Climate-resilient hydropower: Experiences from the EBRD region

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Hydropower is a major source of clean energy in the EBRD region

- Some EBRD countries derive more than 95% of their electricity from hydropower:
  - Albania, Georgia, Kyrgyz Republic, Tajikistan
- Hydropower is renewable, sustainable and typically produces 10x -100x < GHG emissions /kWh than fossil fuels

But hydropower is very sensitive to climatic variability and climate change

- Especially in the climate vulnerable countries of Central Asia

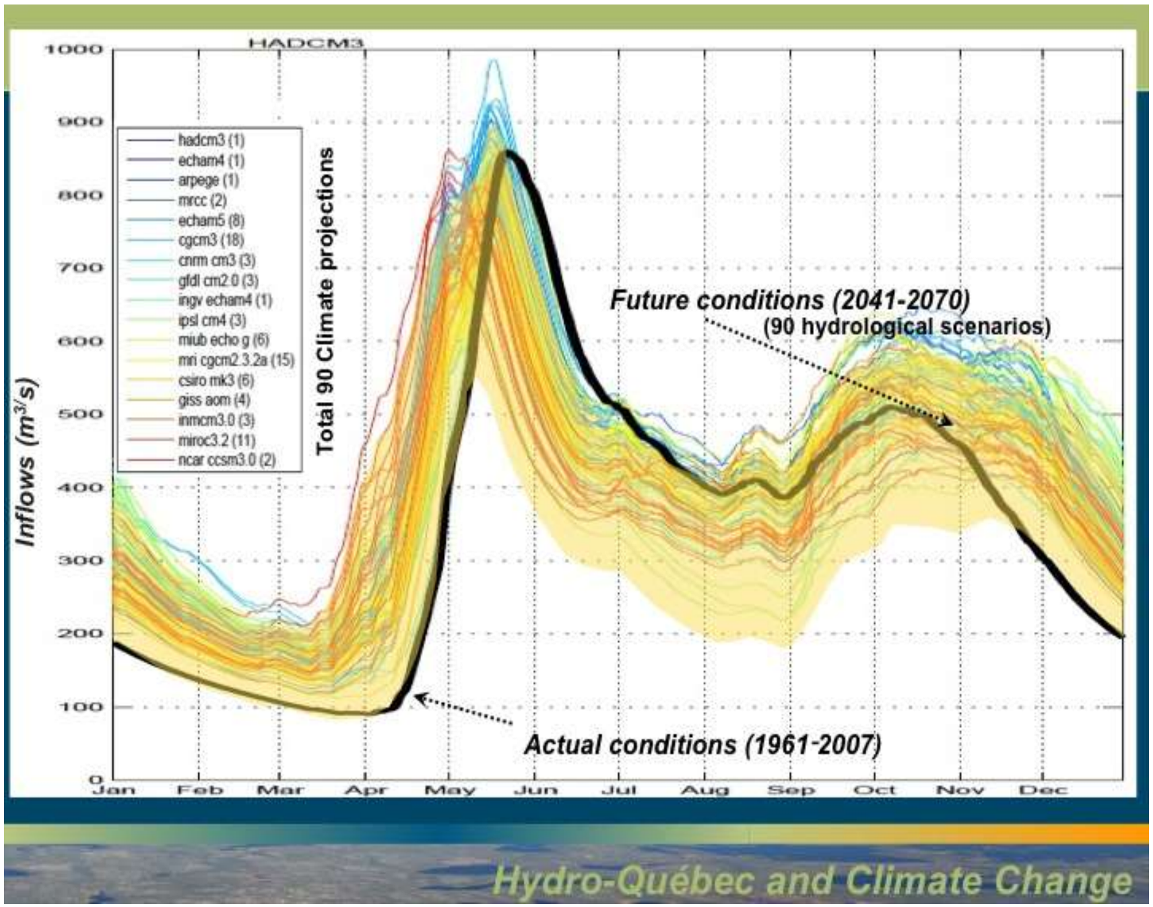
- Glacial hydrology is highly sensitive to climatic variability and change

Energy Systems are Vulnerable – Increasing Awareness

World's energy systems vulnerable to climate impacts, The World Energy Council (WEC), warns

The Guardian, 18 June 2014

Hydropower operators around the world are concerned about climate change



Research by Hydro Quebec indicates that climate change will have significant impacts on flows through HPPs:

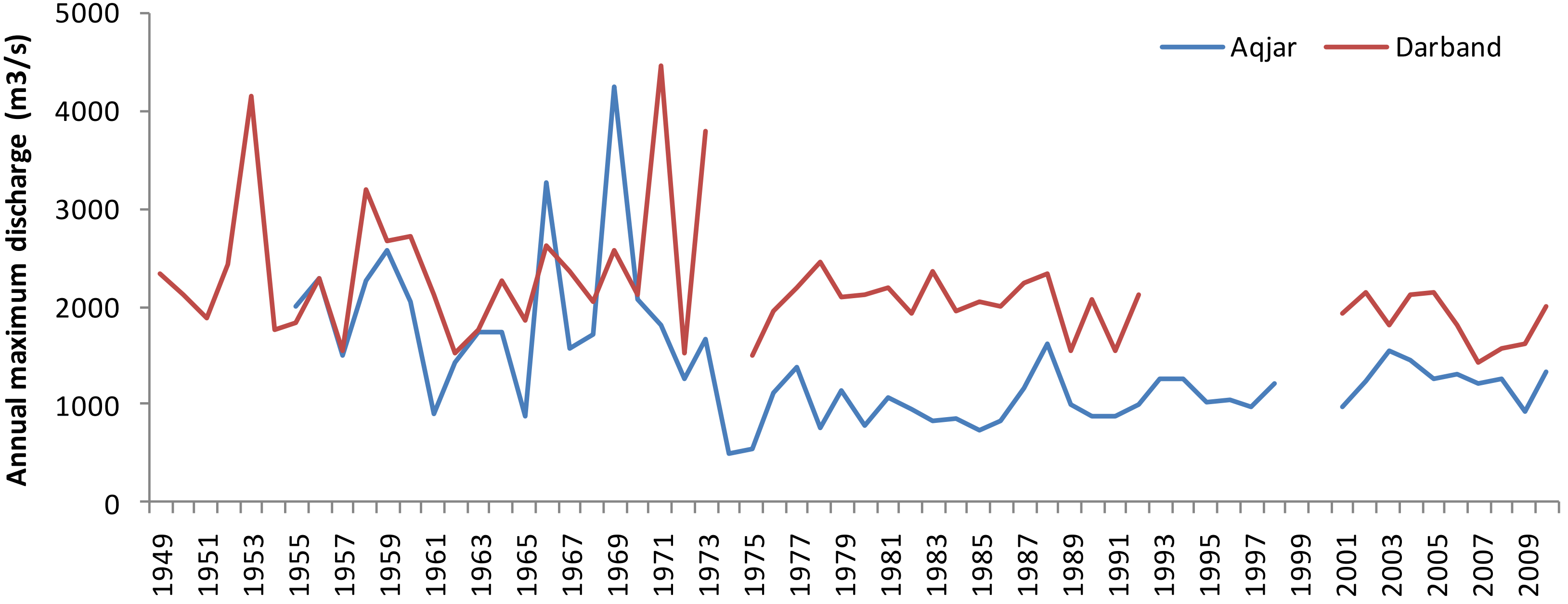
- Earlier spring snowmelt
- Reduced summer flows
- Increased winter flows

All of which has serious implications for:

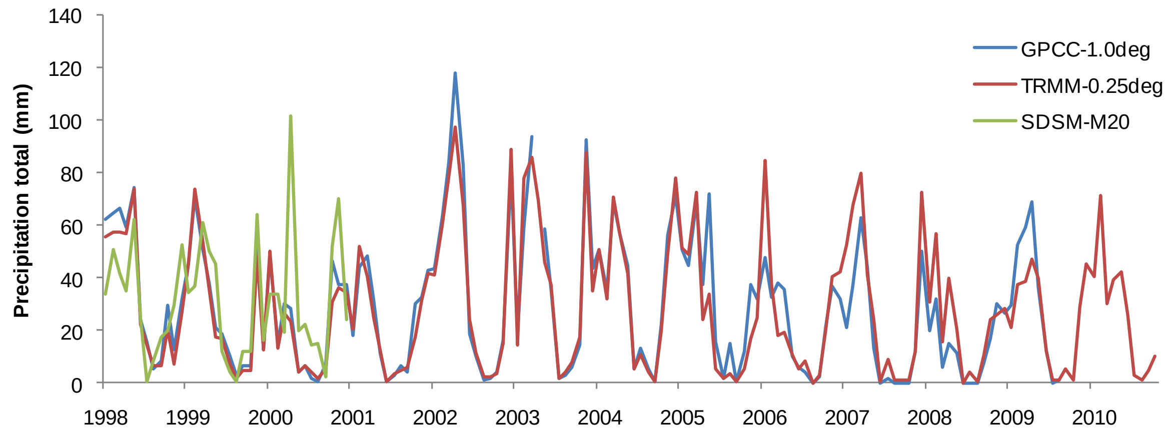
- Power generation capacity
- Management of peak supply and peak demand
- Dam safety and extreme events

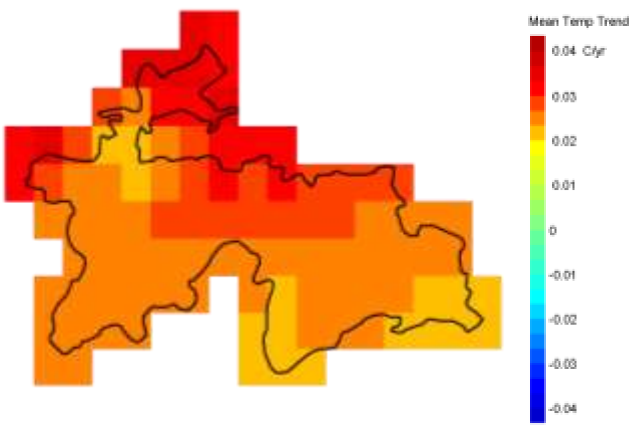
Kairakkum HPP (Tajikistan): putting theory into practice

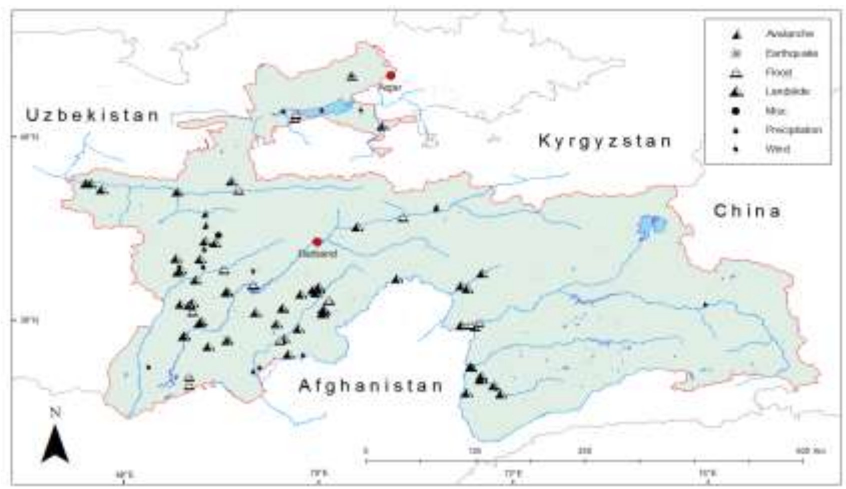
Data assembly and trend analysis



Example data sources



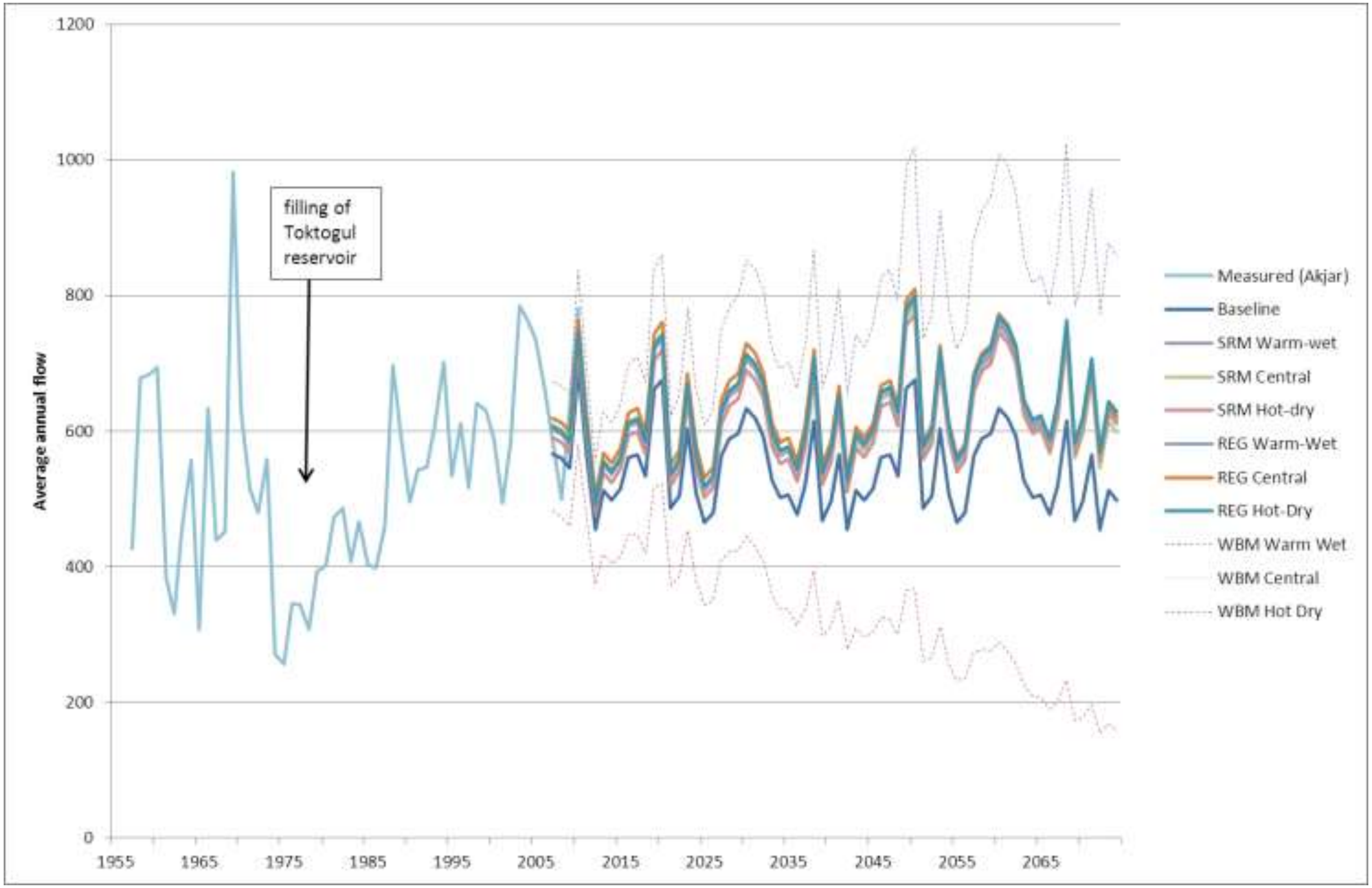




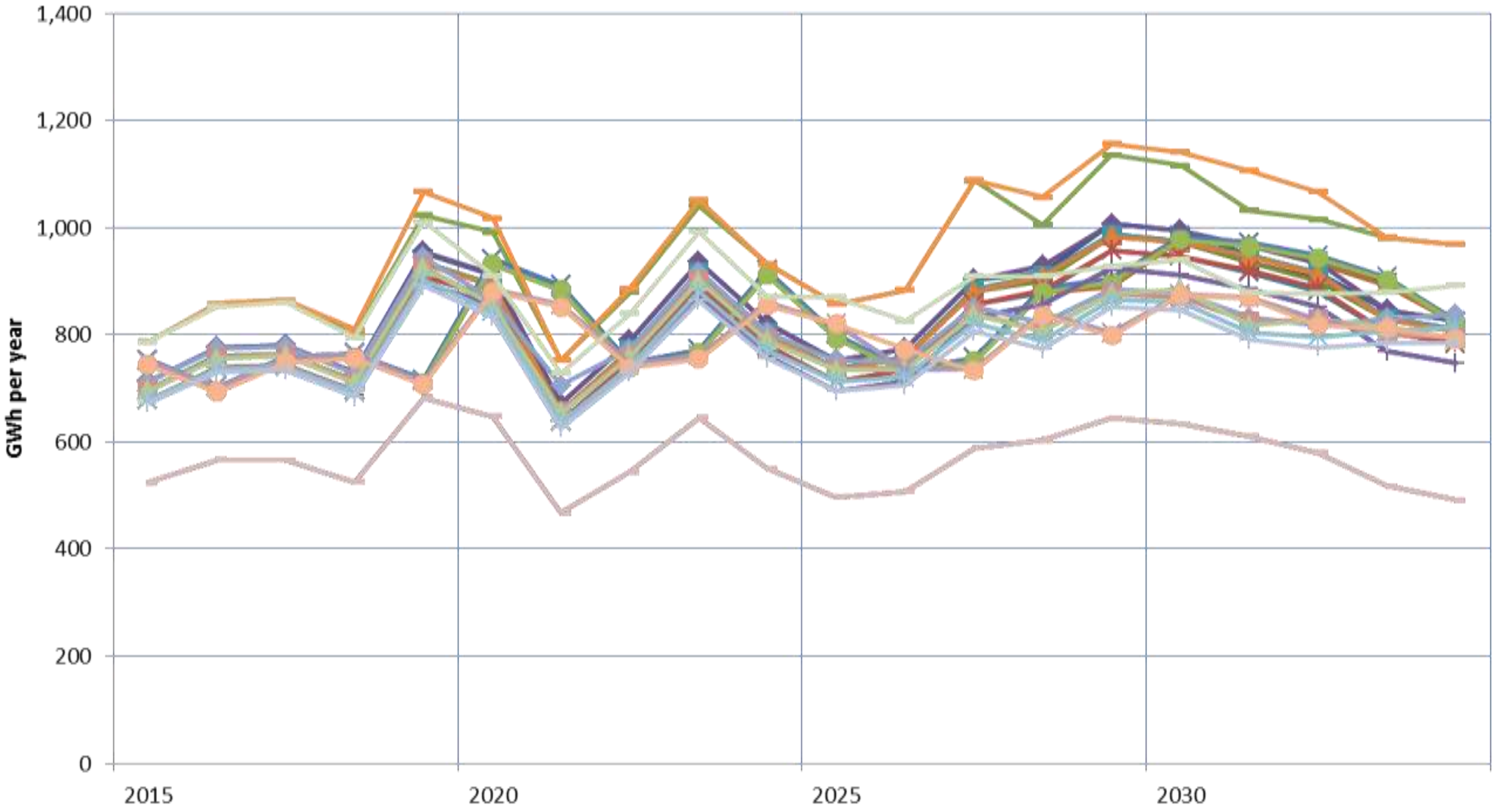
Climate change marker scenarios

Marker scenario		2050s		2080s	
		ΔT	ΔP	ΔT	ΔP
Hot-dry	Driest and most rapid warming member(s)	+4° C	-10%	+6° C	-15%
Central	Ensemble mean precipitation and temperature change	+3° C	+5%	+4° C	+5%
Warm-wet	Wettest and least rapid warming member(s)	+1.5° C	+20%	+2° C	+30%

Measured/simulated inflows 1957 to 2074



Modelled energy generation 2015 - 2050



Basis of economic projections were the scenarios of electricity production

Economic analysis of upgrade options taking into account climate change scenarios

Net present value (€ million)

HydroScenario		Alternative 6 N - 170 MW	7 N - 210 MW	4 N 2 O - 150 MW
Regression Model REG	central	177	143	177
	hot-dry	171	137	171
	warm-wet	171	137	171
Snowmelt Runoff Model SRM	central	170	136	169
	hot-dry	163	129	165
	warm-wet	168	134	168
Watershed Bal. Model WBM	central	157	122	161
	hot-dry	83	48	93
	warm-wet	212	183	199

Hydro Scenario		Alternative 6 N - 170 MW	7 N - 210 MW	4 N 2 O - 150 MW
Regression Model REG	central	0.0	-33.7	-0.3
	hot-dry	0.0	-34.1	-0.2
	warm-wet	-0.4	-34.5	0.0
Snowmelt Runoff Model SRM	central	0.0	-34.1	-0.6
	hot-dry	-2.2	-36.5	0.0
	warm-wet	-0.5	-34.7	0.0
Watershed Bal. Model WBM	central	-4.0	-38.6	0.0
	hot-dry	-10.9	-45.5	0.0
	warm-wet	0.0	-29.1	-12.5
Minimum Regret		-10.9	-45.5	-12.5

Use of min-max analysis to identify the turbine upgrade that gives the best economic performance across the entire range of projected climate change scenarios

Institutional capacity building - essential to embed climate resilience into hydropower management

- **Strengthen capabilities** on data management and record keeping
- **Build long-term collaborative links** around specific PPCR tasks with international partners in research, engineering and academia
- **Run technical workshops** on climate diagnostics, climate risk assessment, and seasonal forecasting with accredited institutions to encourage professional development
- **Study tour to hydropower facilities** in an OECD country in order to gain first-hand experience of best practice
- **Build capacity** to optimise dam safety and maximise energy productivity - develop and apply modifications to dam operating rules based on improved hydro-meteorological forecasts

Financing package: collaboration between EBRD, CIF and donors

Preparatory phase: climate change and hydrological modelling (2010 – 2012)

- Funded by $300K grant from CIF PPCR

Implementation phase: investment design & implementation (2012 onwards)

- Feasibility Study
  - Funded by €800K grant (Austria)
- Implementation to be financed by EBRD and PPCR
  - USD 47 million loan (EBRD)
  - USD 4 million technical cooperation grant (EBRD, UK DFID)
  - USD 11 million grant and USD 10 million concessional finance (CIF PPCR)

Thank you

For more information contact:

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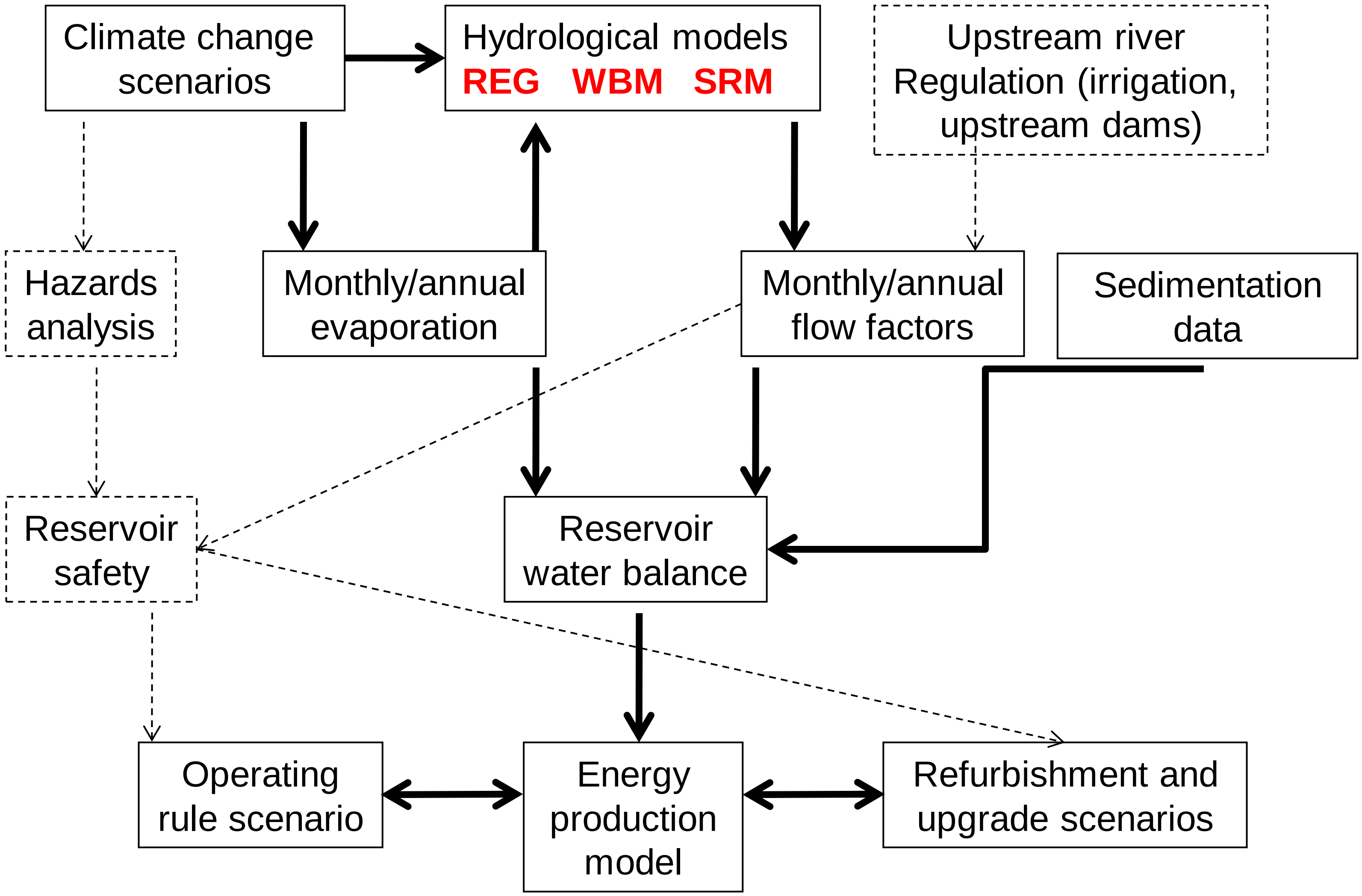
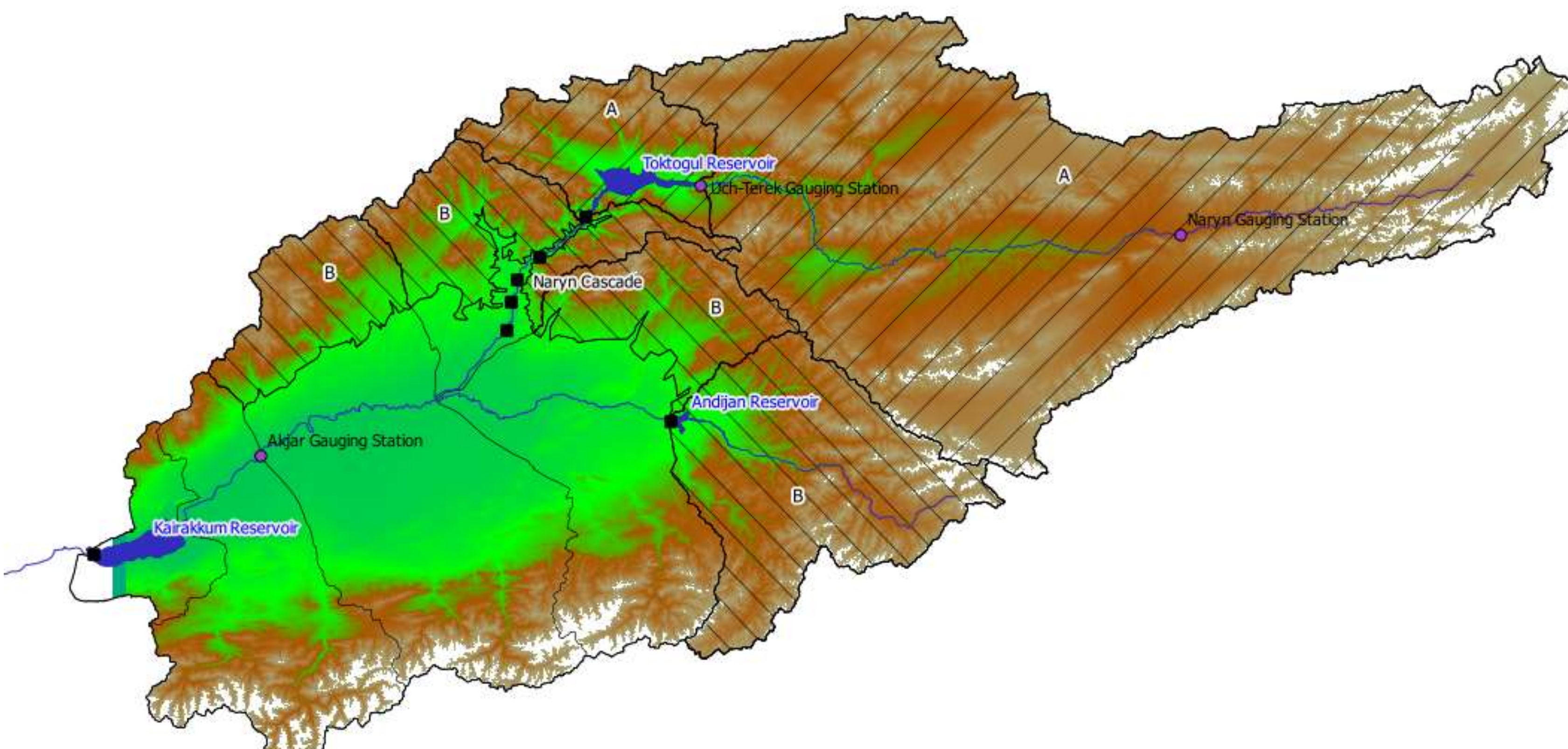
Additional slides

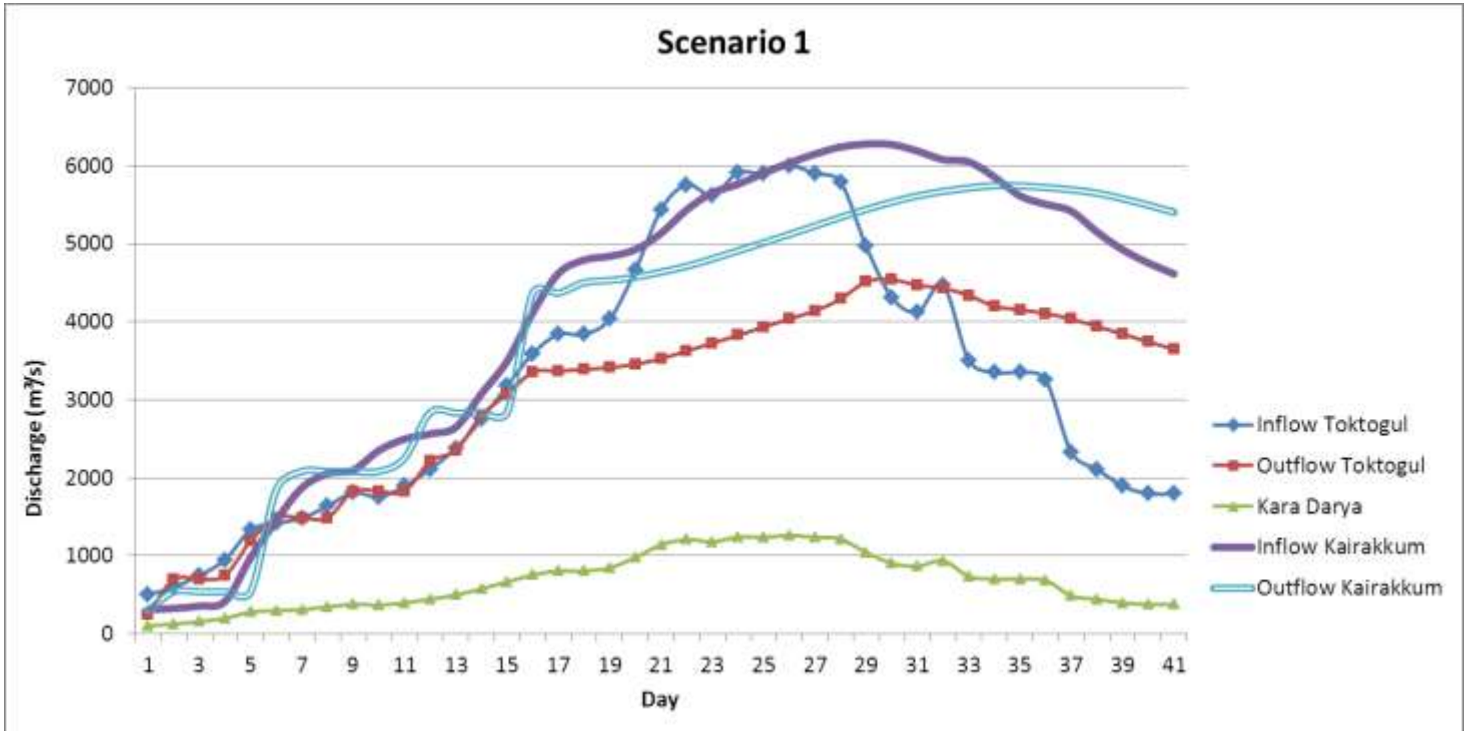
What about non-climate change factors?



What about dam safety?



Probable Maximum Flood (PMF) II



Probable Maximum Flood (PMF) III

	Peak discharge / water level
Current discharge capacity (powerhouse + 6 gated spillways)	5040 m^3/s
Max. observed flood (1969)	4240 m^3/s
Design flood (T = 10000 years)	5571 m^3/s
Max. simulated PMF inflow into Kairakkum reservoir*	6400 - 8800 m^3/s
Max. simulated PMF discharge at Kairakkum Dam*	5750 - 8500 m^3/s
Max. Water Level Reached* (max. flood level: 348.35 m)	349.45 - 351.48 m

Dam crest: 351.50 m

Probable Maximum Flood (PMF) IV

Conclusions:

- Existing discharge capacity is insufficient to safely cope with a Probable Maximum Flood (PMF)
- Attenuating effect of upstream reservoirs is rather limited for a prolonged snowmelt flood if reservoirs are assumed to be full at the beginning of the flood
- Additional uncertainty introduced by climate change; extreme floods are projected to increase in Central Asia.
- Overtopping of the dam must be avoided under any circumstances
- Creation of additional dam safety measures strongly recommended

As an additional measure to increase resilience against climate change impacts