Philipps Universität Marburg

Water resources in Central Asia - status quo and future conflicts in transboundary river catchments – the example of the Zarafshan River (Tajikistan-Uzbekistan)

M. Groll (Philipps-Universität, Marburg, Germany)

Ch. Opp (Philipps-Universität, Marburg, Germany)

R. Kulmatov (National University of Uzbekistan, Tashkent, Uzbekistan)

I. Normatov (Tajik National University of Science and Technology, Dushanbe, Tajikistan)

G. Stulina (SIC ICWC, Tashkent, Uzbekistan)

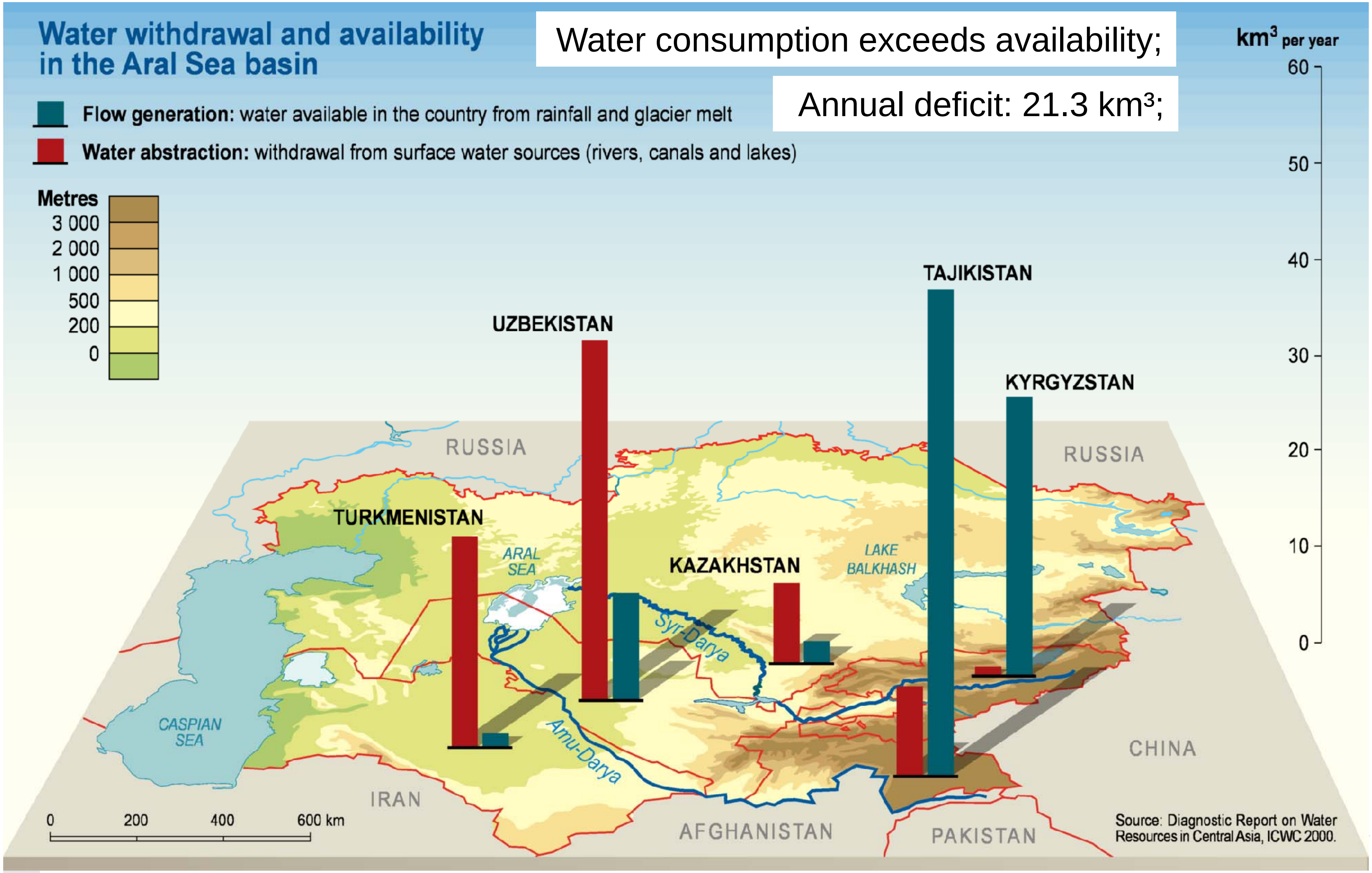
N. Shermatov (Tajik National University of Science and Technology, Dushanbe, Tajikistan)

EGU2014 - Vienna HS2.4.6: Climate Change and Water Resources in Central Asia and Caucasus

Uneven distribution of water availability and demand;

Water consumption exceeds availability;

Annual deficit: 21.3 km³;



THE MAP DOES NOT IMPLY THE EXPRESSION OF ANY OPINION ON THE PART OF THE AGENCIES CONCERNING THE LEGAL STATUS OF ANY COUNTRY, TERRITORY, CITY OR AREA OF ITS AUTHORITY OR DELINEATION OF ITS FRONTIERS AND BOUNDARIES.

MAP BY VIKTOR NOVIKOV AND PHILIPPE REKACEWICZ - UNEP/GRID-ARENDAL - APRIL 2005

Uneven distribution of water availability and demand;

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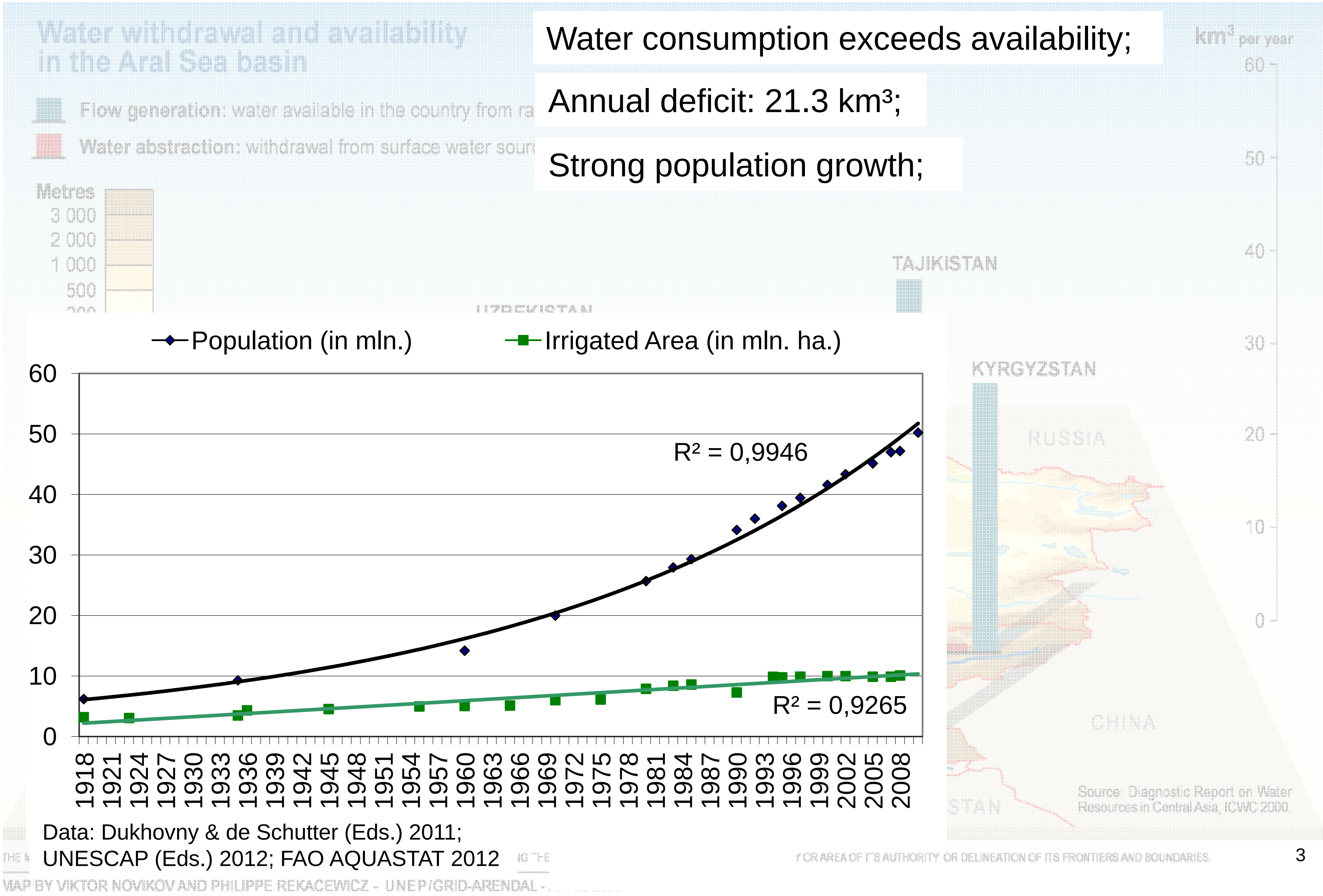
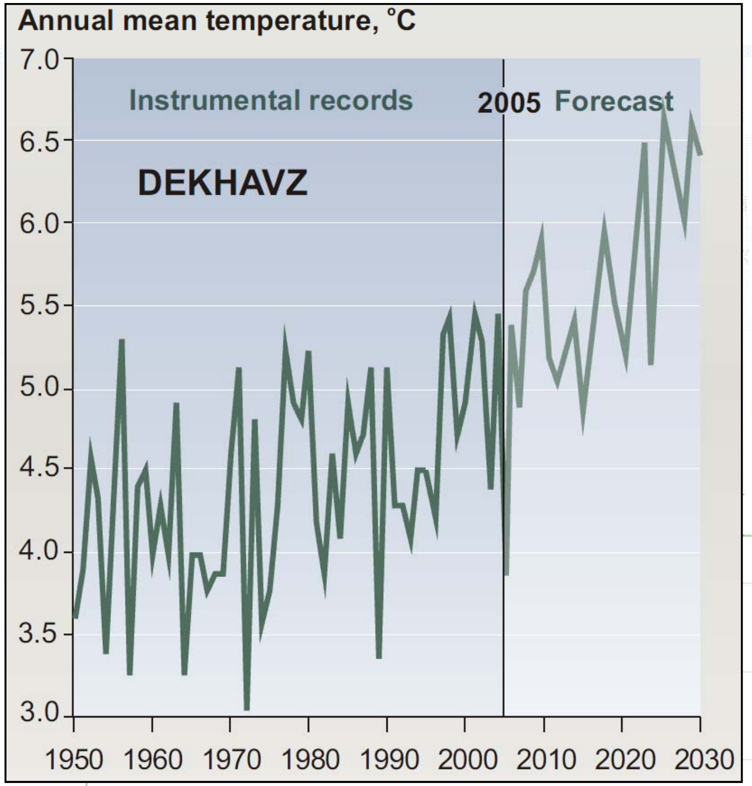
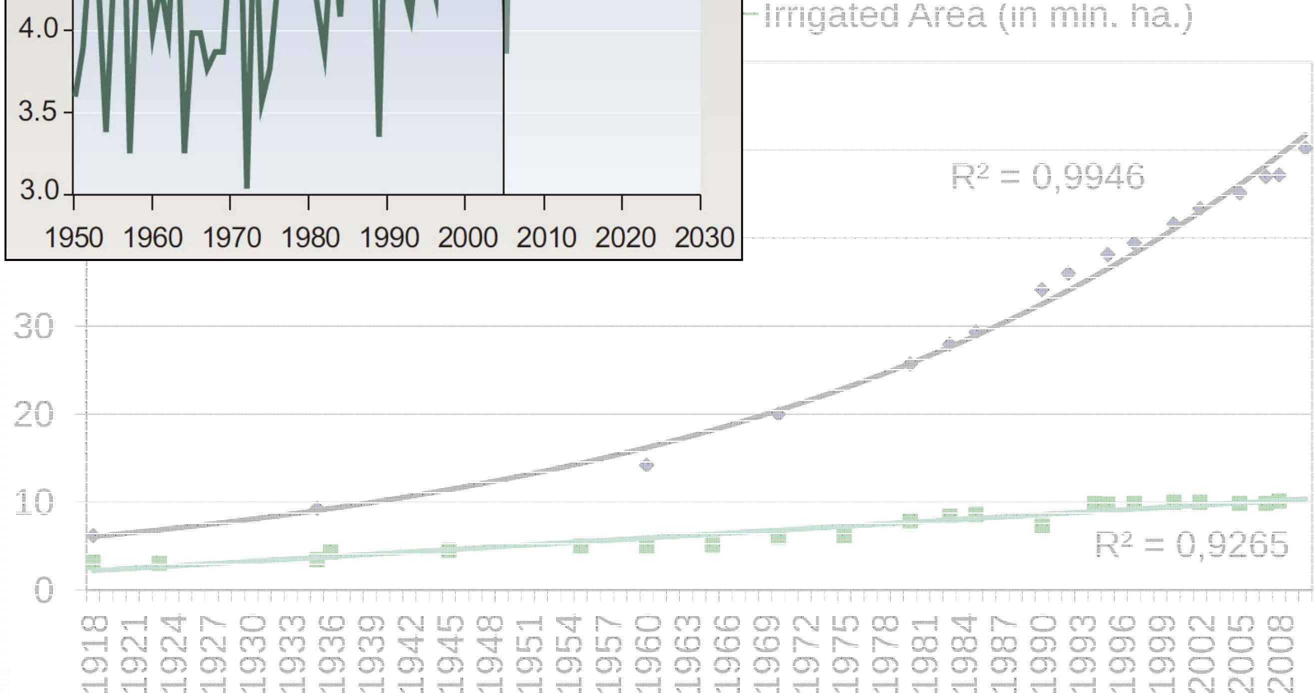


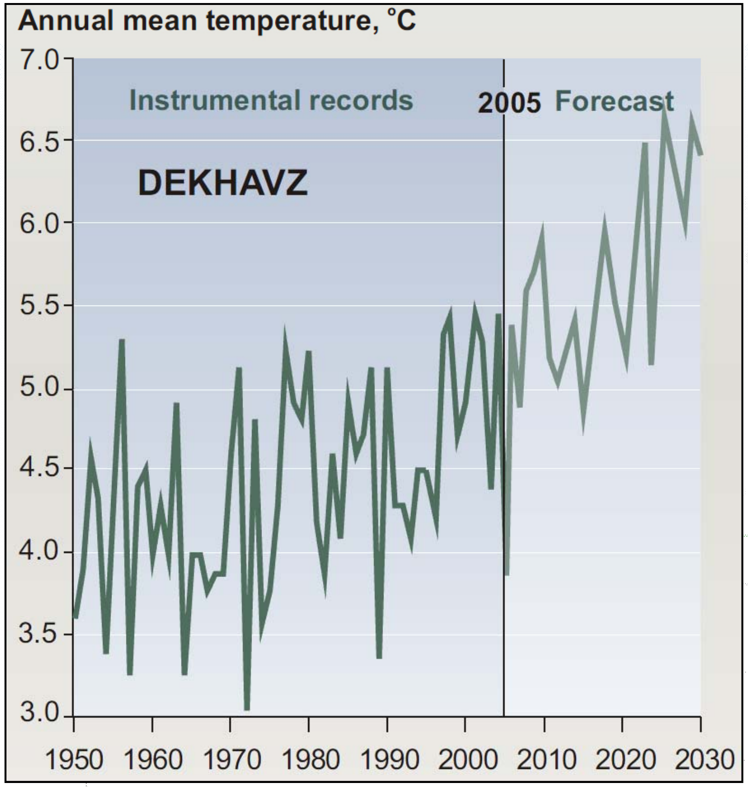
Data: Dukhovny & de Schutter (Eds.) 2011;
UNESCAP (Eds.) 2012; FAO AQUASTAT 2012



- Uneven distribution of water availability and demand;
- Water consumption exceeds availability;
- Annual deficit: 21.3 km³;
- Strong population growth;
- Temperature increase since the middle of the 20th century: **+2°C** in the Turan lowland; **+0.5°C** in the mountain regions;



Data: Global Historical Climate Network, Agaltseva (2004, 2008), Ibatullin et al. (2009), Sorg et al. (2012)



- Uneven distribution of water availability and demand;
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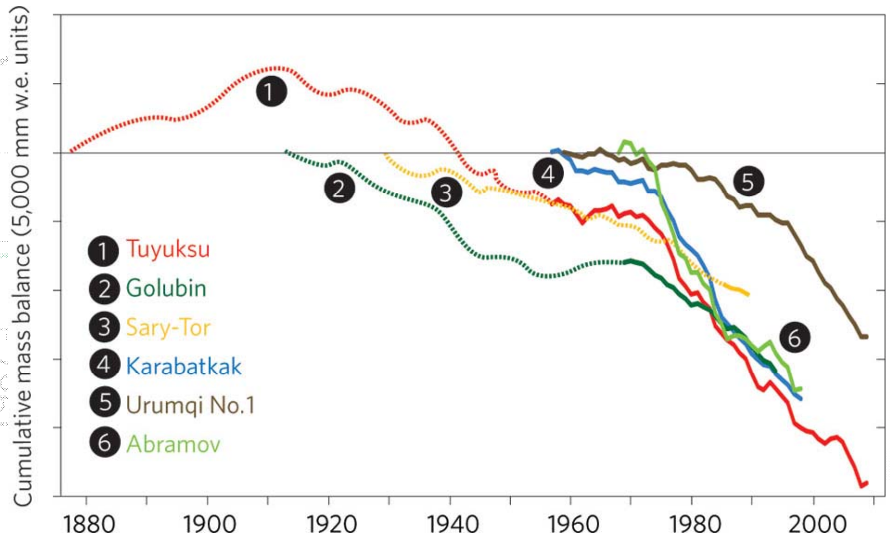
- Annual deficit: 21.3 km³;
- Strong population growth;
- Temperature increase since the middle of the 20th century: **+2°C** in the Turan lowland; **+0.5°C** in the mountain regions;
- Accelerated glacier melting -> long-term reduced discharge;
- Increased water demand due to higher evapotranspiration rates.

Managing the water resources will be the biggest challenge for the Central Asian countries in the 21st century.



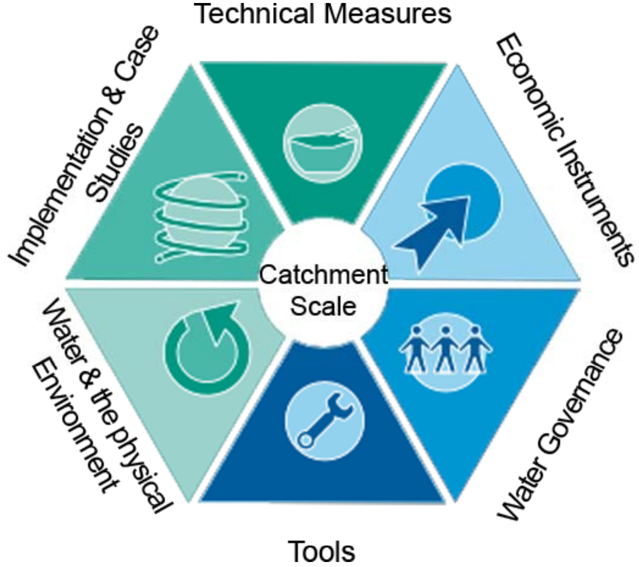
Data: Global Historical Climate Network, Agaltseva (2004, 2008), Ibatullin et al. (2009), Sorg et al. (2012)

A solid data base is essential for any management attempt.

In CA the available data is often fragmented and insufficient – especially in small and medium sized catchments.

Managing the water resources will be the biggest challenge for the Central Asian countries in the 21st century.

Integrated Water Resource Management



Water-Energy-Food-Nexus

www.iwrm-education.de; Hoff (2011)

River length (2010): 810 km,
Catchment size (2010): 40,600 km²

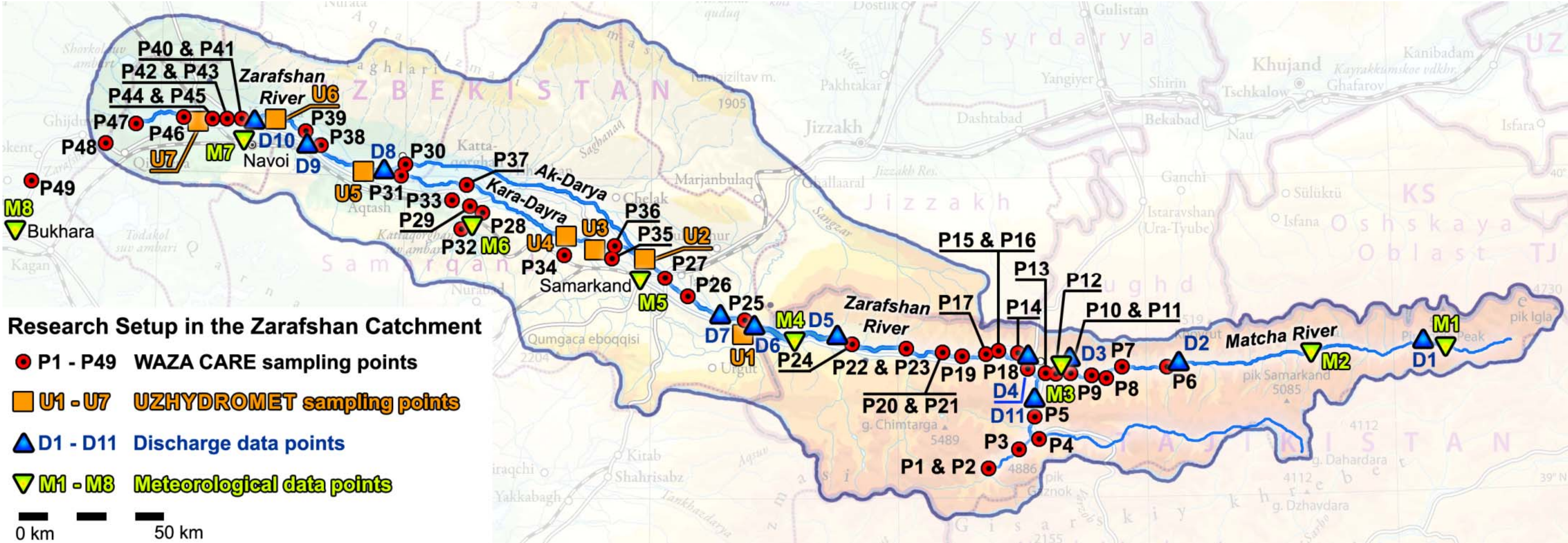
Semi-arid lowland
High evaporation, densly settled oases

Intensive use of the available water resources (irrigation farming, municipal and industry)

Glaciated mountain region
High relief energy & scarce vegetation

Limited use of the available water resources (ore mining and processing, pastures, municipal)
High hydropower potential

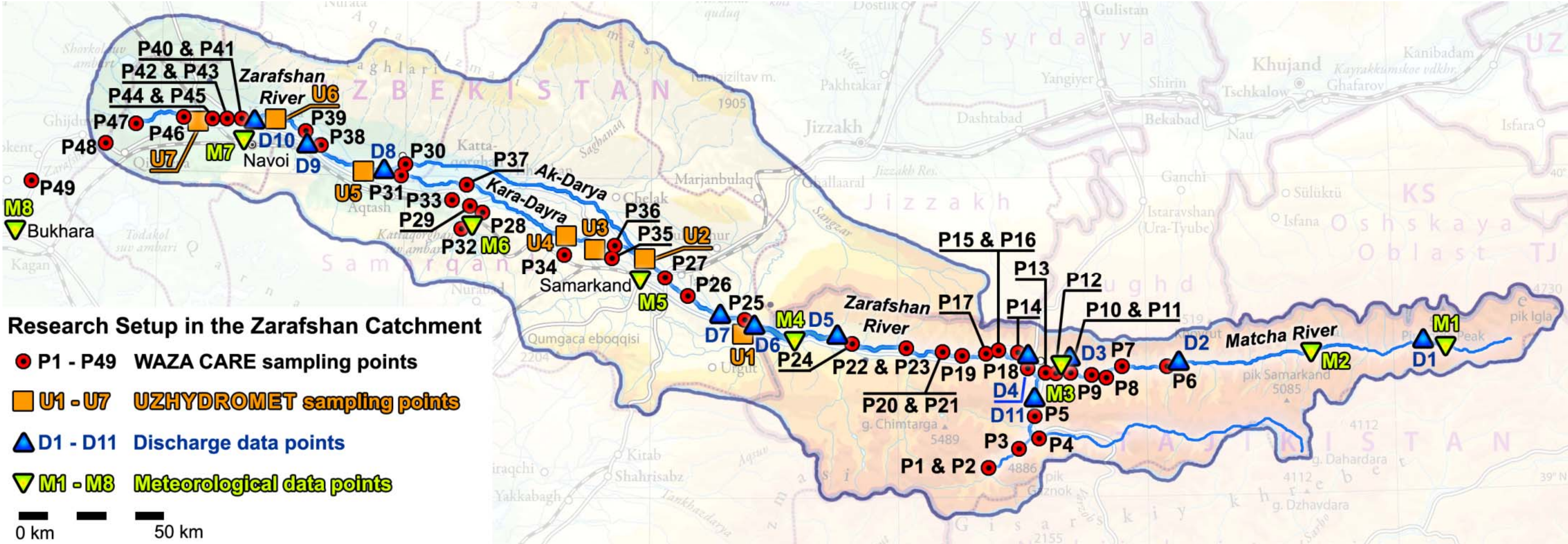
Data sources



- 8 meteorological stations (30+ years of temp. and precipitation data)
- 11 hydrological stations (up to 100 years of discharge data)
- 49 sampling points for the water quality (one-time measurements during the WAZA CARE field campaign in May 2010)
- 7 water quality sampling stations operated by the UZHYDROMET (data for 2008-2012)
- Statistical data (population, irrigation and drainage, etc.) available online

Groll et al. (2013)

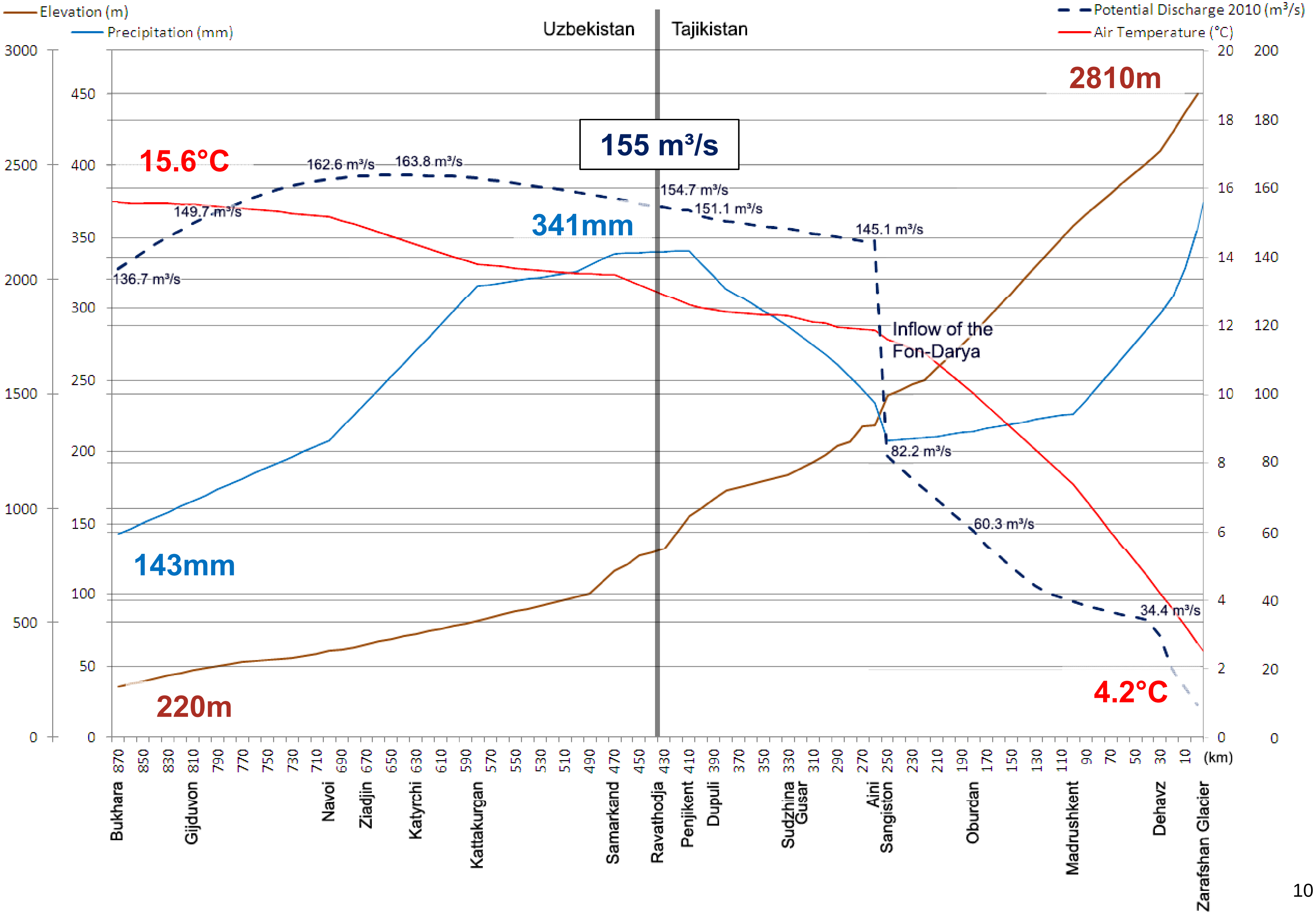
Data sources

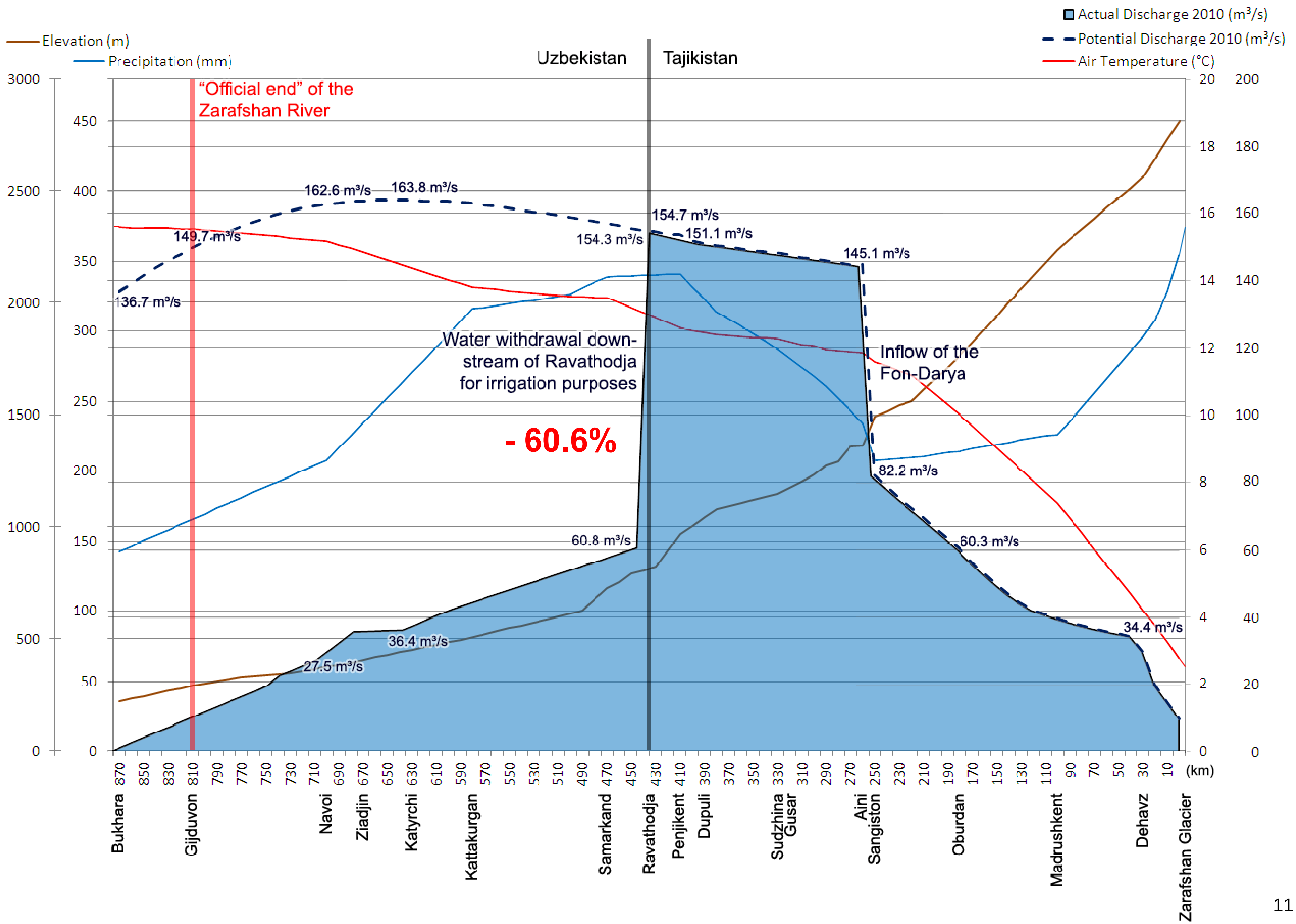


- 8 meteorological stations
- 11 hydrological stations
- 49 sampling points for the water quality
- 7 UZHYDROMET stations
- Statistical data
- Spatial Data (elevation, …)

Integrate into a simple conceptual 1D-model for first estimations about possible future developments.

Groll et al. (2013)


Elevation (m)
Precipitation (mm)
Uzbekistan
Tajikistan
Potential Discharge 2010 (m³/s)
Air Temperature (°C)
2810m
155 m³/s
15.6°C
162.6 m³/s
163.8 m³/s
154.7 m³/s
151.1 m³/s
149.7 m³/s
341mm
145.1 m³/s
136.7 m³/s
Inflow of the Fon-Darya
82.2 m³/s
60.3 m³/s
143mm
34.4 m³/s
4.2°C
220m
(km)
Bukhara
Gijduvon
Navoi
Ziadjin
Katyrchi
Kattakurgan
Samarkand
Ravathodja
Penjikent
Dupuli
Sudzhina Gusar
Aini Sangiston
Oburdan
Madrushkent
Dehavz
Zarafshan Glacier


Elevation (m)
Precipitation (mm)
Uzbekistan
Tajikistan
Actual Discharge 2010 (m³/s)
Potential Discharge 2010 (m³/s)
Air Temperature (°C)
"Official end" of the Zarafshan River
162.6 m³/s
163.8 m³/s
149.7 m³/s
136.7 m³/s
154.3 m³/s
154.7 m³/s
151.1 m³/s
145.1 m³/s
Water withdrawal down-stream of Ravathodja for irrigation purposes
- 60.6%
Inflow of the Fon-Darya
82.2 m³/s
60.8 m³/s
60.3 m³/s
36.4 m³/s
27.5 m³/s
34.4 m³/s
(km)
Bukhara
Gijduvon
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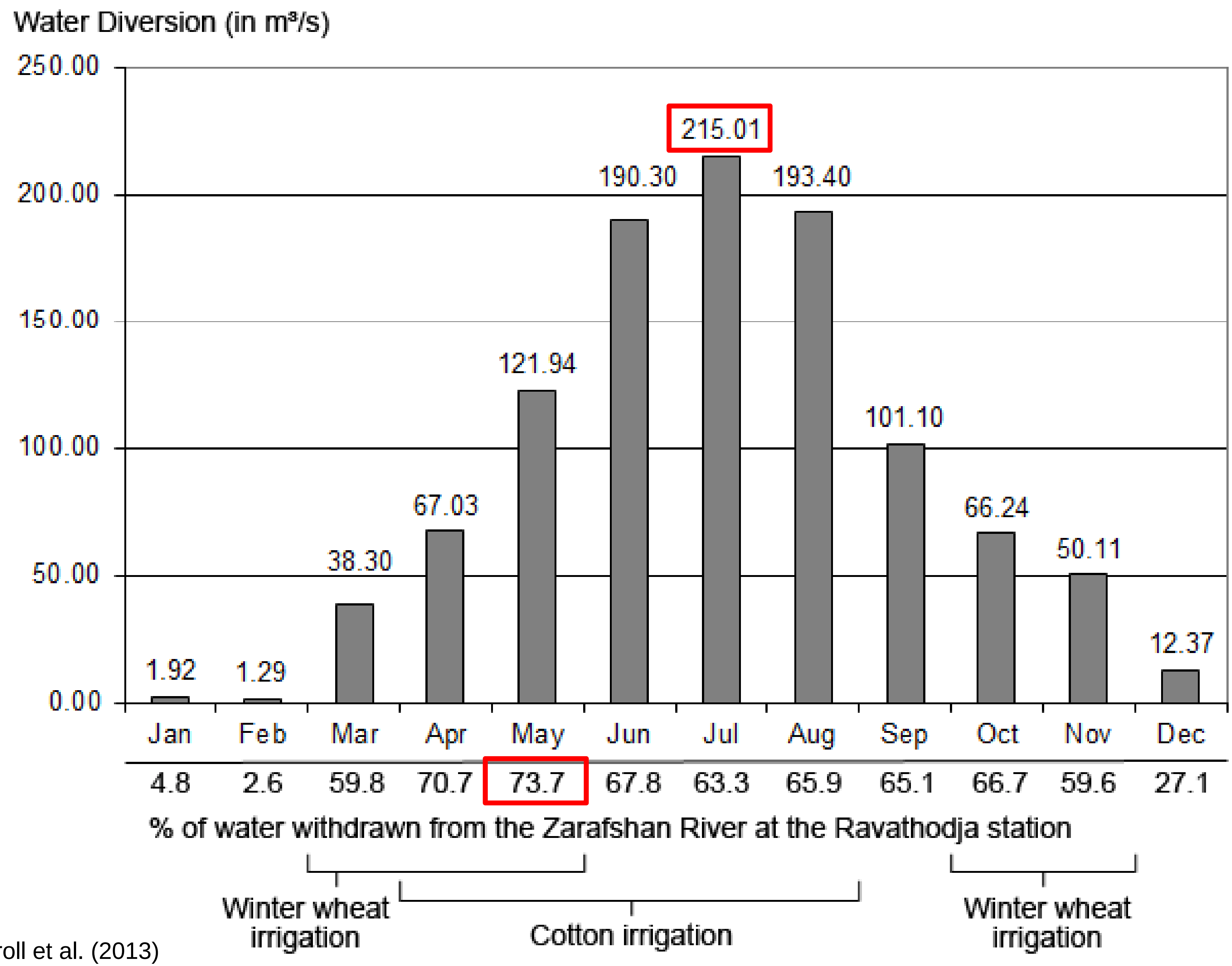
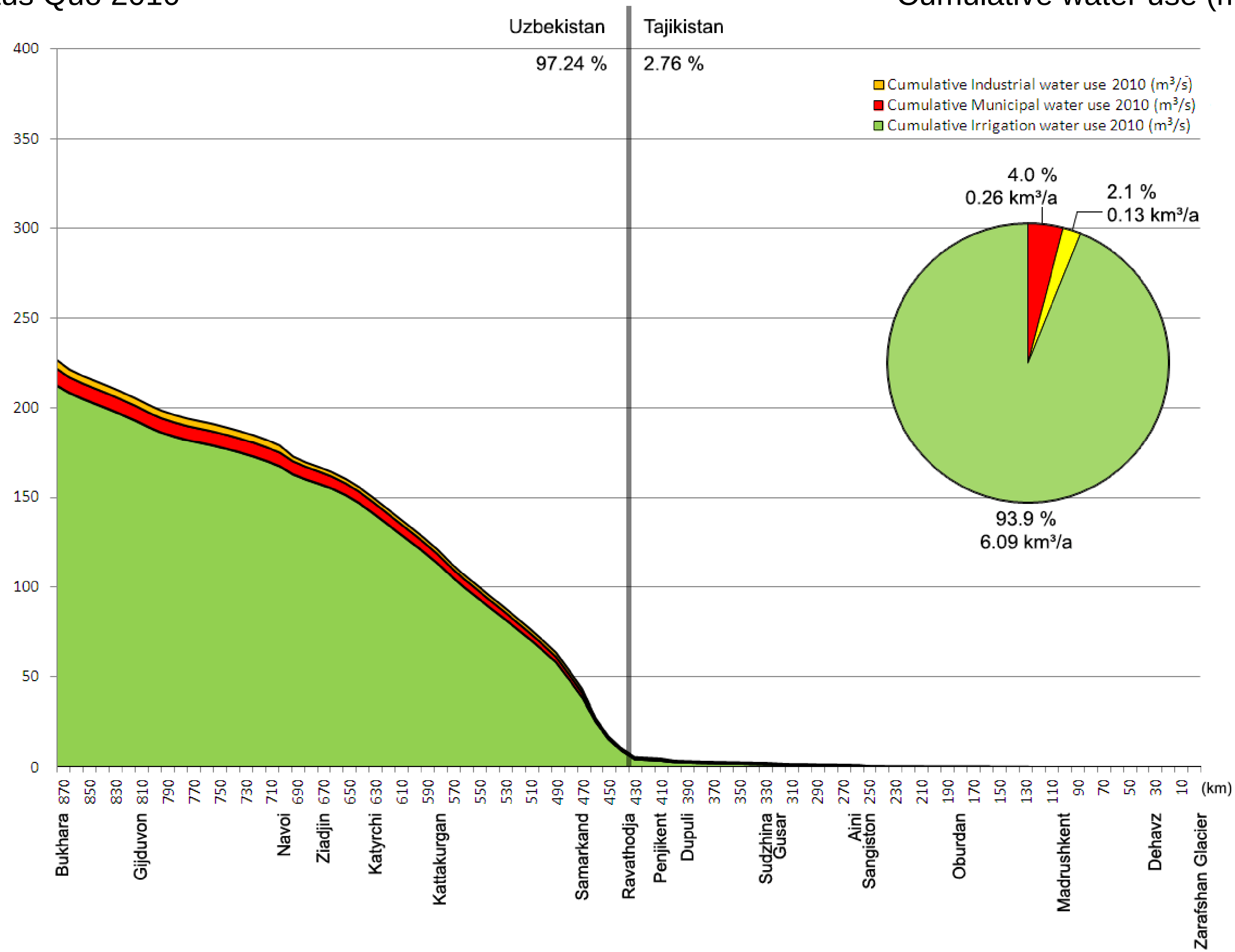


Groll et al. (2013)

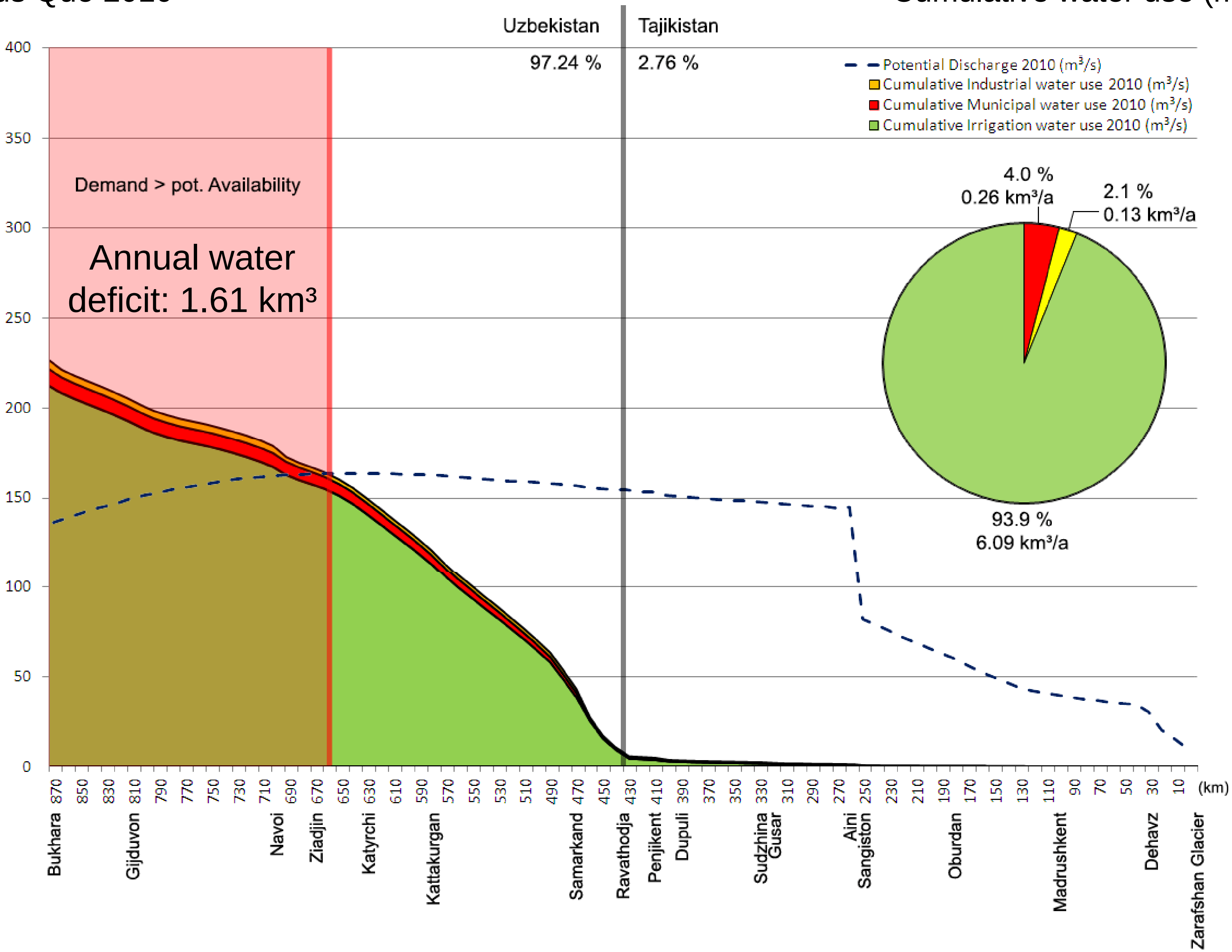
Status Quo 2010

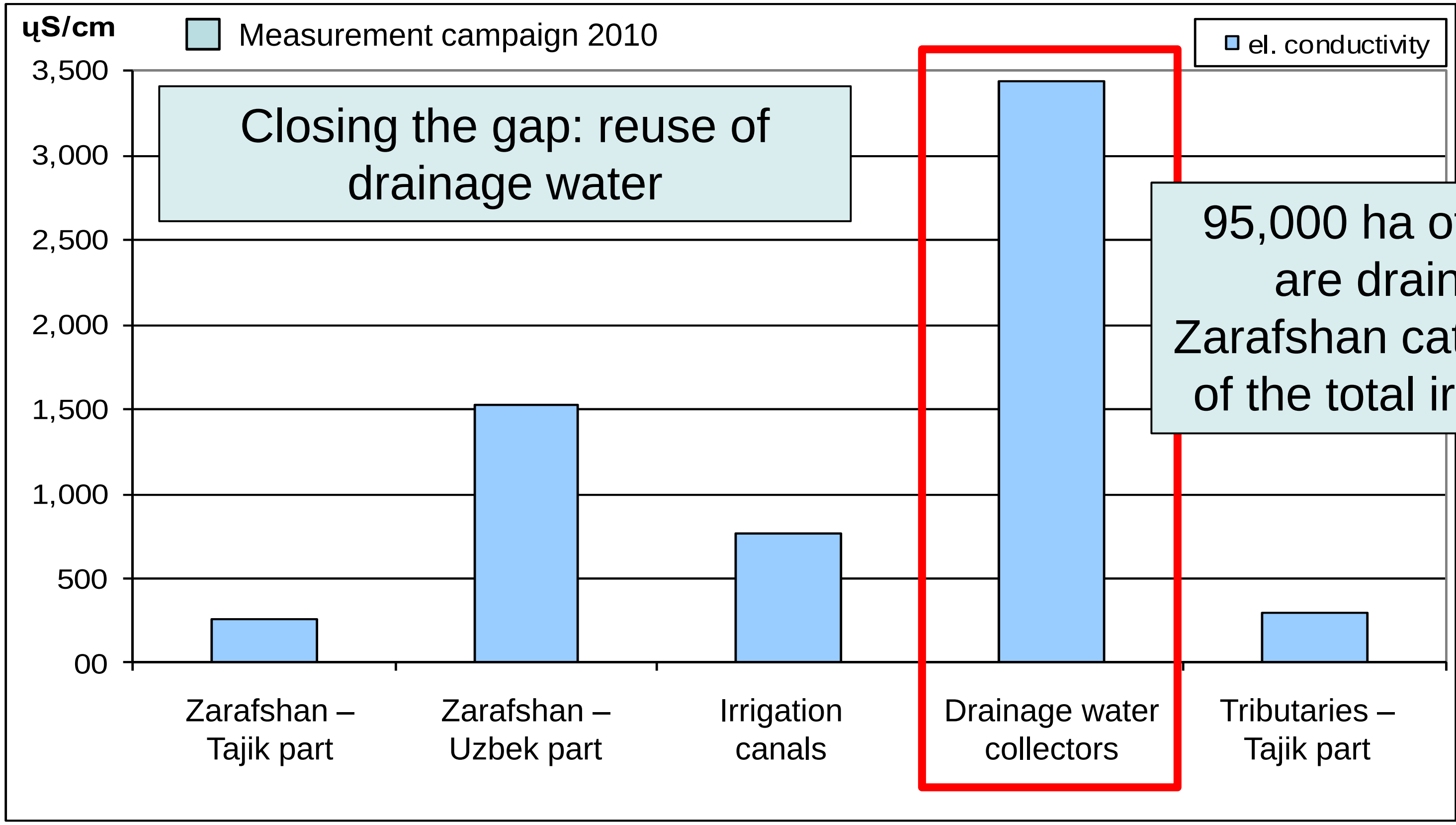
Cumulative water use (m³/s)



Status Quo 2010

Cumulative water use (m³/s)





Closing the gap: reuse of drainage water

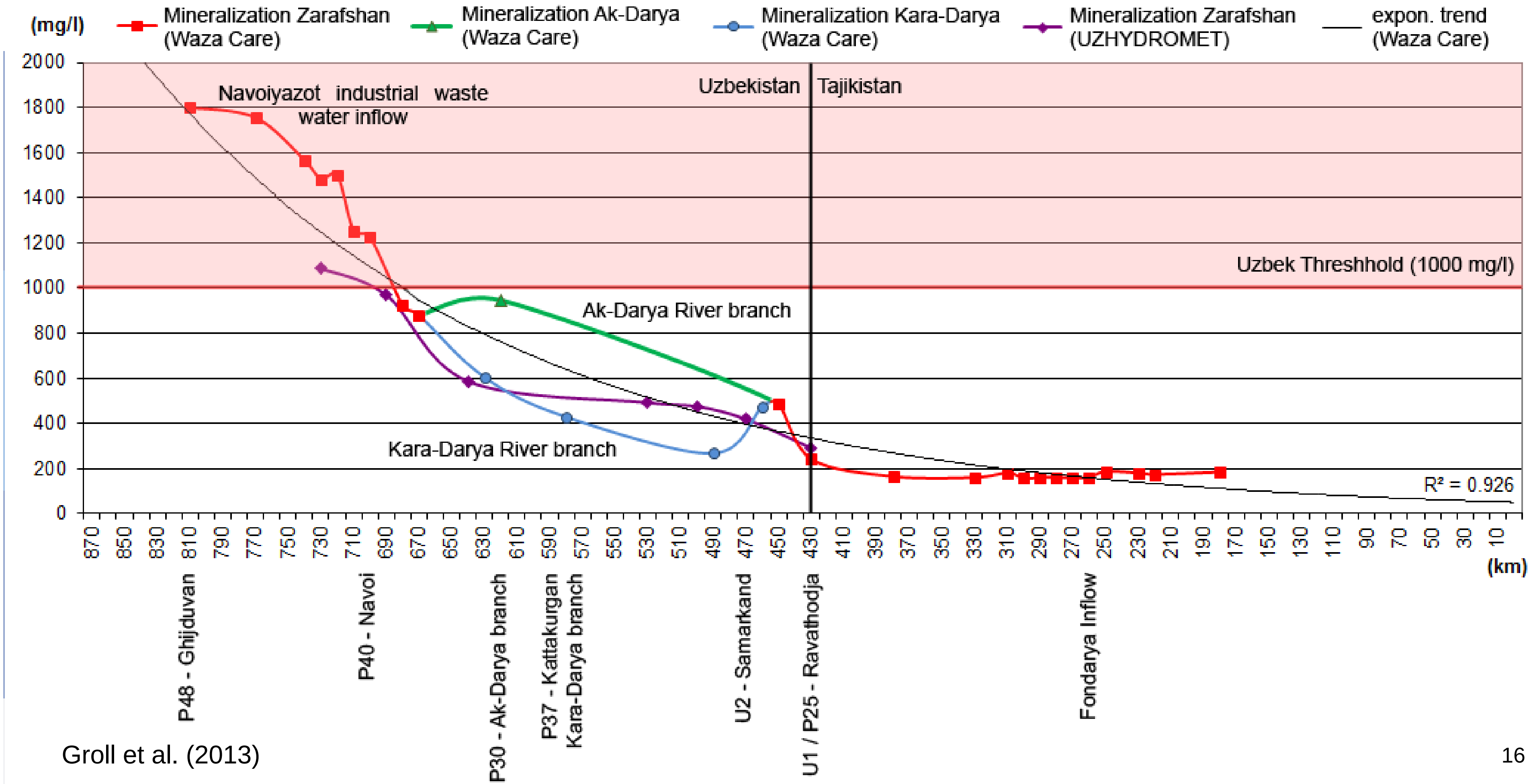
95,000 ha of arable land are drained in the Zarafshan catchment (58% of the total irrigated area)

Province	Drainage water (km^3/year)	% of irrigation water	Average mineralization (g/l)
Samarkand	1.40	57%	0.9
Navoi	0.82	45%	2.4
Bukhara	0.095	12%	2.3

Groll et al. (2013), Alihanov (Ed.) (2008)

The water quality in the lower Zarafshan catchment is highly impaired

- Drainage water – nutrients (nitrate & phosphate)
- Industrial waste water (Navoiyazot) – nitrate, chromate, copper & phenols
- Waste water from upstream mining acitivies – antimon, zinc, mercury



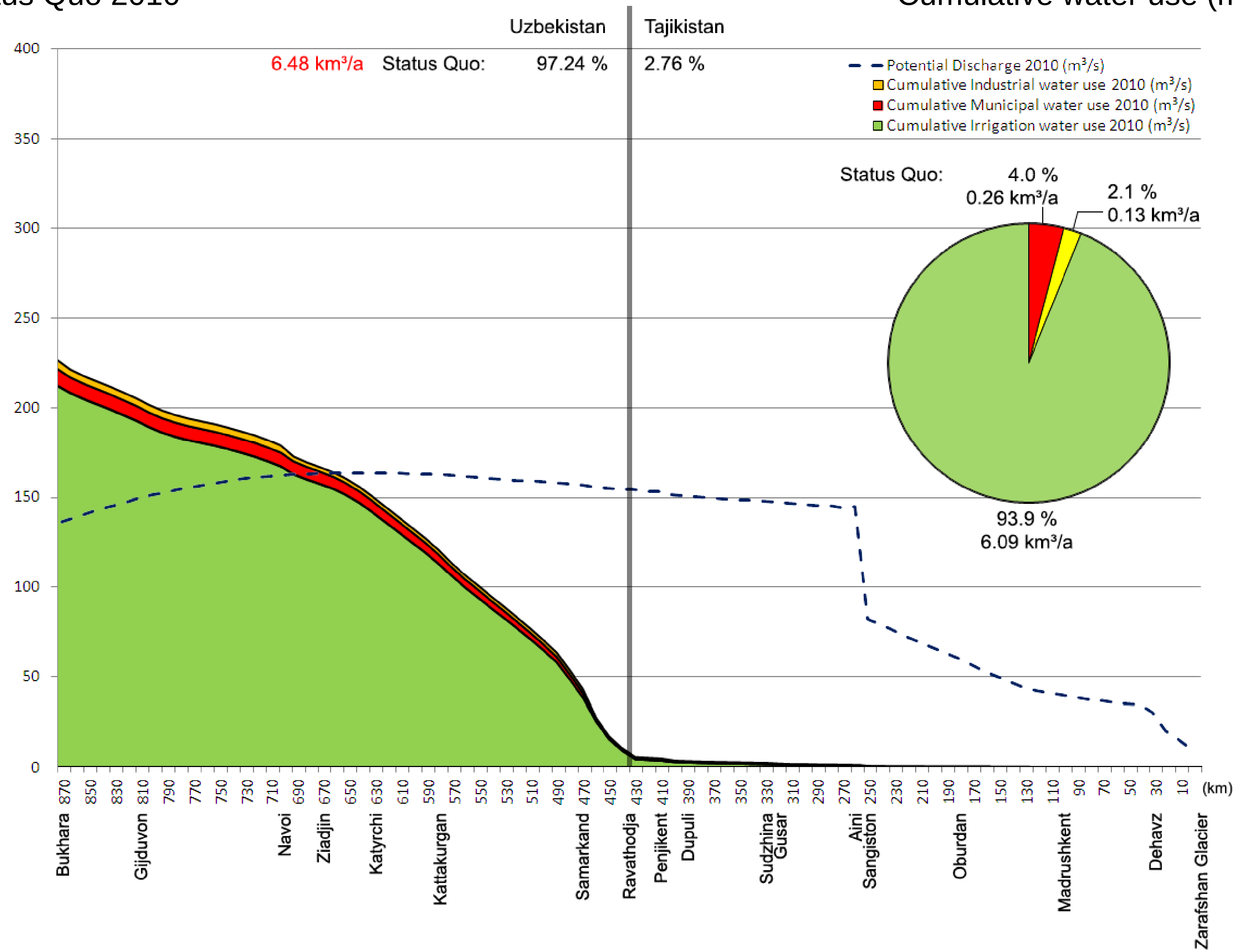
Groll et al. (2013)

Scenarios for the year 2030 - Scenario assumptions

Parameter	Scenario 1 „Baseline“	Scenario 2 „Best Case“	Scenario 3 „Socio-econ. Growth“	Scenario 4 „Worst Case“
Temp. increase	T: +0.3°C U: +1.12°C	T: +0.3°C U: +1.12°C	T: +0.3°C U: +1.12°C	T: +0.6°C U: +2.24°C
Population growth	+36.2% (+1.7%/a)	+33% (linear)	+45.7% (accelerated growth)	+45.7% (accelerated growth)
Economic growth	T: +4%/a U: +8%/a	T: +2%/a U: +4%/a	T: +6%/a U: +12%/a	T: +6%/a U: +12%/a
Irrigated Area	T: +2.5% U: +5%	T: +0.0% U: +0.0%	T: +5.0% U: +10.0%	T: +5.0% U: +10.0%
Cotton/ Wheat	T: 15/85 U: 50/50	T: 0/100 U: 40/60	T: 25/75 U: 60/40	T: 25/75 U: 60/40
HPP	-	-	Number: 5 Power: 515 MW +Irrigation: 27,500 ha Water diversion: $20 m^3/s$	Number: 5 Power: 515 MW +Irrigation: 27,500 ha Water diversion: $22 m^3/s$

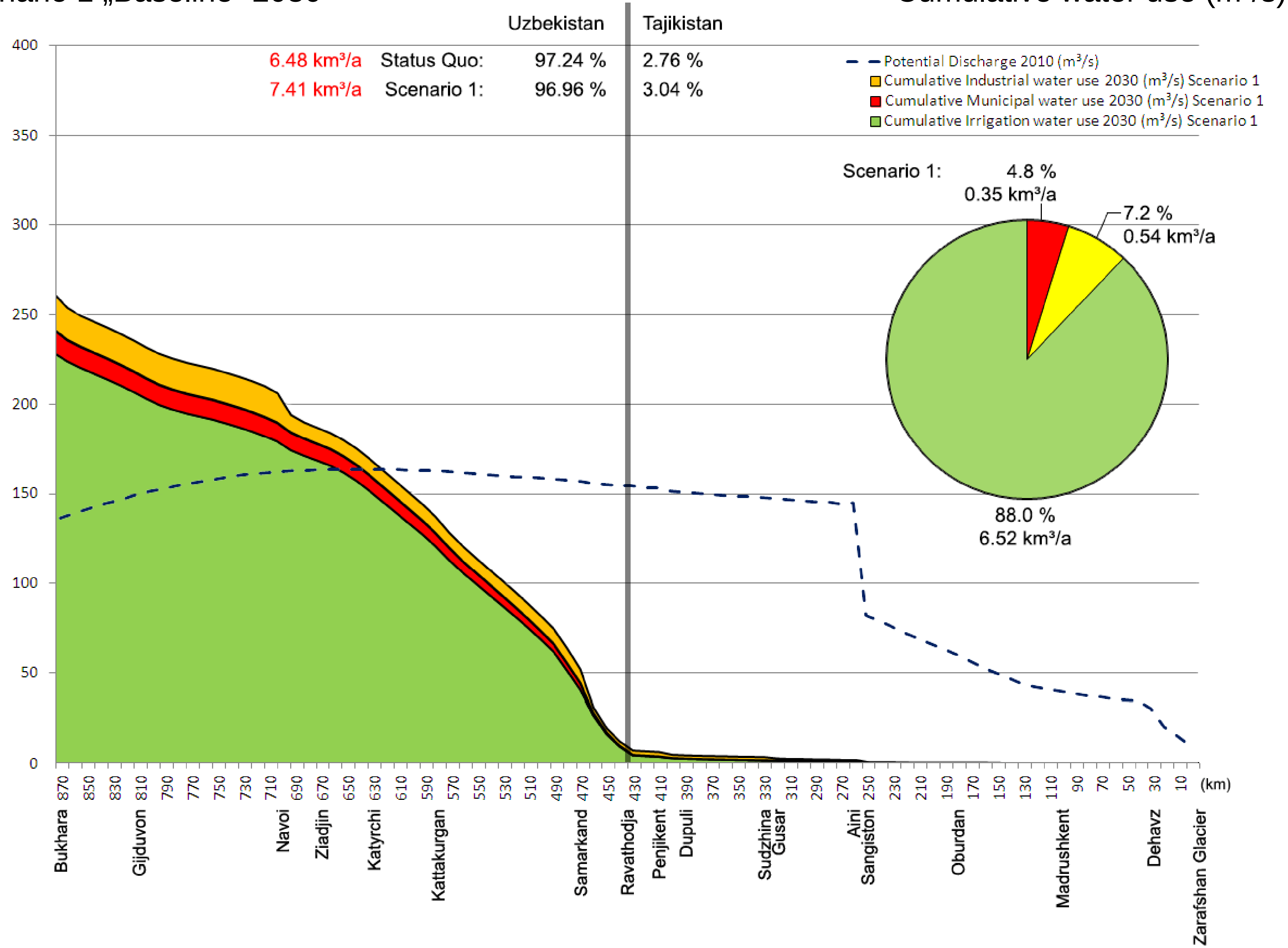
Status Quo 2010

Cumulative water use (m^3/s)



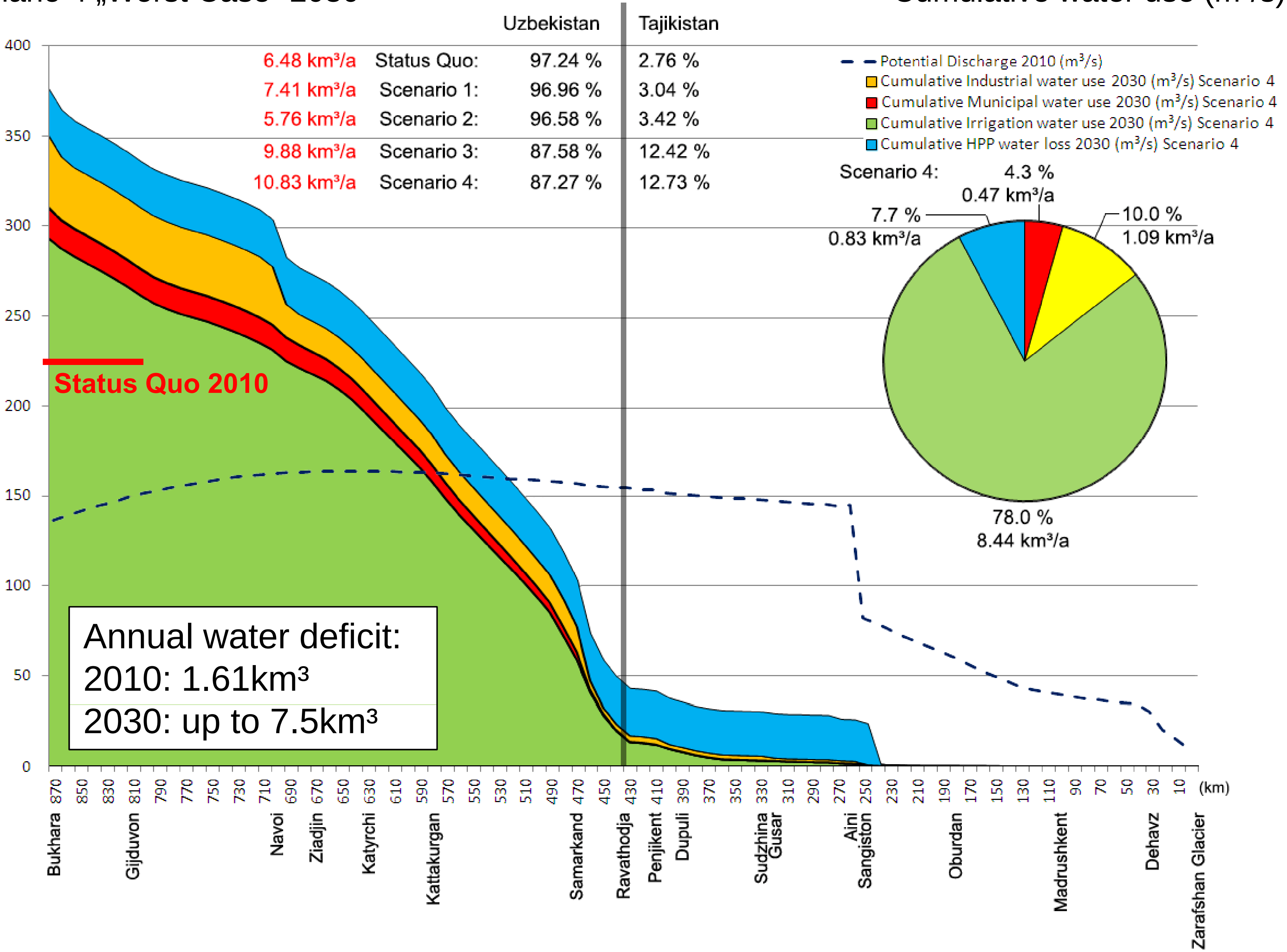
Scenario 1 „Baseline“ 2030

Cumulative water use (m³/s)



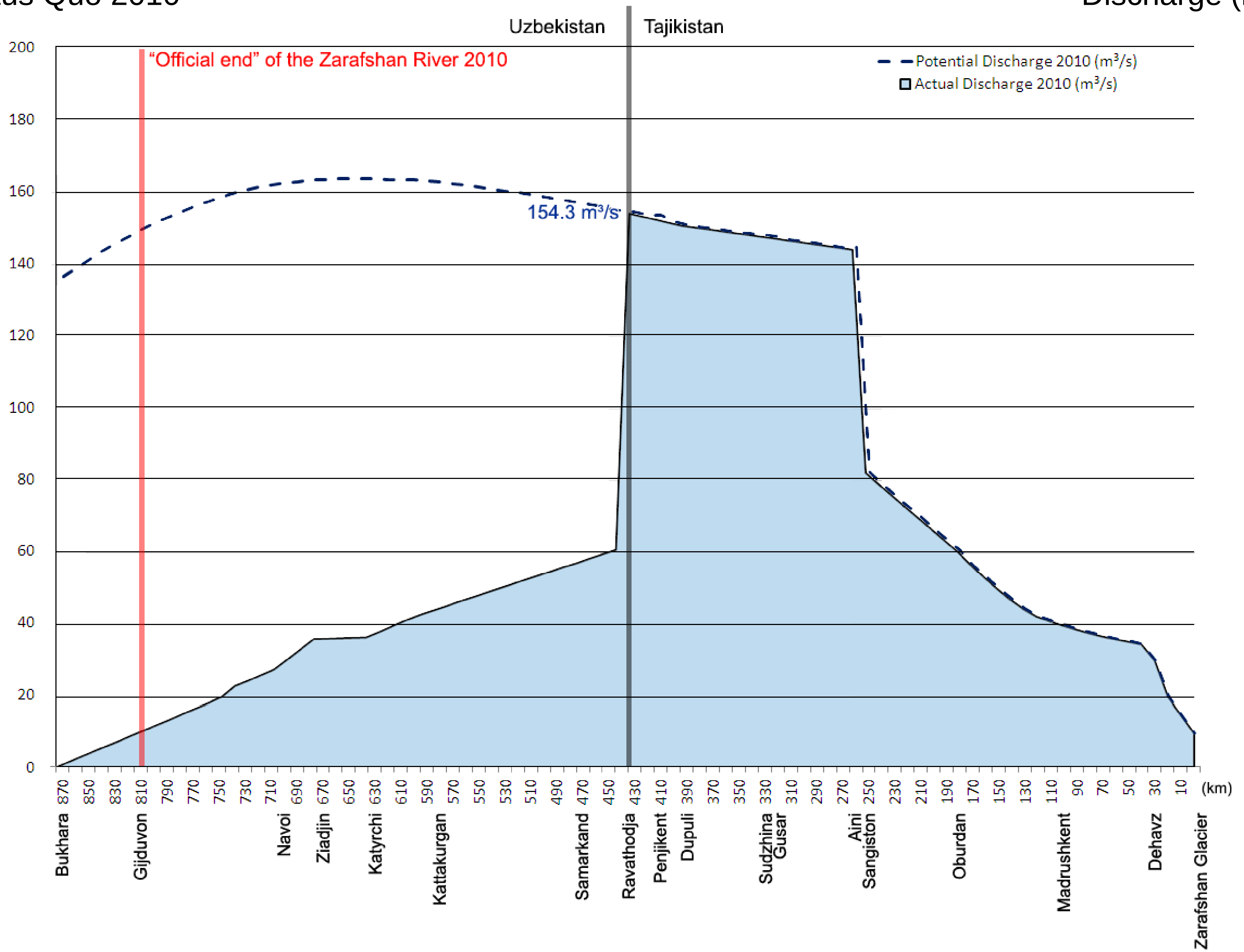
Scenario 4 „Worst Case“ 2030

Cumulative water use (m^3/s)



Status Quo 2010

Discharge (m³/s)



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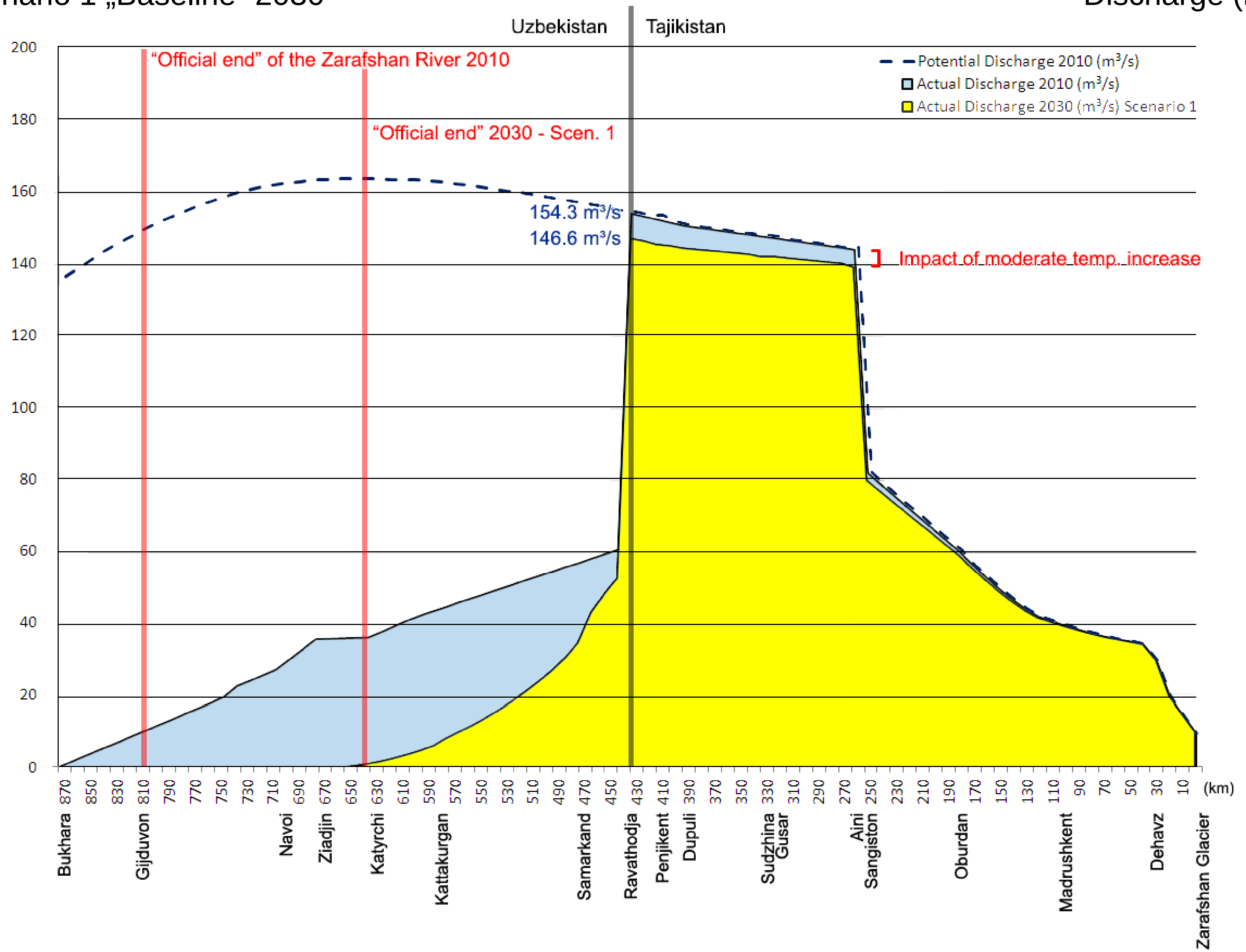
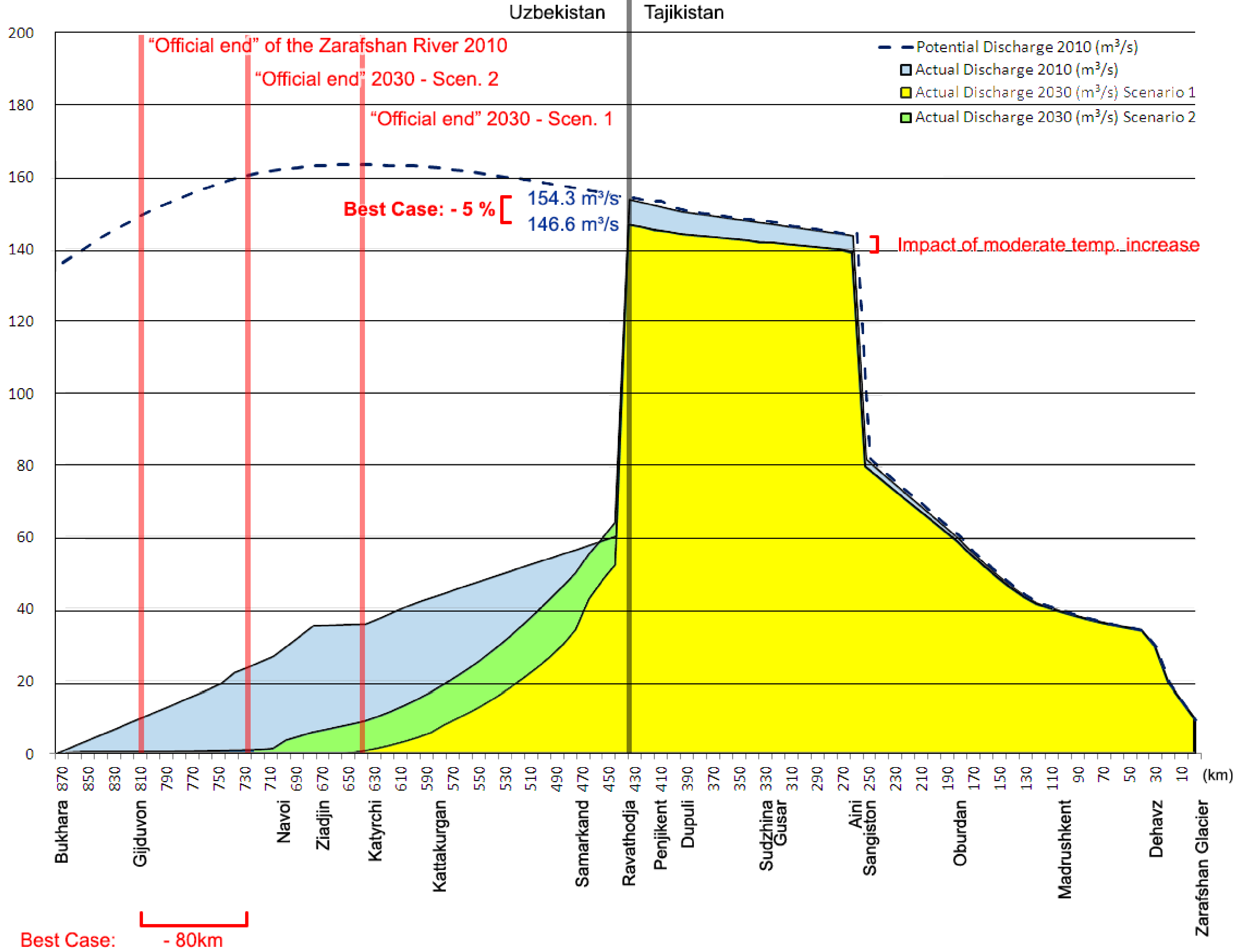


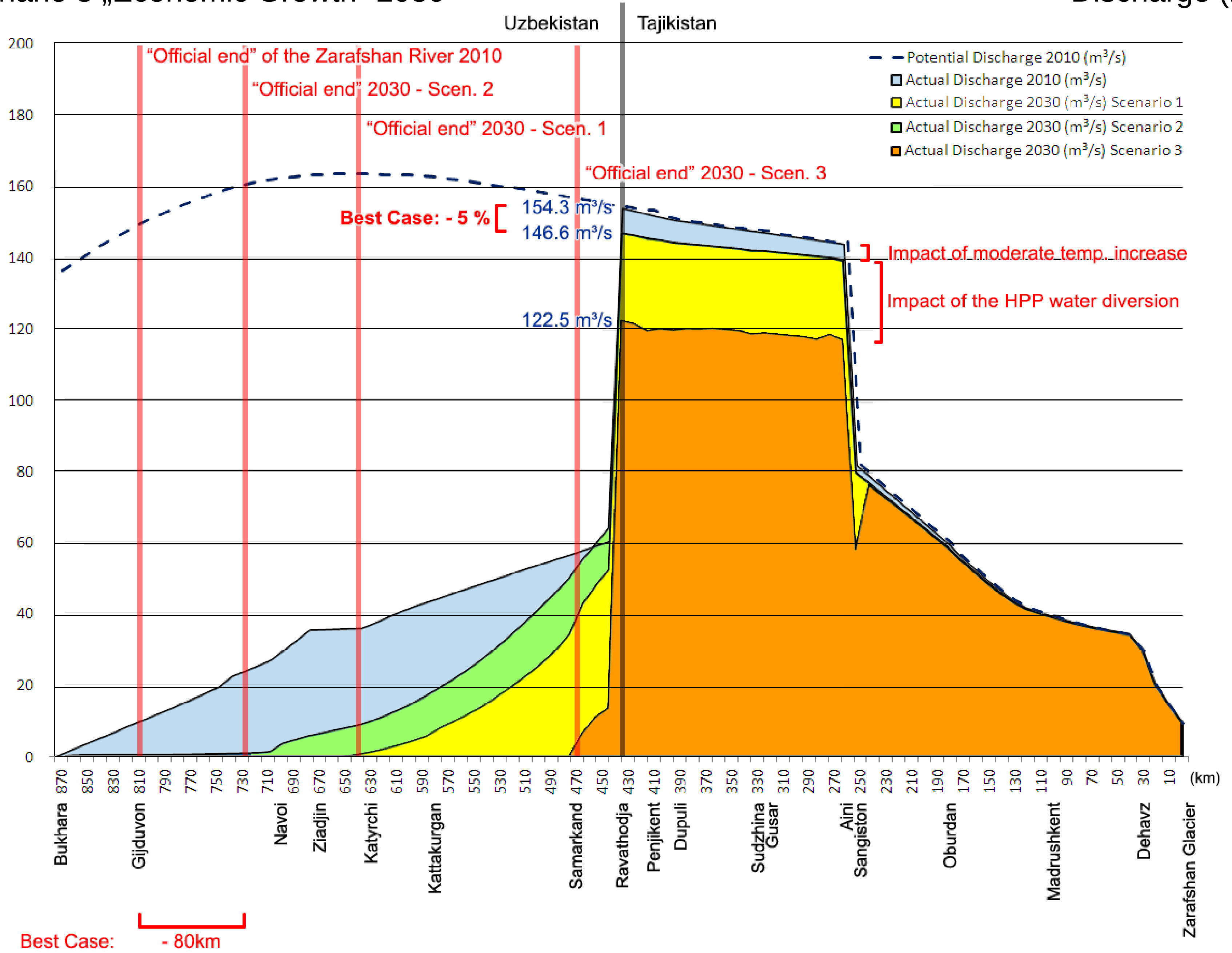
Scenario 2 „Best Case“ 2030

Discharge (m³/s)



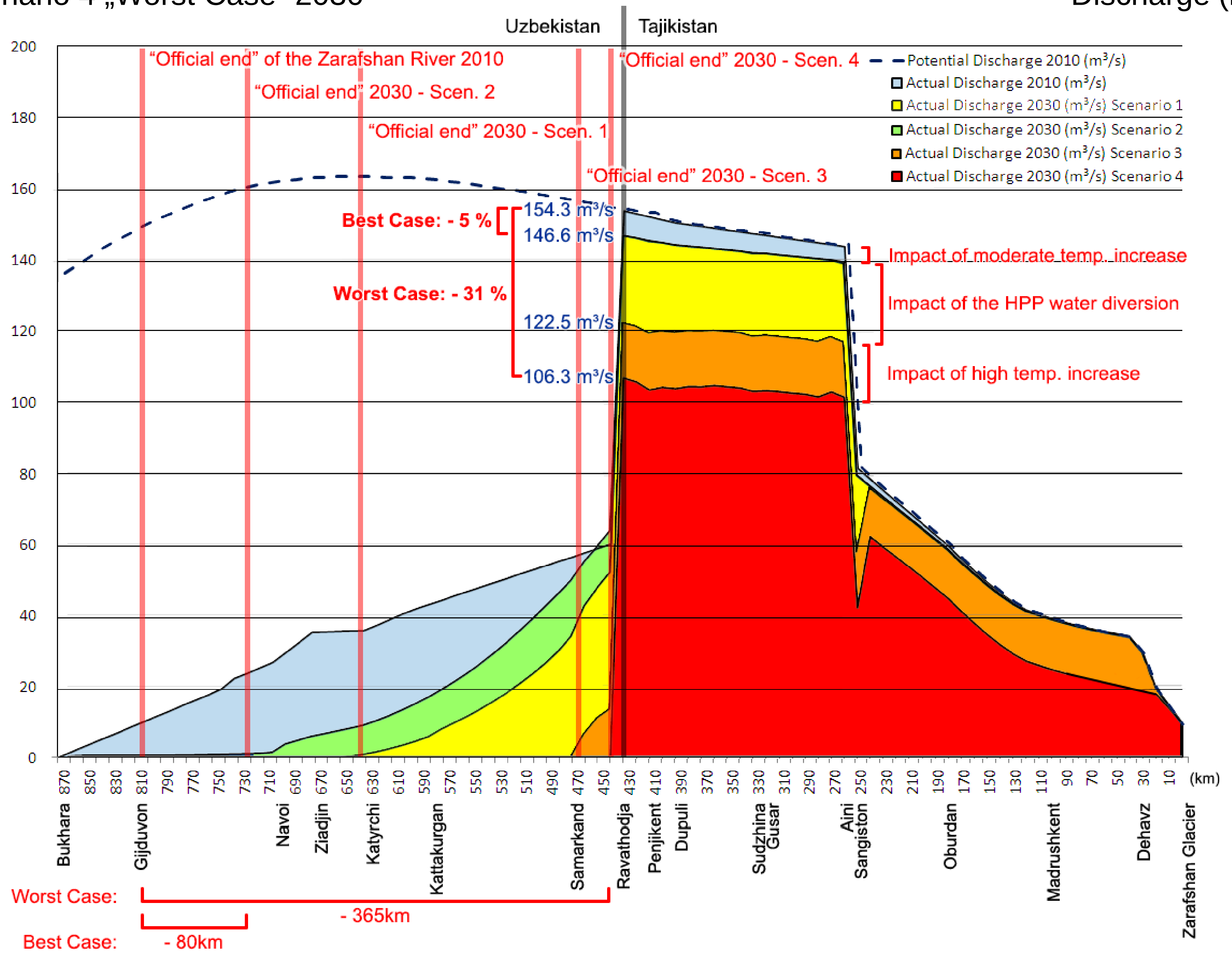
Scenario 3 „Economic Growth" 2030

Discharge (m³/s)



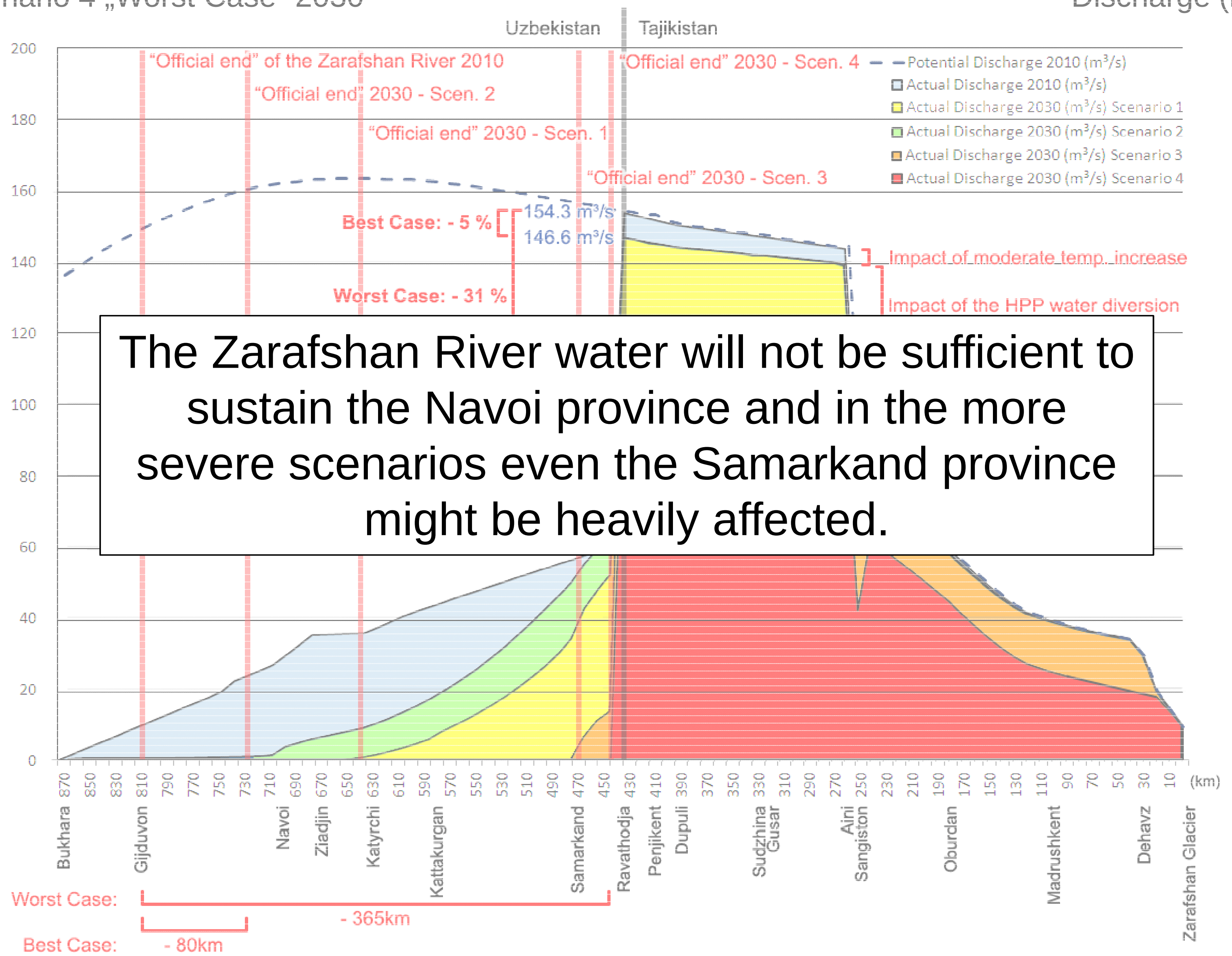
Scenario 4 „Worst Case“ 2030

Discharge (m³/s)



Scenario 4 „Worst Case“ 2030

Discharge (m³/s)



The Zarafshan River water will not be sufficient to sustain the Navoi province and in the more severe scenarios even the Samarkand province might be heavily affected.

Summary

Status Quo:

- The water consumption exceeds the available resources (1.6 km^3 annual deficit);
- The water quality in the lower Zarafshan River catchment is already critical;
- The drainage water from the irrigated areas is the main source of pollution;

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Scenarios for 2030:

- The water demand and the annual deficit will increase, for the latter to up to 7.5 km³ (4.7x);
- Even the „Best Case“ scenario will not improve the status quo significantly;
- More water will be consumed in the Tajik part of the catchment, the HPP could have a major impact (quantity & seasonality of the discharge);
- Securing the water provision in the lower catchment will become more and more difficult – especially in dry years;

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<u>Outlook for 2050:</u>

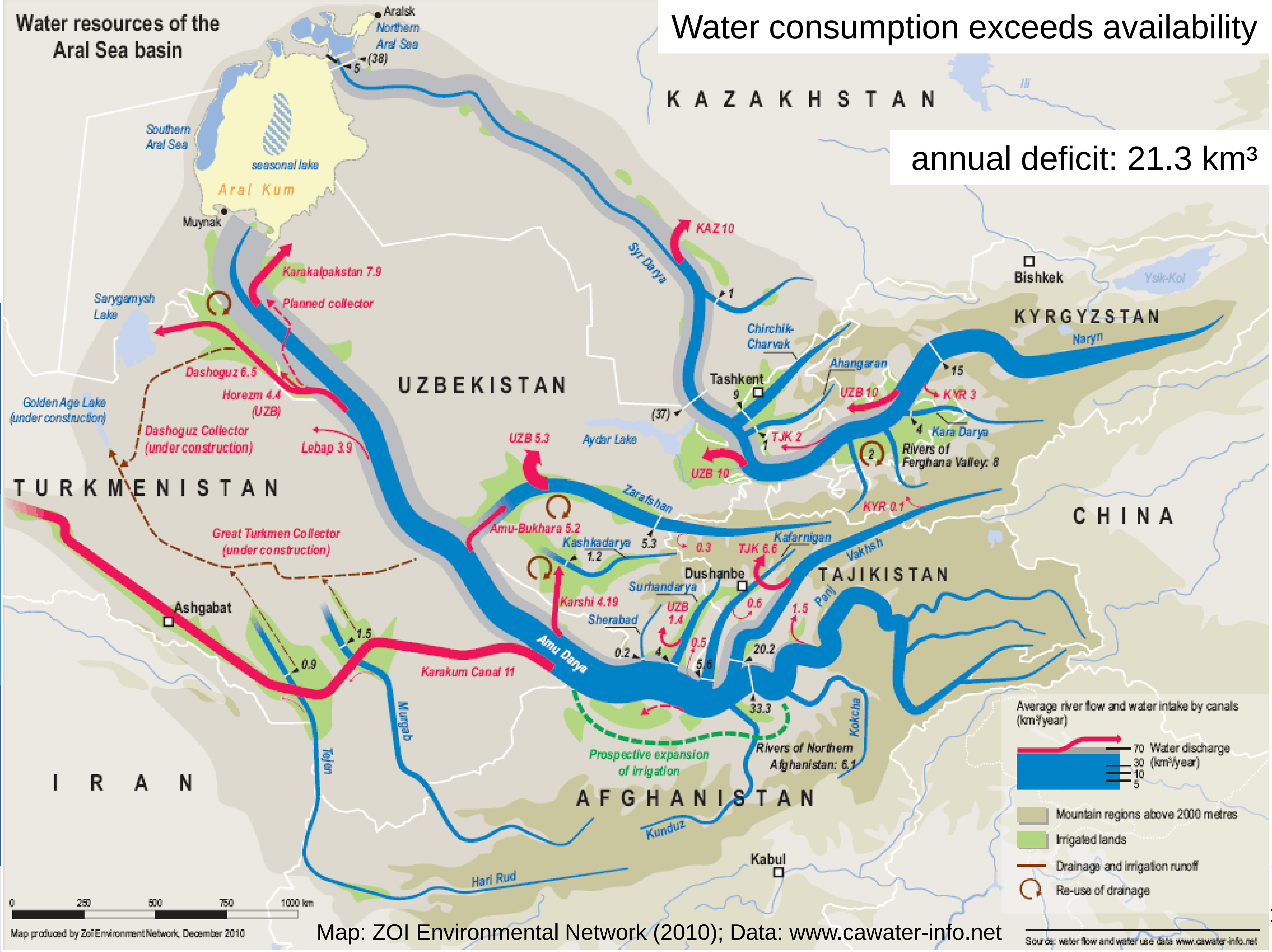
- The accelerated glacier retreat will reduce the discharge of the Zarafshan and further increase the annual water deficit.

Conclusions

- Business as usual will not solve the problem;
- Even the best case scenario approach might not be good enough;
- Water saving instruments have to be applied (increase water use efficiency);
- There is a strong need for a transboundary cooperation and an integrated resource management plan and the time to start it is now.

Water consumption exceeds availability

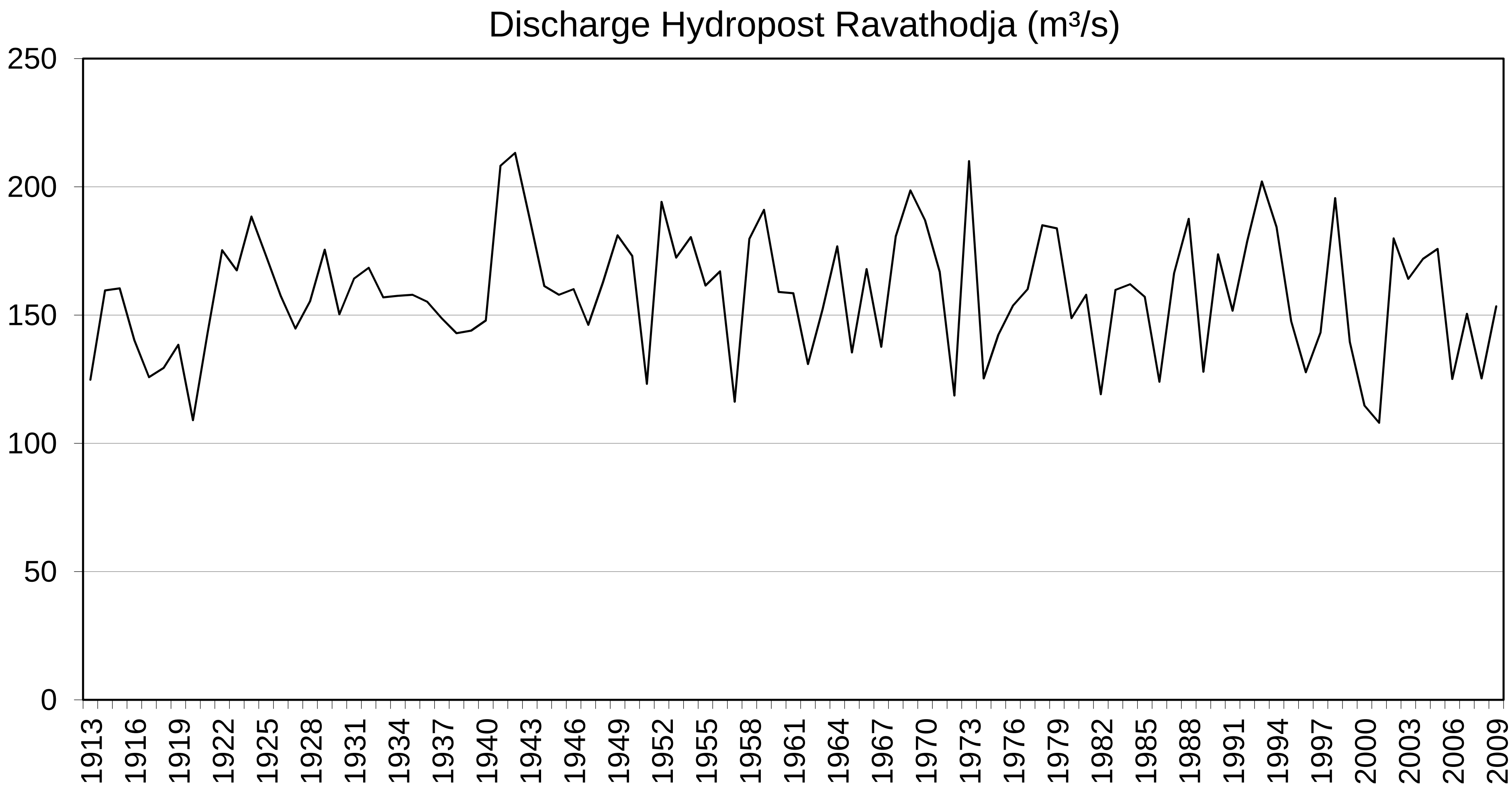
annual deficit: 21.3 km³



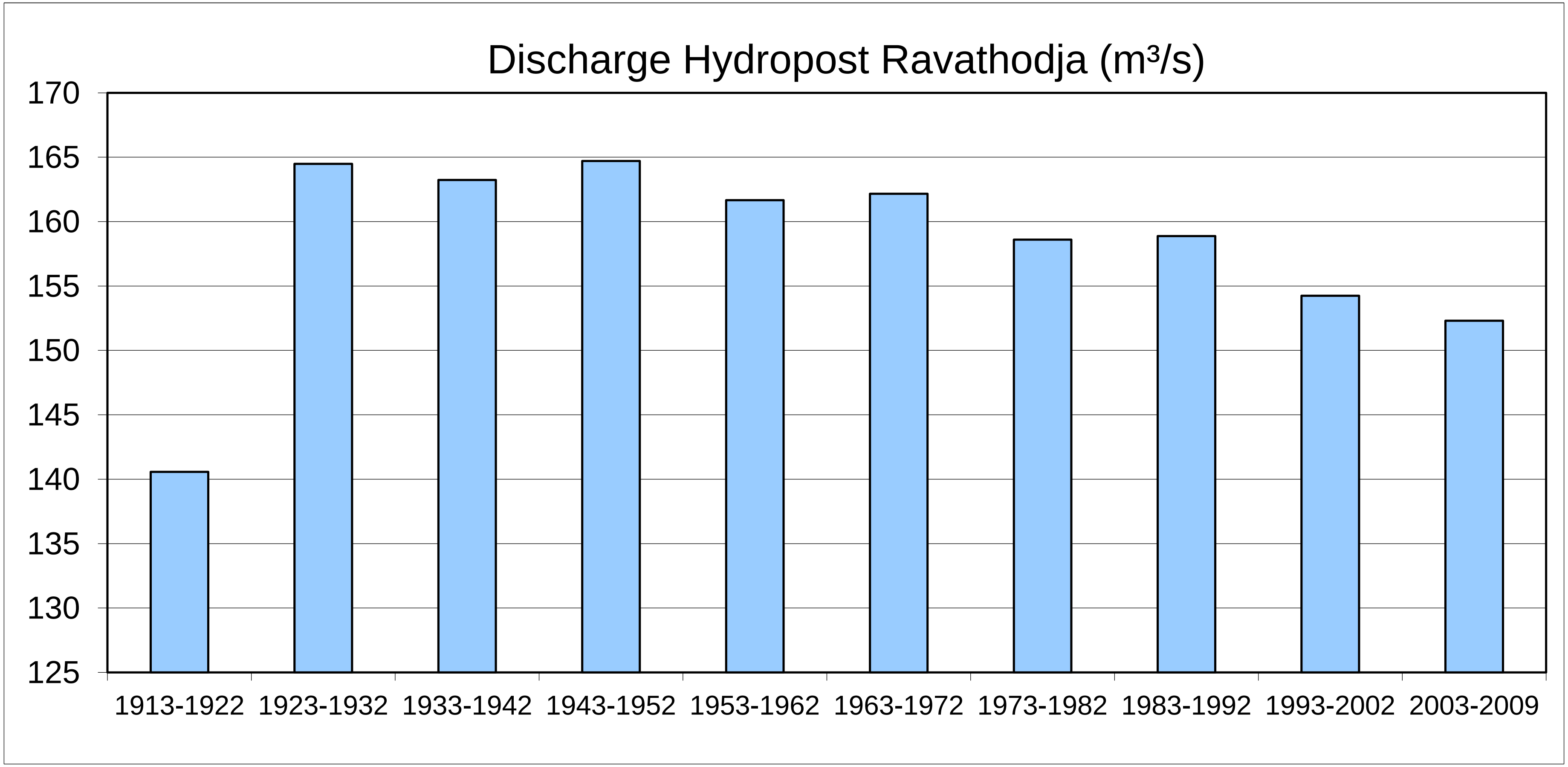
Map: ZOI Environmental Network (2010); Data: www.cawater-info.net

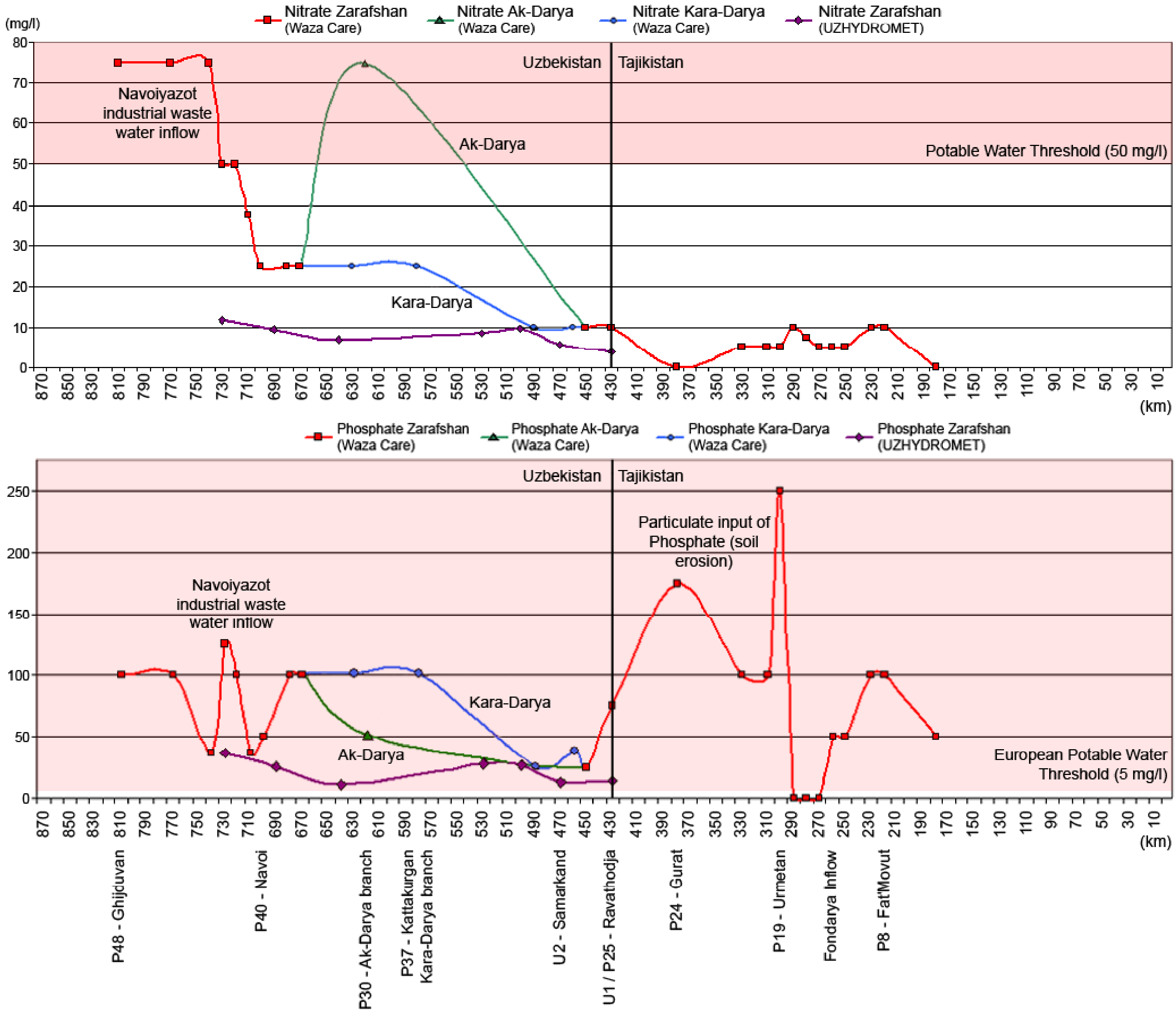



Highly dynamic discharge with year-to-year changes of up to 23%
The water deficit will vary from year to year – drought years could be more severe than the scenarios suggest

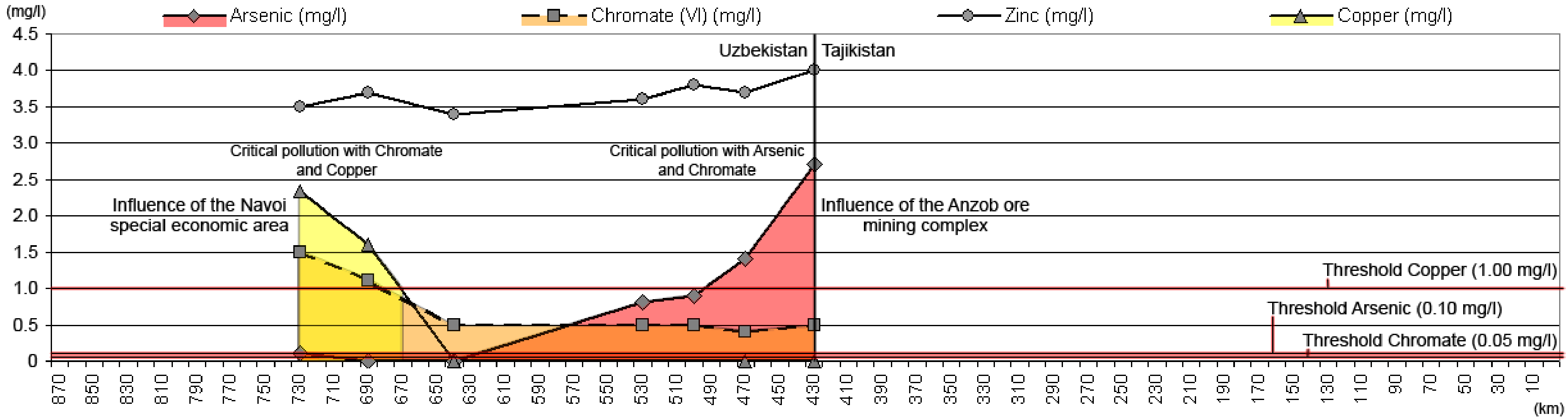


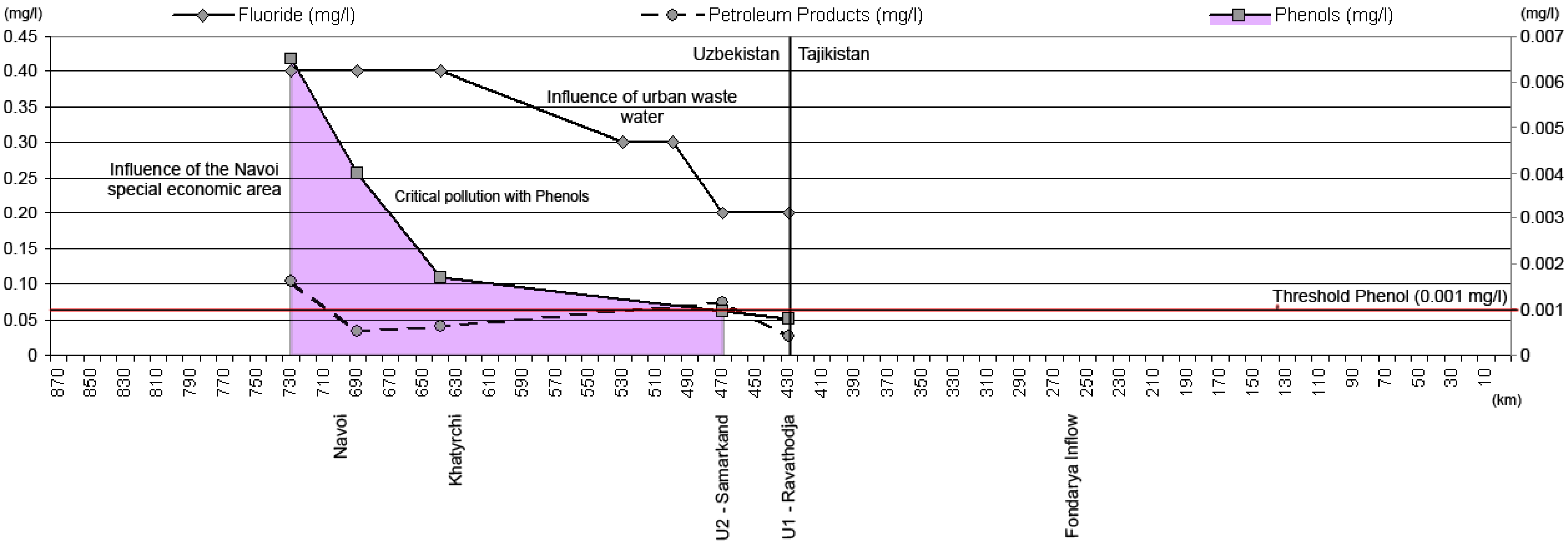
Overall decrease of the runoff since the 1940s



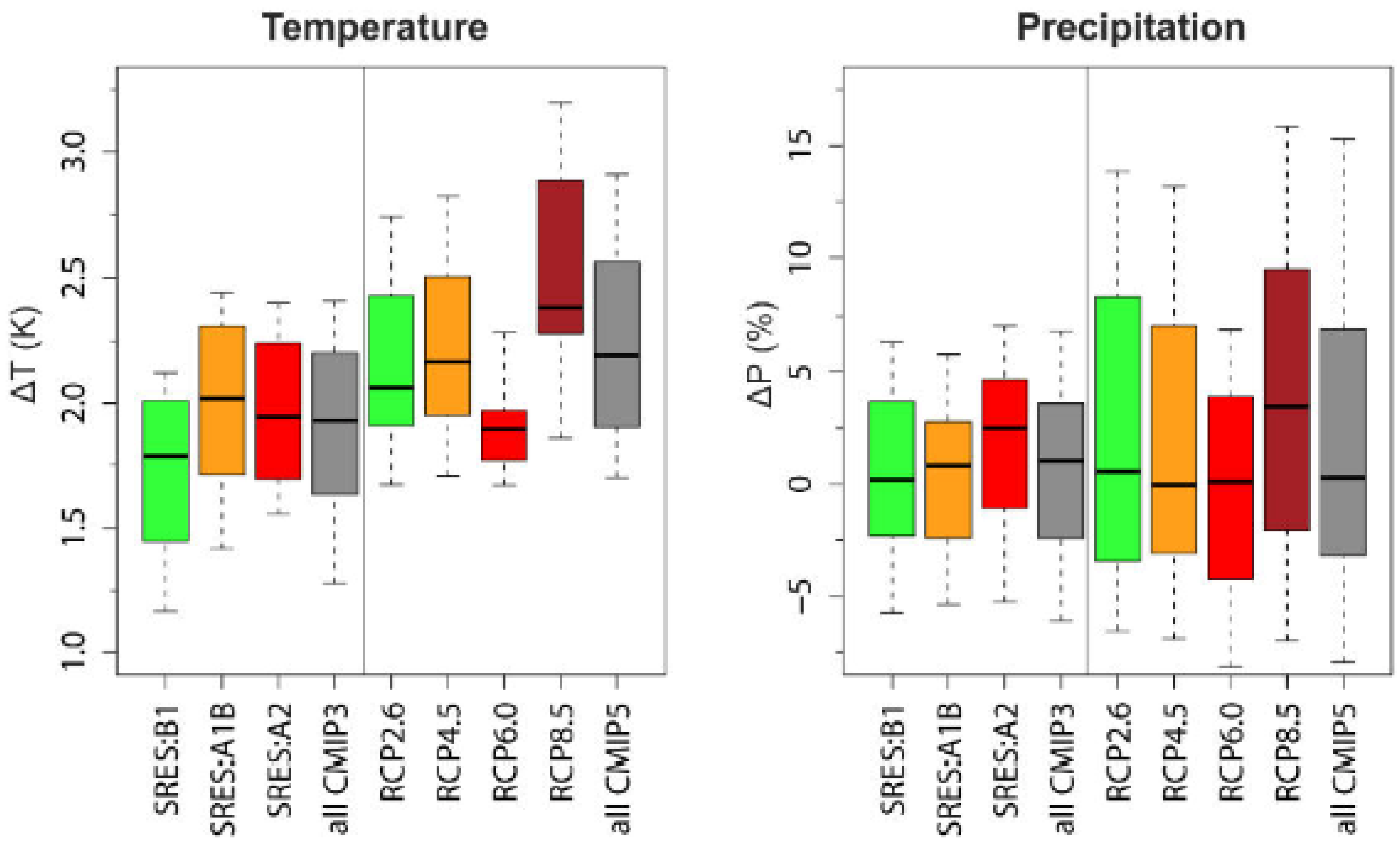


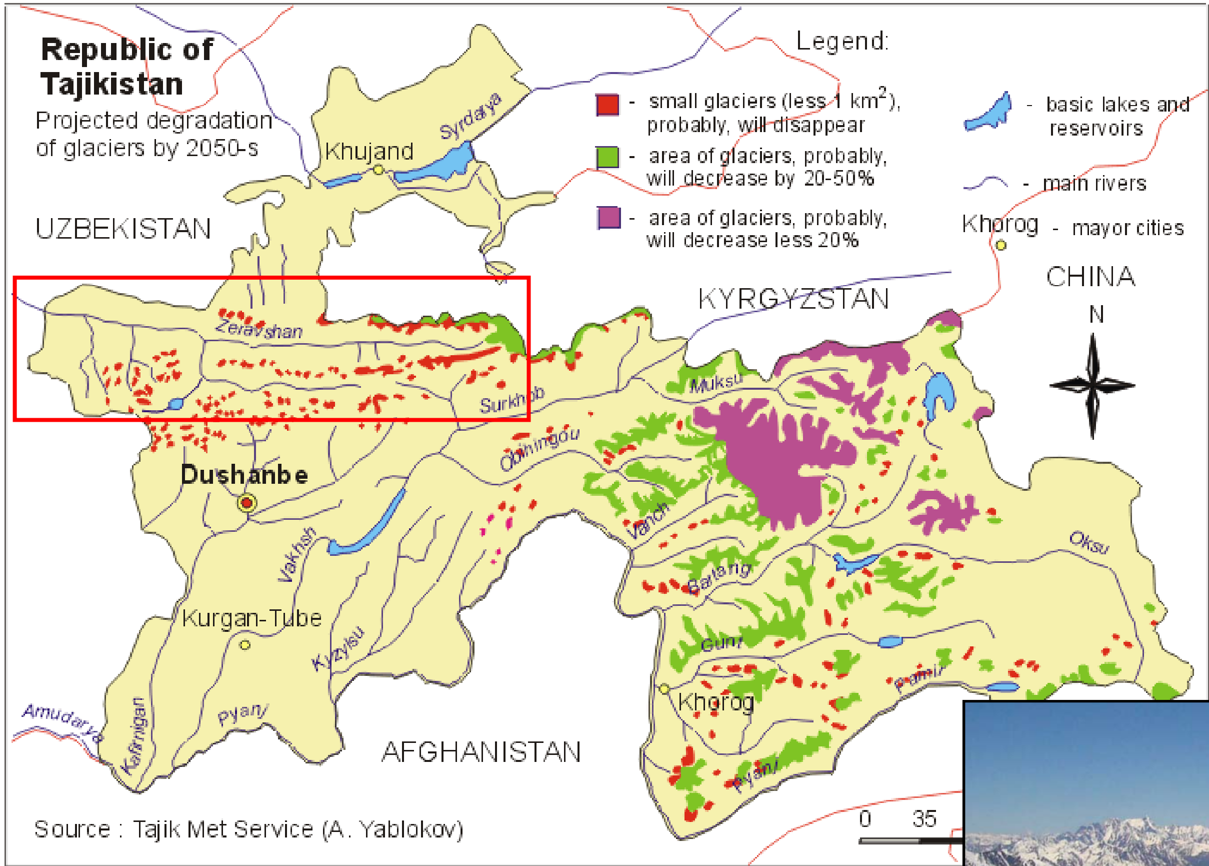
Nitrate Zarafshan (Waza Care)
Nitrate Ak-Darya (Waza Care)
Nitrate Kara-Darya (Waza Care)
Nitrate Zarafshan (UZHYDROMET)
(mg/l)
Uzbekistan
Tajikistan
Navoiyazot industrial waste water inflow
Ak-Darya
Kara-Darya
Potable Water Threshold (50 mg/l)
(km)
Phosphate Zarafshan (Waza Care)
Phosphate Ak-Darya (Waza Care)
Phosphate Kara-Darya (Waza Care)
Phosphate Zarafshan (UZHYDROMET)
Uzbekistan
Tajikistan
Particulate input of Phosphate (soil erosion)
Navoiyazot industrial waste water inflow
Kara-Darya
Ak-Darya
European Potable Water Threshold (5 mg/l)
(km)
P48 - Ghijduvan
P40 - Navoi
P30 - Ak-Darya branch
P37 - Kattakurgan Kara-Darya branch
U2 - Samarkand
U1 / P25 - Ravathodja
P24 - Gurat
P19 - Urmetan
Fondarya Inflow
P8 - Fat'Movut


(mg/l)
Arsenic (mg/l)
Chromate (VI) (mg/l)
Zinc (mg/l)
Copper (mg/l)
Uzbekistan
Tajikistan
Critical pollution with Chromate and Copper
Critical pollution with Arsenic and Chromate
Influence of the Navoi special economic area
Influence of the Anzob ore mining complex
Threshold Copper (1.00 mg/l)
Threshold Arsenic (0.10 mg/l)
Threshold Chromate (0.05 mg/l)
(km)


(mg/l)
Fluoride (mg/l)
Petroleum Products (mg/l)
Phenols (mg/l)
(mg/l)
Uzbekistan
Tajikistan
Influence of urban waste water
Influence of the Navoi special economic area
Critical pollution with Phenols
Threshold Phenol (0.001 mg/l)
(km)
Navoi
Khatyrchi
U2 - Samarkand
U1 - Ravathodja
Fondarya Inflow

CMIP5 ensemble results for Central Asia in 2050 (Lutz et al. 2013)





Annual Retreat of the Central Asian Glaciers:

	1900-1950	1950-2000
Min.	0.026%	0.14%
Max.	0.5%	1.0%

Retreat of the Zarafshan glacier since 1990: **0,25%** to **0,33%** per year;

Data: Agaltseva & Konovalov (2005), Aizen et al. (1997), Chub (2011), Eizen (2008), Glazirin (2009), Hagg et al. (2007), Hoelzle & Wagner (2010), Homidov (2009), Normatov et al. (2012), Perelet (2008), Yakovlev (2010)

In 2050 the discharge of the Central Asian rivers will be **25%** to **50%** lower than in 2000.

At the same time the water demand will be at least **30%** higher than today.

The annual water deficit could increase from 21.3 km³/a to **92-120 km³/a**.

Data: Agaltseva (2008), Dukhovny & de Schutter (Eds.) (2011), Spektorman & Petrova 2008; UZHYDROMET (Eds.) 2008
Photo: Mustaeva (2007)

Scenario assumptions – Hydropower usage

Tajikistan has the largest water resources of all the Central Asian countries:

- 845 km³ stored in more than 14,500 glaciers
- Annual discharge of 64 km³ (55.4% of the total discharge within the Aral Sea basin)
- 61.3% of these resources could be used (technical and financial viable)
- Today only **5%** are used for HPP and irrigation
- Because of the growing population the amount of agricultural land per capita will decrease from 0.116 ha (2006) to **0.08 ha** (2015)
- Because of the growing population and the economic growth the need for energy increased from 1 Bln. kWh (1990) to **5 Bln. kWh** (2006) – annual deficit of **3-3.5 Bln. kWh**

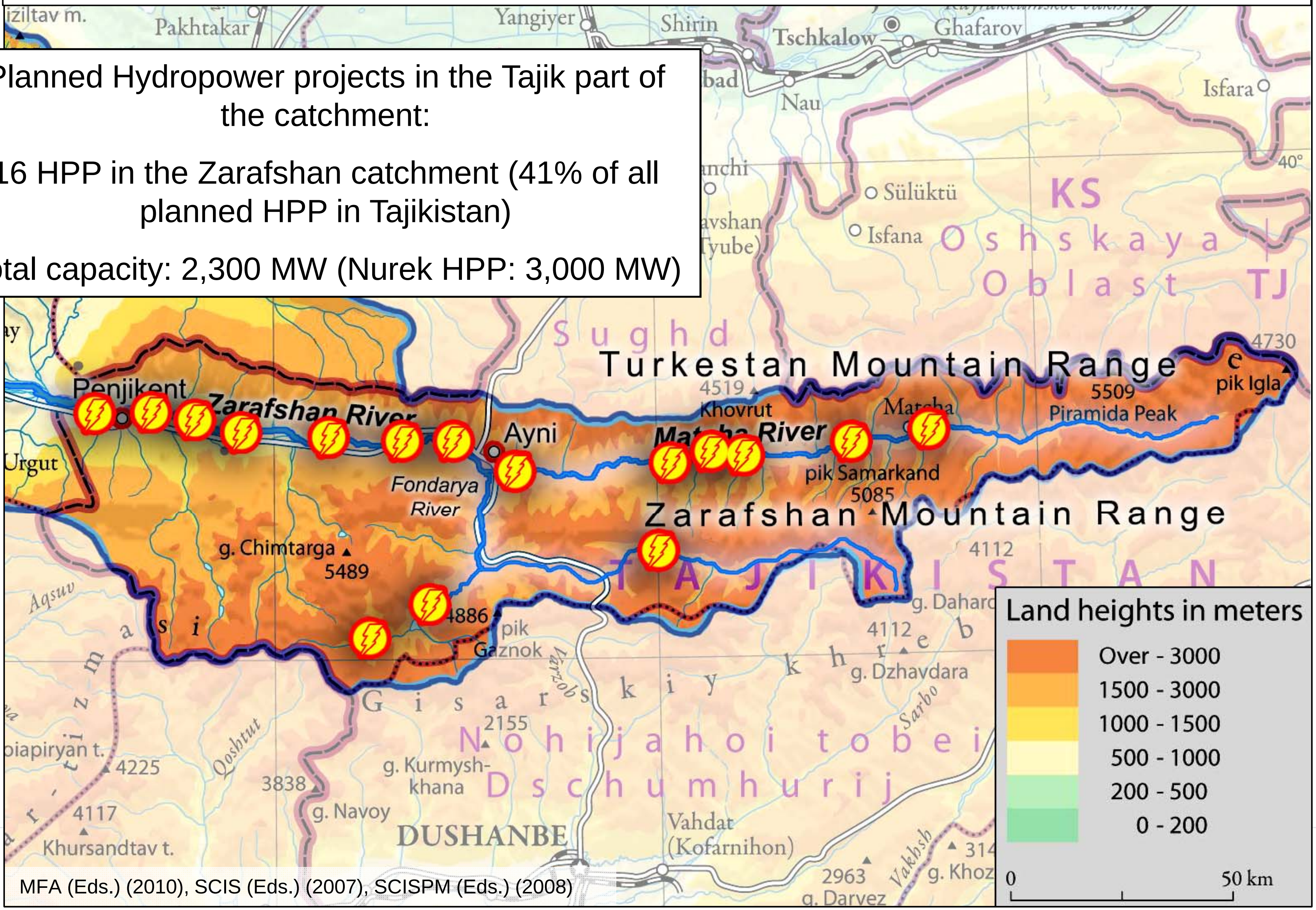
Data: Desilets & Lambert 2011, Eschanov 2006, Libert et al. 2008, MIWa (Eds.) 2006, Musayeva et al. 2009, Nazirov 2002, SCIS (Eds.) 2007, Wegerich et al. 2007

Improving the food and energy security are at the centre of the Tajik national strategies for the next decades.

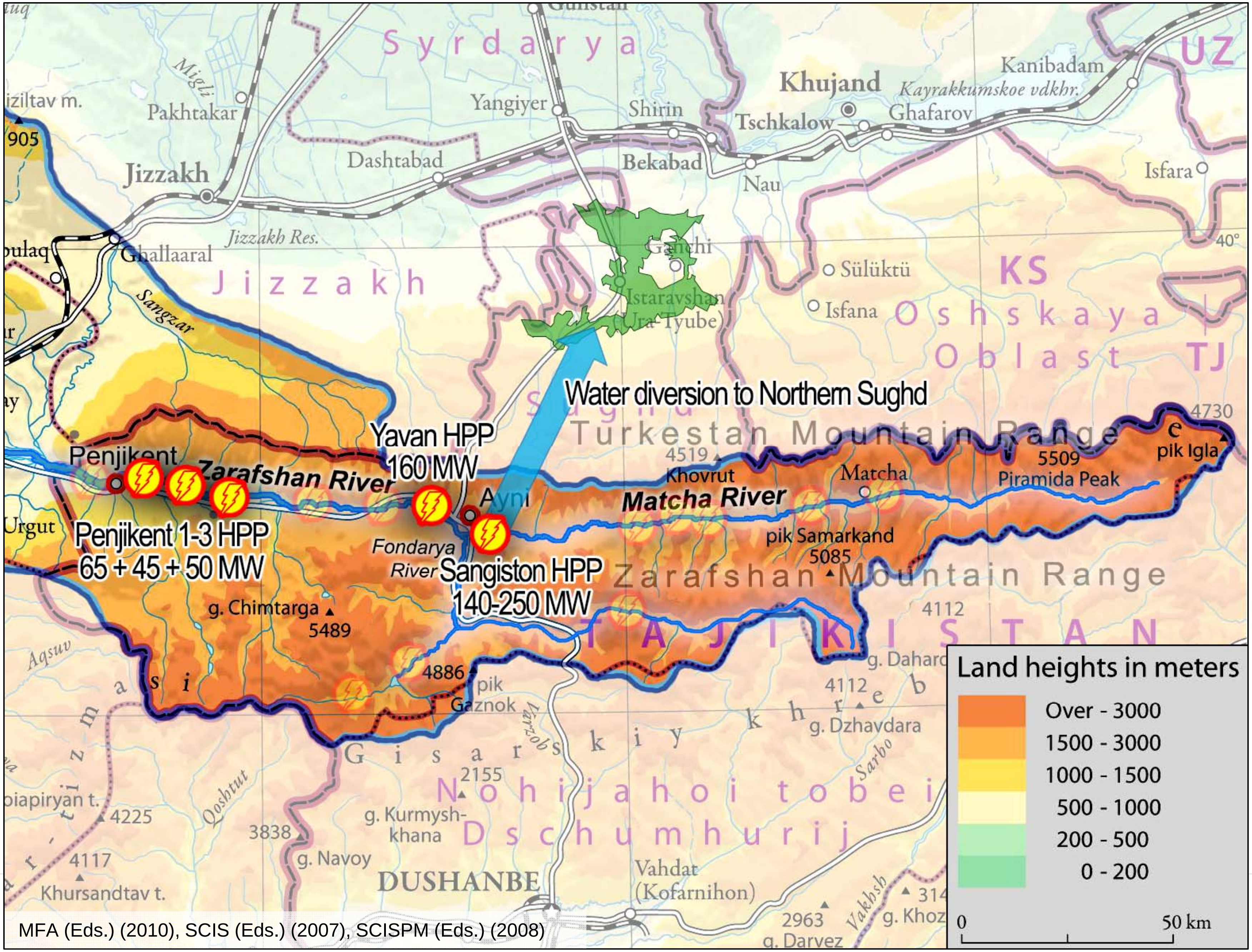
Planned Hydropower projects in the Tajik part of the catchment:

16 HPP in the Zarafshan catchment (41% of all planned HPP in Tajikistan)

Total capacity: 2,300 MW (Nurek HPP: 3,000 MW)



MFA (Eds.) (2010), SCIS (Eds.) (2007), SCISPM (Eds.) (2008)



MFA (Eds.) (2010), SCIS (Eds.) (2007), SCISPM (Eds.) (2008)