***no longer peaked in summer*** but ***rather in winter***.

Toktogul Reservoir

International Water Management in the Naryn/Syr Darya Basin

Period 2: 1991-1997:

- The main political problem since 1991 concerned ***upstream-downstream antagonisms***.
- ***Upstream interests*** derived from seasonal water demands are ***diametrically opposed to downstream water demands*** and interests.

UPSTREAM

Kyrgyzstan is eager to ***store water between spring and autumn*** and to release this water between winter and spring for hydropower production.

DOWNSTREAM

Uzbekistan and Kazakhstan, by far the largest consumers of ***irrigation water*** in the river basin, wish to obtain much more water during the ***growing season*** (April to Sept.) than in the nongrowing season (Oct. to March).

They prefer ***low water*** releases in ***winter***, because high flows in winter may cause floods due to ice in the river bed, which reduces water flow capacity.

- Thus, the ***principal problem*** to be solved is to ***coordinate the management*** of the Naryn/Syr Darya ***cascade of reservoirs*** that are located entirely in Kyrgyzstan, and in particular the ***handling of trade-offs*** between consumptive water use for downstream irrigation purposes in summer and nonconsumptive use for upstream energy production in Kyrgyzstan in winter.

Toktogul Reservoir

International Water Management in the Naryn/Syr Darya Basin

Period 3: 1998-today:

- In March 1998 Kazakhstan, Kyrgyzstan, and Uzbekistan signed an ***international upstream-downstream water agreement***. This accord marks the beginning of Period 3.
- It addresses strong asymmetries of interests through economic exchanges.

Upstream-downstream water agreement

- The water management system put in place in 1998 holds that during the ***vegetation season***, ***Kyrgyzstan releases more water*** than it needs for its own hydropower demand, and the resultant ***energy surplus is distributed to Kazakhstan and Uzbekistan***.
- ***Outside the growing season*** (October 1–April 1), Uzbekistan and Kazakhstan ***supply Kyrgyzstan with energy resources*** (electricity, natural gas, fuel oil, and coal) in amounts that are approximately equivalent to the electricity they receive from Kyrgyzstan during the growing season.

Table 1 Release Schedule of Toktogul Reservoir as Established in the 1998 Treaty

Month	1	2	3	4	5	6	7	8	9
q [m^3/s]	495	490	300	230	270	500	650	600	190

Source: Data available at http://ocid.nacse.org/tfdd/index.php.

Cotton monoculture in Uzbekistan

Uzbekistan is the world's second 29 largest cotton exporter.
In 2006, the raw cotton crop was more than 3.6 million tons, which is 20% more than it was in 2000.

Syr Daria: Upstream – Downstream outlook

Problems of Water Supply in Climate Change Conditions

- ***Mountainous lakes*** of Central Asia located in the runoff formation area on the territory of Uzbekistan and cross-border states – Tajikistan and Kyrgyzstan are mainly the potential source of clean and fresh water.
- Under conditions of progressing climate aridization and retention of existing situation with water resource management ***further growth*** of river ***water salinity*** level can be expected.

Desertification due to saline soil spreading

Sudochie Lake during an extremely law water period