

**About a need to develop a regional integrated water-energy model for  
the estimation of national development options in the countries of  
Central Asia (The Aral Sea basin)**

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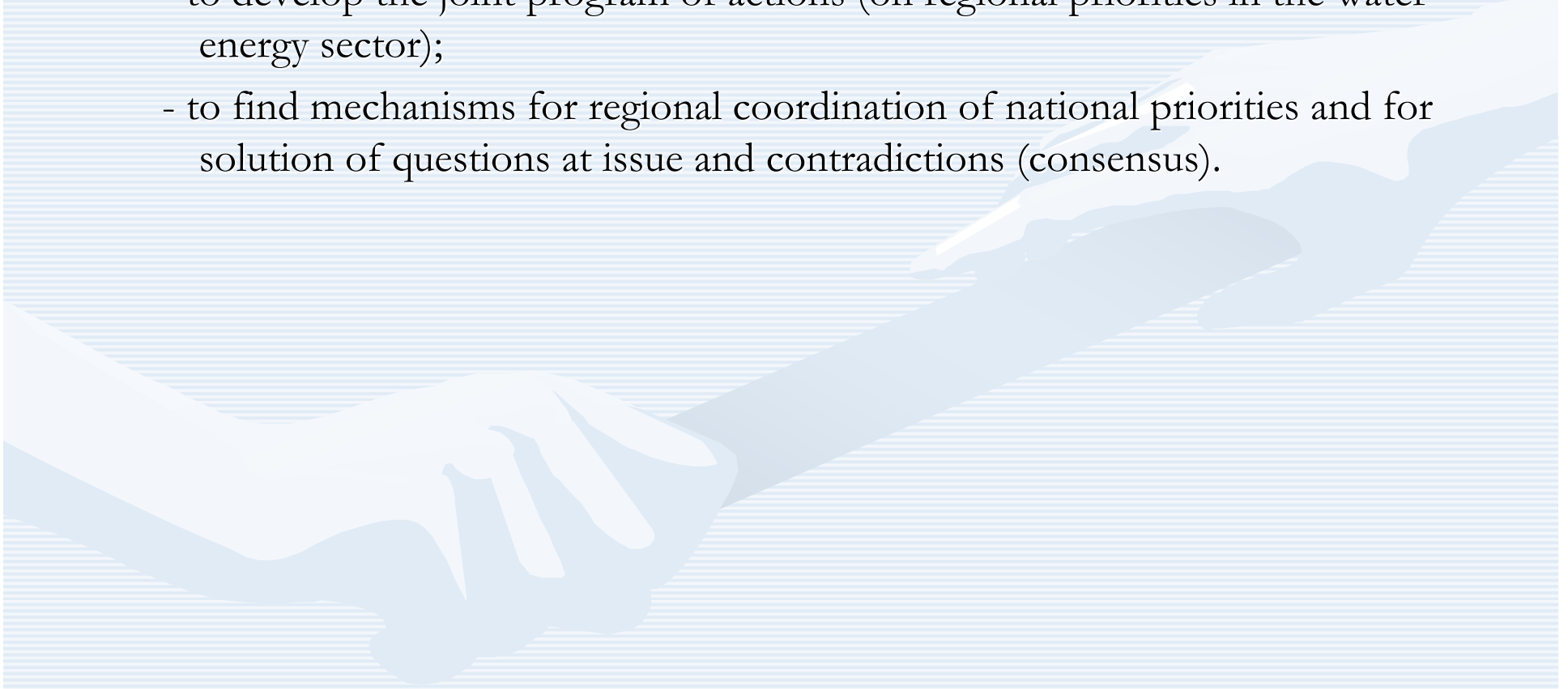
- **Plan of actions.**
- **Our experience.**
- **Our approaches**

**What we have:**

- national development **strategy** (taking into account use of water-energy potential),
- regional energy and water-management structure (uniting and limiting our endeavors),
- general will to regional cooperation and sustainable development in the region.

**We have the following objectives:**

- to develop the joint program of actions (on regional priorities in the water-energy sector);
- to find mechanisms for regional coordination of national priorities and for solution of questions at issue and contradictions (consensus).



## We do not have:

- agreed on (between the countries) **tools of the regional analysis** of the national development scenarios (water-energy sector), taking into account future challenges and destabilizing factors (climate, globalization).

## **We know:**

- new **integrated** approaches based on the advanced world experience are needed;
- one must take into account mistakes of the last research and attempts to find the optimal regional scenarios of country development (water sector).

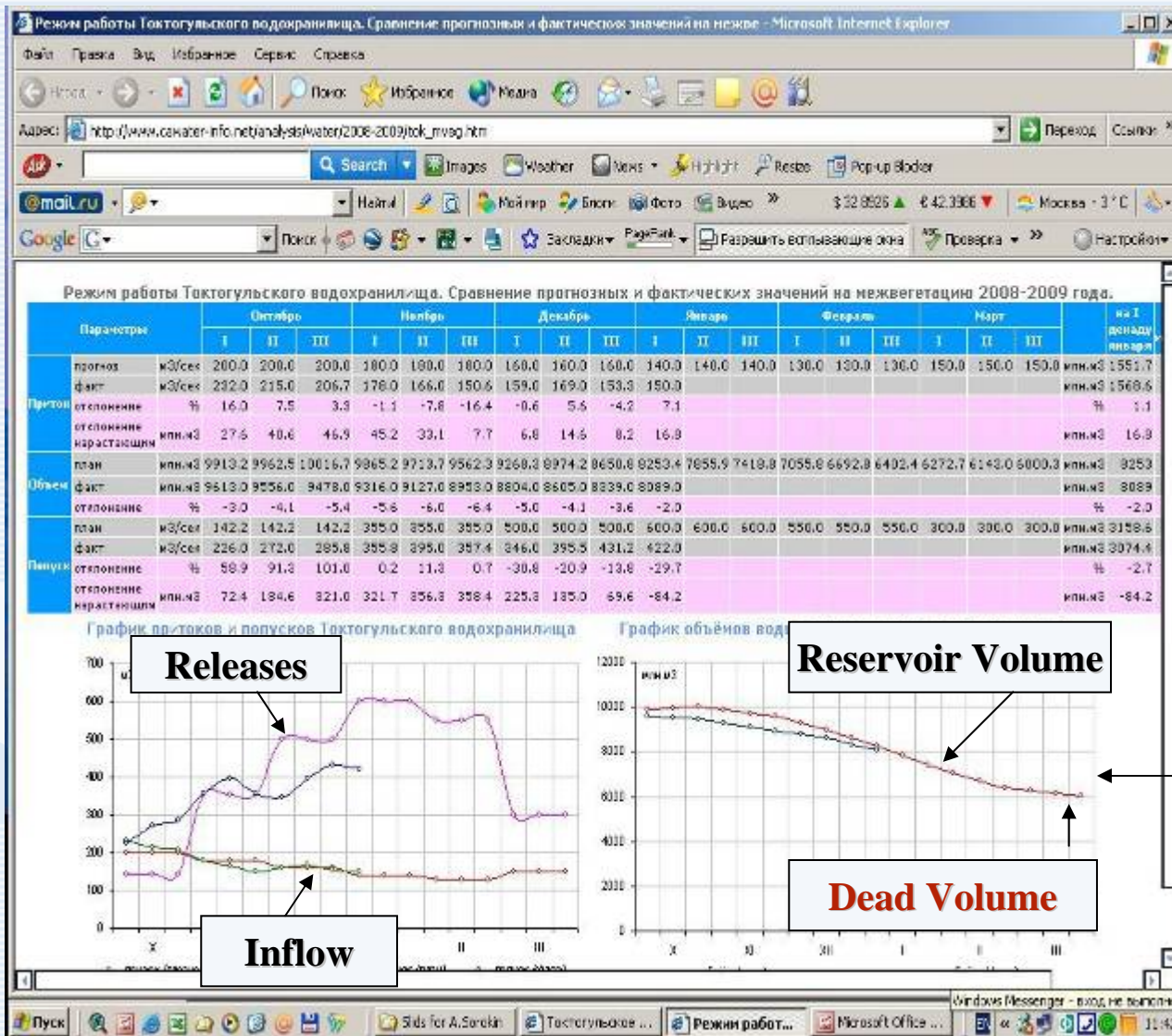
## Our experience

- Central Asia Regional Water **Information Base**: Portal and Information System
- Analytical instruments and **models**,
- Modeling **results** for integrated water management in river basins: Chirchik-Akhangaran-Keles basin (**RIVERTWIN**) , **Rogun**



# CAREWIB ANALYTICAL DATA (www.cawater-info.net)

## Toktogul HPS: Reservoir mode, October 2008 - 2009



**Inflow:**

- forecast,
- actual,
- deviation

**Reservoir Volume:**

- plan, actual, deviation

**Releases:**

- plan,
- actual,
- deviation

This is a result of large (winter) releases after 1992 and absence of the long-term flow regulation

Объемы попусков, боковой приточности и водозаборов на участке Токтогул-Кайракум. Сравнение прогнозных и фактических значений межвегетацию 2008-2009 года.

Параметры		Октябрь			Ноябрь			Декабрь			Январь			Февраль			Март							
		I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III					
Попуск из водоз-ща	прогноз	м3/сек	142.2	142.2	142.2	355.0	355.0	355.0	500.0	500.0	500.0	600.0	600.0	600.0	550.0	550.0	550.0	300.0	300.0	300.0				
	факт	м3/сек	226.0	272.0	285.8	355.8	395.0	357.4	346.0	395.5	431.2	422.0												
	отклонение	%	58.9	91.3	101.0	0.2	11.3	0.7	-30.8	-20.9	-13.8	-29.7												
	отклонение нарастающим	млн.м3	72.4	184.6	321.0	321.7	356.3	358.4	225.3	135.0	69.6	-84.2												
Бок. приточность	прогноз	м3/сек	216.0	216.4	219.1	378.0	379.1	390.2	375.1	381.5	368.2	391.0	383.5	378.7	399.3	402.4	400.1	342.5	330.8	319.4				
	факт	м3/сек	252.7	267.9	284.5	349.1	402.5	379.9	330.0	286.7	329.2	392.0												
	отклонение	%	17.0	23.8	29.9	-7.6	6.2	-2.6	-12.0	-24.8	-10.6	0.3												
	отклонение нарастающим	млн.м3	31.7	76.3	138.4	113.5	133.8	124.9	86.0	4.1	-33.0	-32.2												
Водозабор, в т.ч.:	прогноз	м3/сек	182.2	177.9	148.9	64.9	31.9	12.6	12.6	23.3	33.3	69.9	76.3	71.5	74.9	73.8	121.6	168.5	204.7	222.1				
	факт	м3/сек	189.1	181.1	175.3	139.4	89.4	102.1	96.2	57.2	89.7	91.0												
	отклонение	%	3.8	1.8	17.8	114.7	180.0	709.9	663.2	145.6	169.2	30.1												
	отклонение нарастающим	млн.м3	6.0	8.8	33.9	98.3	147.9	225.2	297.4	326.7	380.3	398.5												
Кыргызия	прогноз	м3/сек	6.2	5.8	5.0	5.5	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	5.2	7.9	млн.м3	23.3	36.7		
	факт	м3/сек	3.9	3.5	4.1	3.9	3.2	2.6	0.1	0.0	0.0	0.0								млн.м3	18.7	18.7		
	отклонение	%	-37.5	-38.9	-19.3	-29.2	-19.4														млн.м3	-19.7	-4.6	
	отклонение нарастающим	млн.м3	-2.0	-3.9	-4.9	-6.3	-6.9	-4.7	-4.6	-4.6	-4.6	-4.6									млн.м3	-19.7	-4.6	
Таджикистан	прогноз	м3/сек	16.5	13.4	6.7	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	10.6	20.7	24.1	млн.м3	37.0	90.3	
	факт	м3/сек	6.0	5.7	6.4	7.9	5.6	1.8	2.8	1.8	0.0	0.0									млн.м3	33.4	33.4	
	отклонение	%	-63.4	-57.2	-5.6	43.8																млн.м3	-9.7	-3.6
	отклонение нарастающим	млн.м3	-9.0	-15.6	-16.0	-13.9	-9.1	-7.5	-5.2	-3.6	-3.6	-3.6									млн.м3	-9.7	-3.6	
Узбекистан	прогноз	м3/сек	159.5	158.7	137.1	53.9	27.9	12.6	12.6	23.3	33.3	69.9	76.3	71.5	74.9	73.8	116.8	156.4	178.7	190.1	млн.м3	609.8	1423.1	
	факт	м3/сек	179.2	171.8	164.9	127.6	80.6	97.6	93.3	55.4	89.7	91.0									млн.м3	016.5	016.5	
	отклонение	%	12.4	8.3	20.3	136.7	188.7	674.9	640.6	137.8	169.2	30.1										млн.м3	66.7	66.7
	отклонение нарастающим	млн.м3	17.0	28.4	54.8	118.5	163.9	237.4	307.2	334.9	388.5	406.7										млн.м3	406.7	406.7

Kyrgyzstan Intake

Tajikistan Intake

Uzbekistan Intake

River reach: Toktogul – Kayrakum

- Inflow,
- Return flow,
- Releases,
- Intake

Comparison of actual and planned (forecast) data

График отклонений плановых и фактических значений попуска, боковой приточности и водозабора

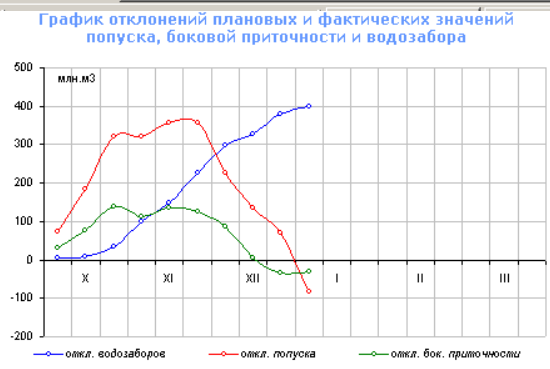
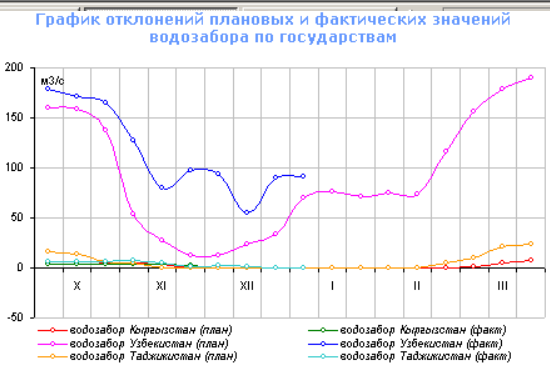


График отклонений плановых и фактических значений водозабора по государствам

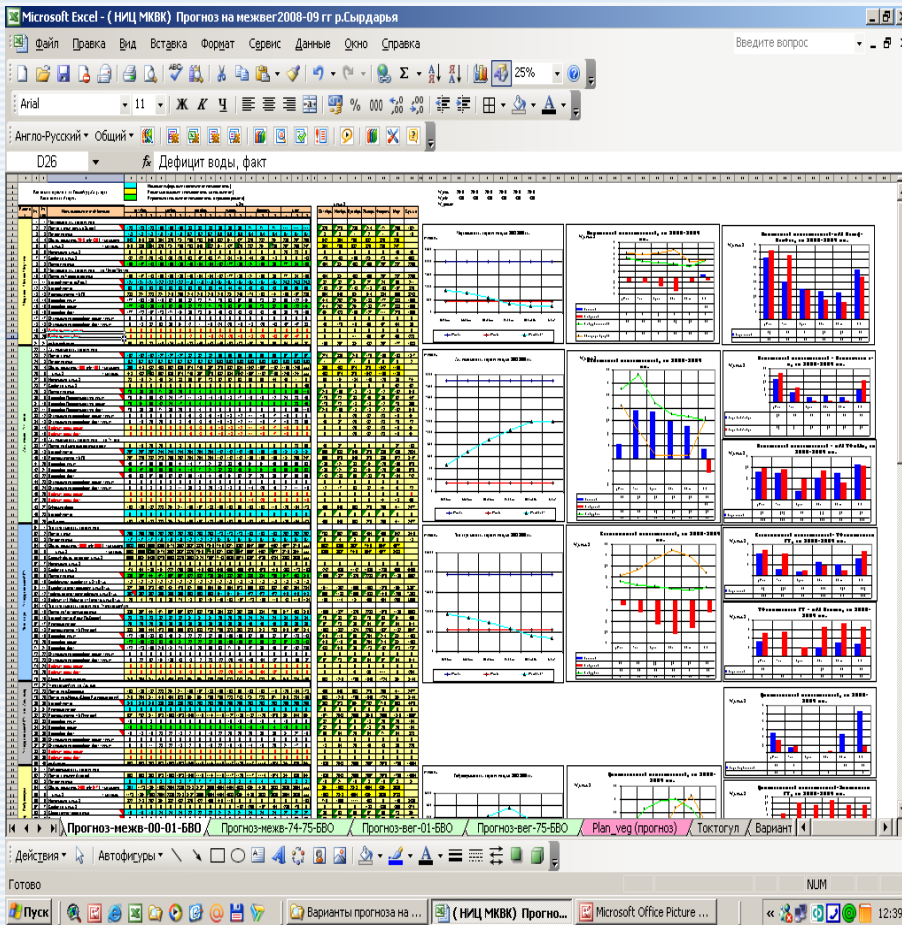


Примечание: отклонение вычисляется по формуле 100\*(план[прогноз]-факт)/план[прогноз]



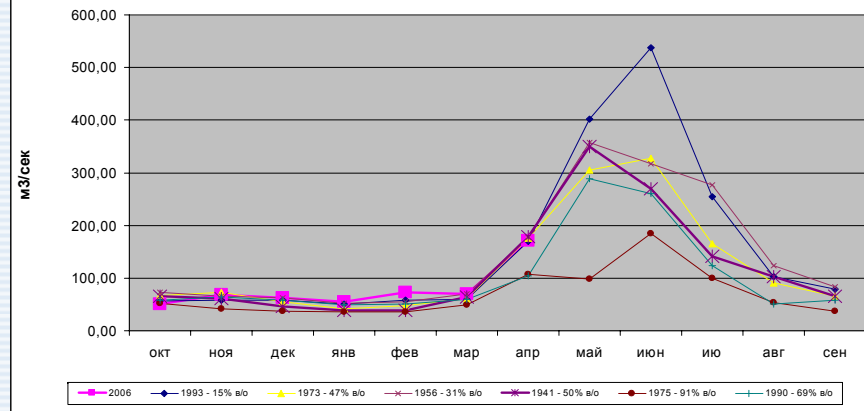
# Reservoirs and rivers water balances

Syrdarya basin: strategies of flow regulation by reservoirs and HPS (Toktogul, Kambarata 1,2)



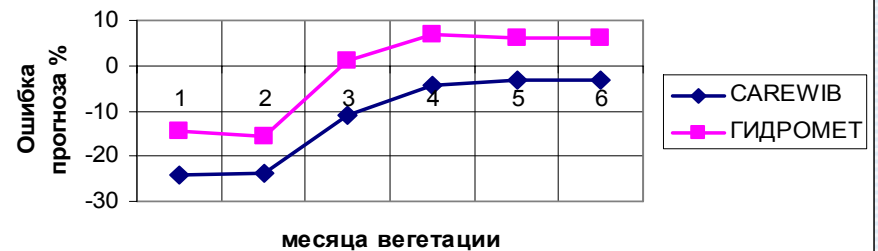
# Estimation of basins' flow probabilities by year-analogue (river hydrographs, air temperature, rainfall)

Inflow into Andijan reservoir



Hydromet and CAREWIB data

Forecast error of Inflow into Charvak reservoir for the growing season 2006, progressive total (forecast-actual)/actual\*100 %



# Steps of development of regional basin models in SIC ISWC as a DSS tool for integrated assessment of water situation

## **Aral Sea Basin Management Model ASB-mm** (1 step) – UNDP:

- Social-economic base of Globesing model (M.Misarovich)
- Hydrologic model in GAMS
- Interface (Resource Analysis, The Netherlands, SIC ISWC)

## **ASB-mm** (2 step) – Projects NATO SFP 974357 INTAS - 0511:

- Aral Sea Coastal Zone (Priaralye) and Aral Sea

## **INTEGRATED model (RIVERTWIN)** – new modeling concept (Chirchic-Ahangaran basin):

- Adaptation of EU models - HBV, QUAL2K, EPIC, WEAP,...
- Blocs of runoff formation, groundwater, industrial and urban zones,
- Ecologic model,
- GIS-interface (integration and interpretation of modeling results)
- Interface for BWO “Syrdarya”

**NEXT STEP** – Adaptation of new modeling concept for Aral Sea Basin, including – Syrdarya basin, Amudarya model



## A REGIONAL MODEL FOR INTEGRATED WATER MANAGEMENT IN TWINNED RIVER BASINS (RIVERTWIN) – CHIRCHIK-AHANGARAN BASIN

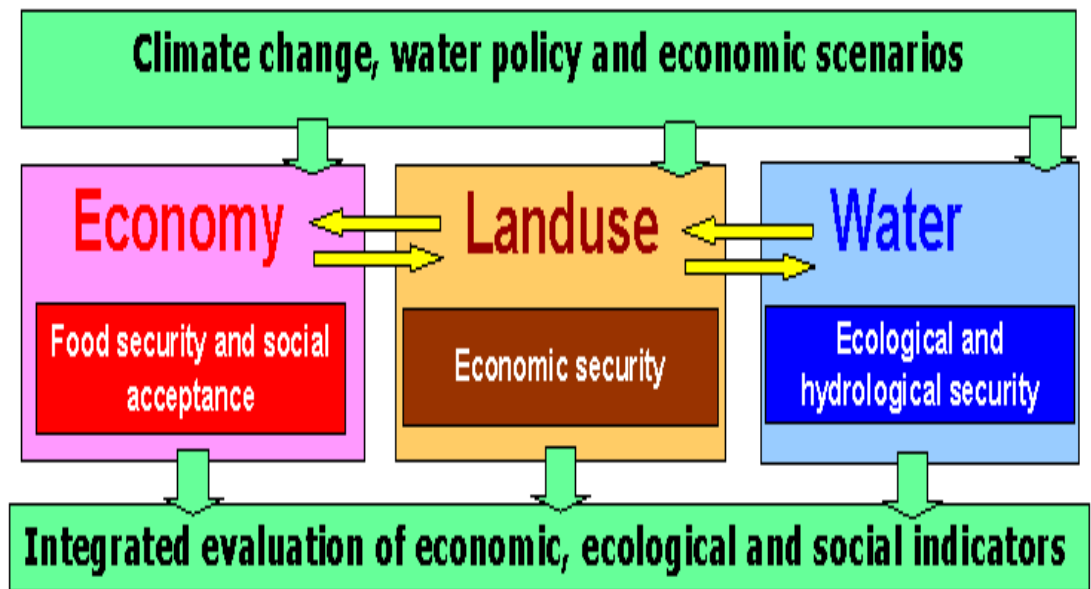
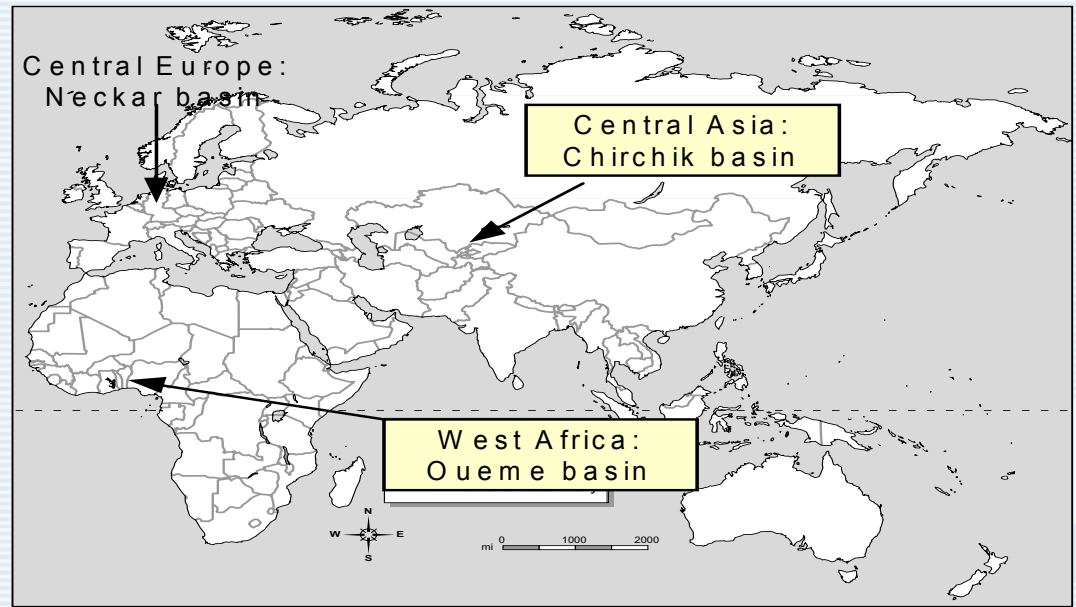


- HBV - runoff formation model
- HydRWT - water-energy model
- QUAL-Chirchik - ecological model
- Reqwat - agricultural water use module
- SEM - economic block
- DB - scenarios and data (climatic block, water block, land use, hydropower,...)
- Interface – input data, scenario selection (Business as Usual Optimistic, from user), visualization and analysis of the results

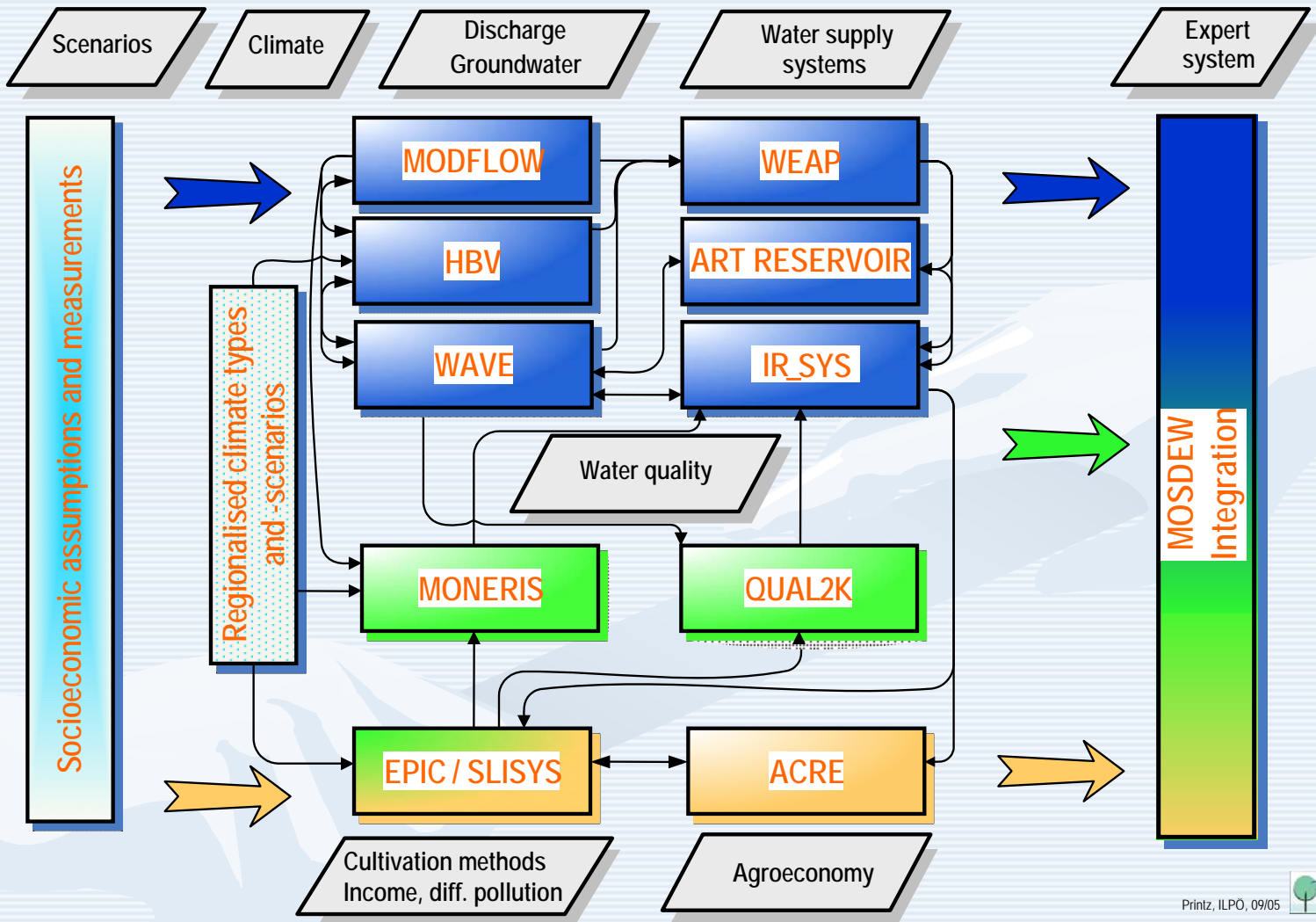


Chirchik-Ahangaran basin is an object of management, natural-anthropogenic system, consists of following sub-systems:

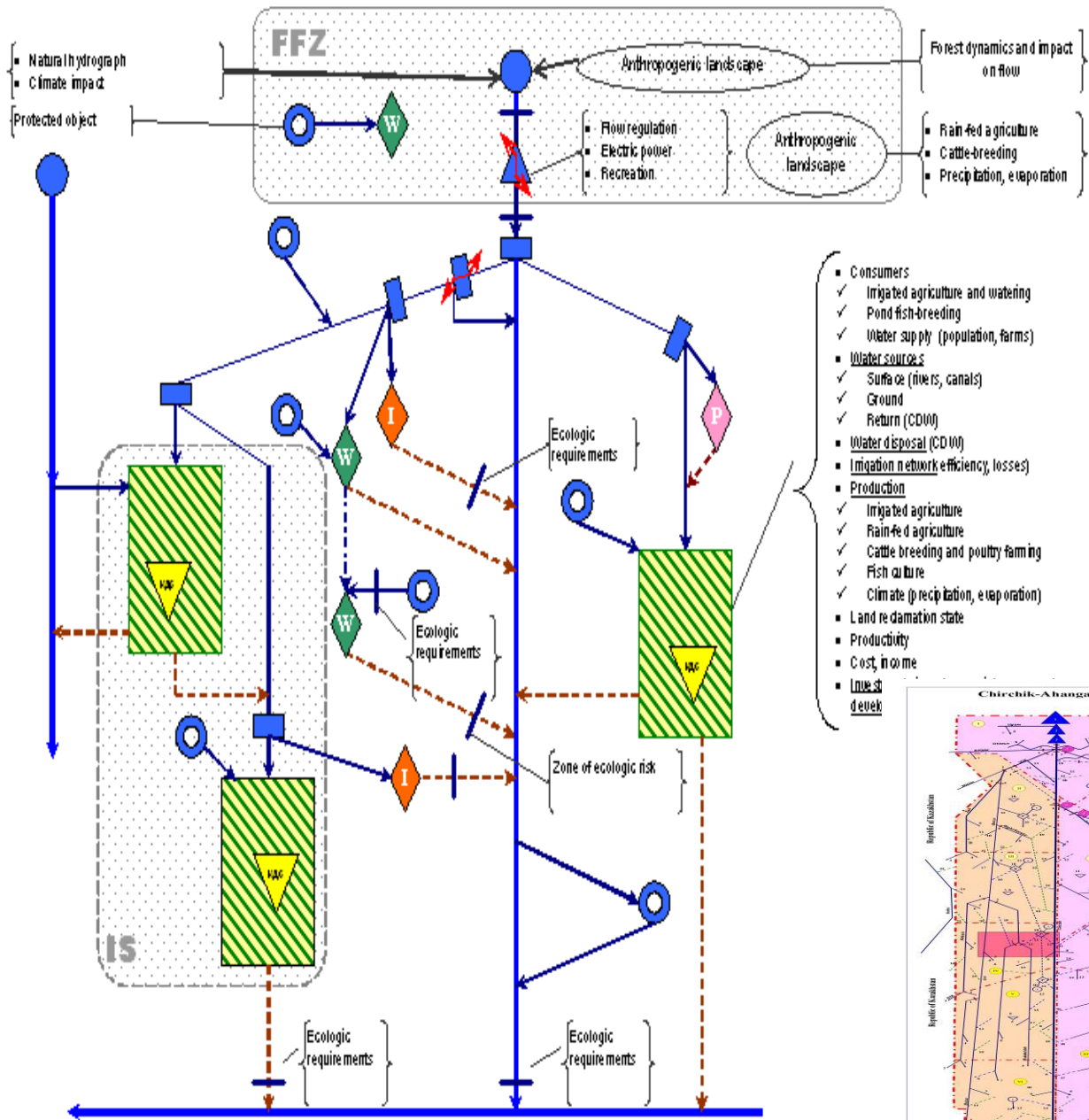
- Water resources formation
- Water resources distribution
- Water resources use
- Water resources protection



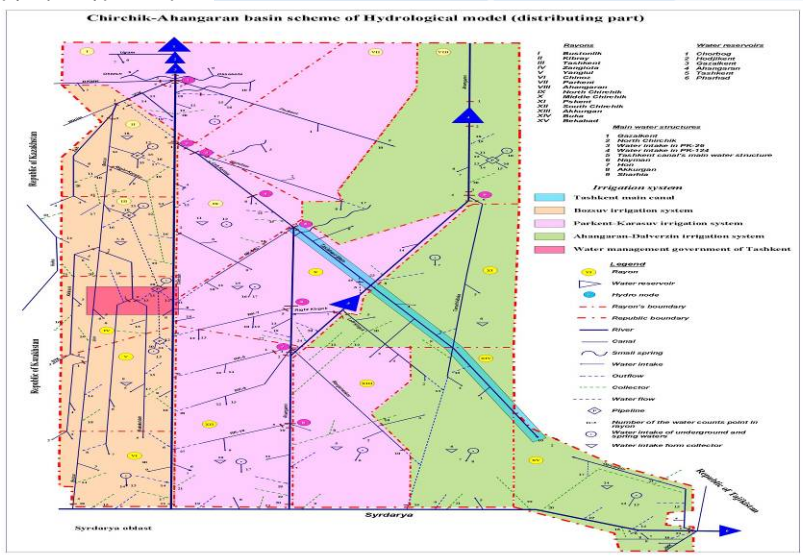
# INTEGRATED COUPLING SCHEME CHIRCHIK RIVER BASIN



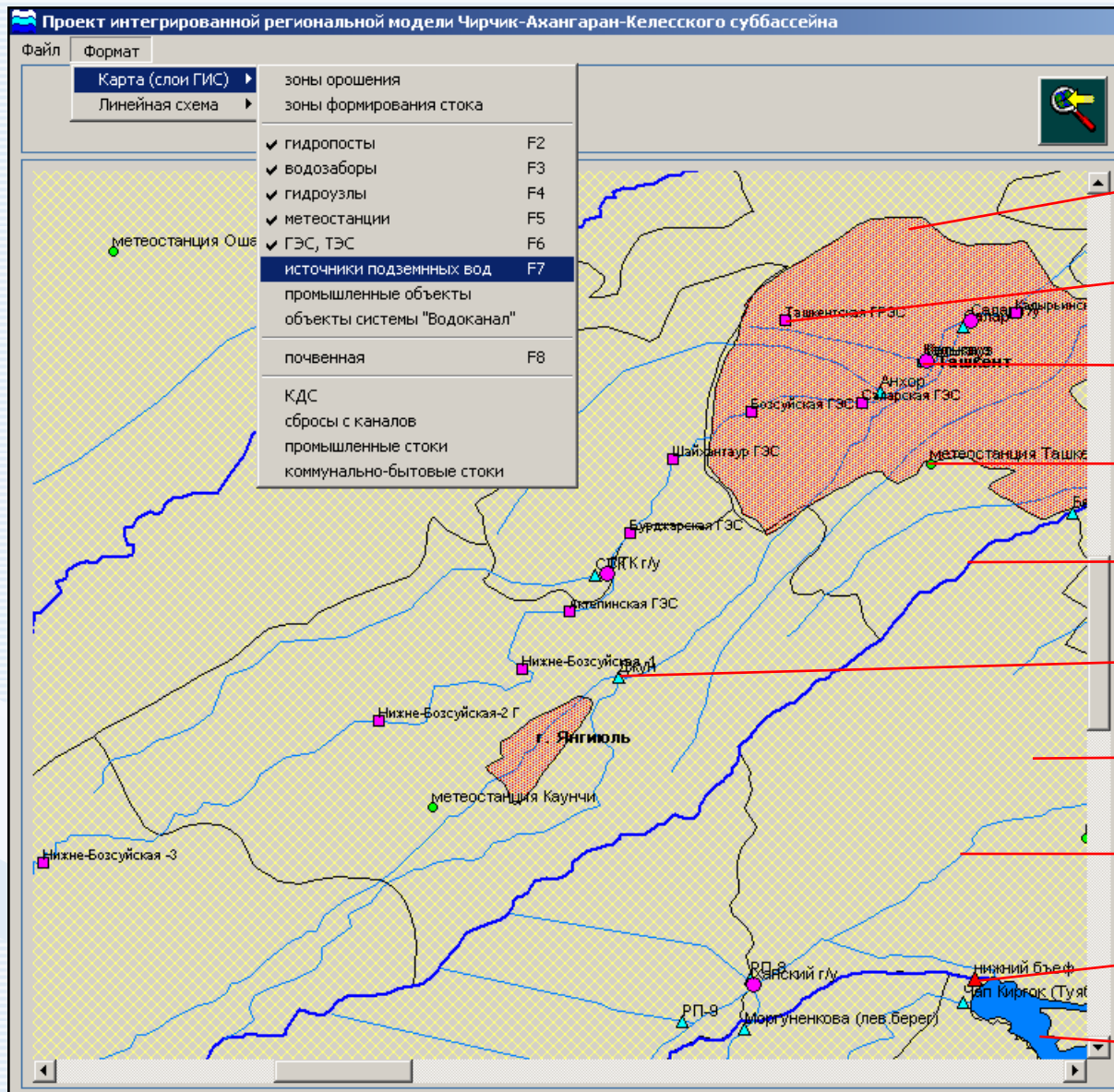
## Modeling objects' coordination (NAS principal scheme)



- water formation zones
- ground water deposits
- rivers
- reservoirs
- irrigation systems
- water works
- power station
- cities
- wastes



# GIS layers in the interface window (RIVERTWIN)



TOWNS

HPP, TPP

STRUCTURES

METEOSTATIONS

RIVERS

INTAKES

DISTRICTS

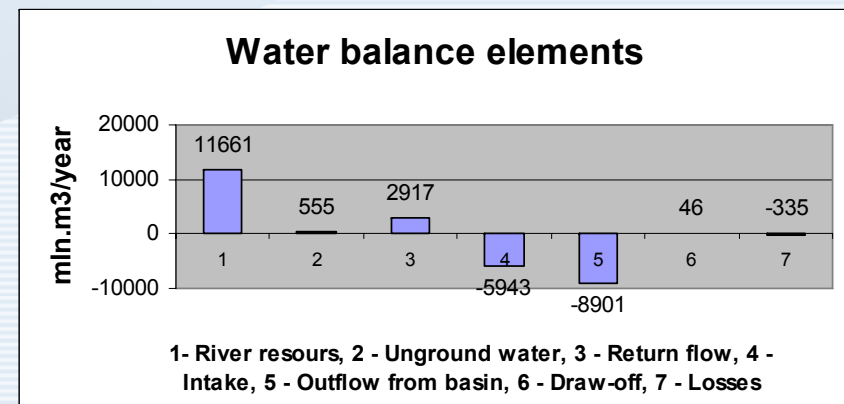
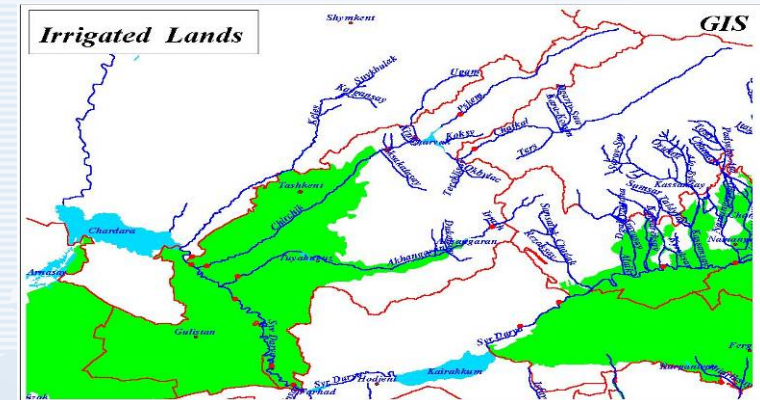
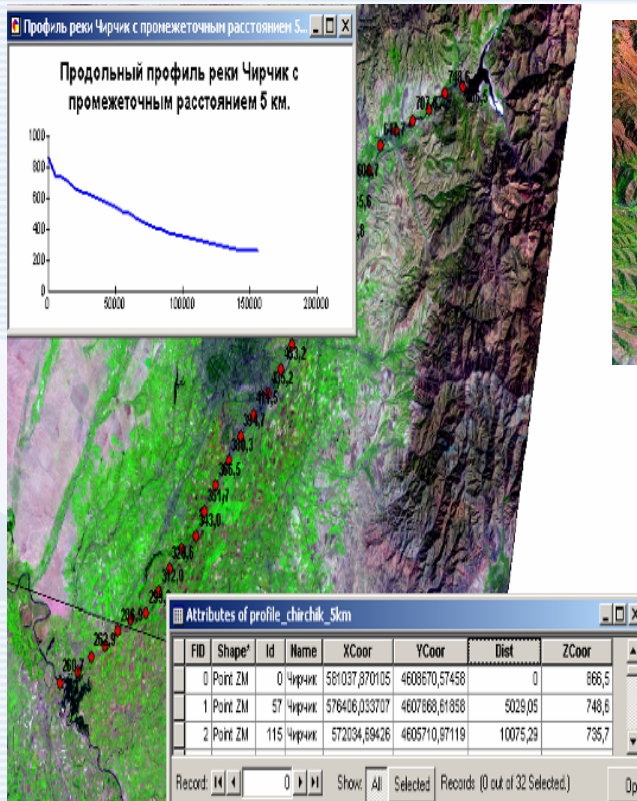
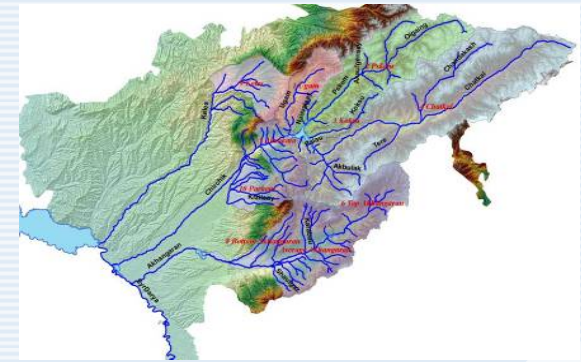
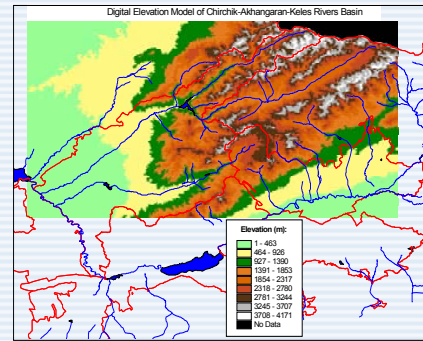
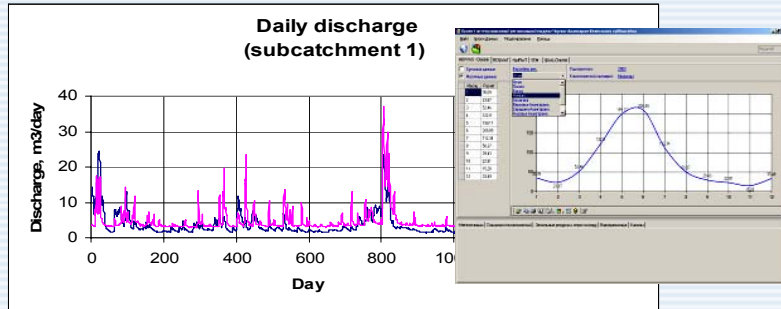
CANALS,  
COLLECTORS

HYDROPOSTS

RESERVOIRS



# RIVERTWIN Models



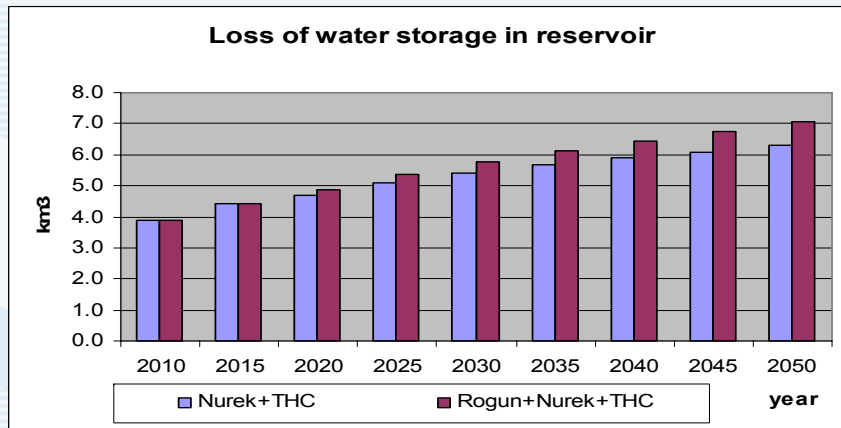


**The impact of Rogun HPS** (full reservoir level is 1290 m)  
**on economic indicators of development of the countries**  
**within the Amudarya basin for the period up to 2050**  
**(million \$/year) / SIC ICWC, V.Dukhovny, A.Sorokin**

**MODELING**

**Combined mode:**  
 Rogun works in a power mode and Nurek in a compensatory irrigation mode.  
 At a joint **power mode** of Rogun and Nurek, additional **damages** in irrigation are observed.

Scenarios for a joint operation of Rogun and Nurek HPSs	Increase (+) and decrease (-) of production of irrigated farming	Effect of electricity generated at Rogun HPS	Total effect in the basin
<b>Combined</b>	+ 19	195	214
<b>Irrigation</b>	+ 57	188	245
<b>Power</b>	<b>- 79</b>	195	116



**Losses of regulating capacity of reservoirs (storage losses from sedimentation) / Project INCO JAYHUN, STC 'Toza Darya', A.Sorokin**

**Variant 1: Nurek and Tuyamuyun**

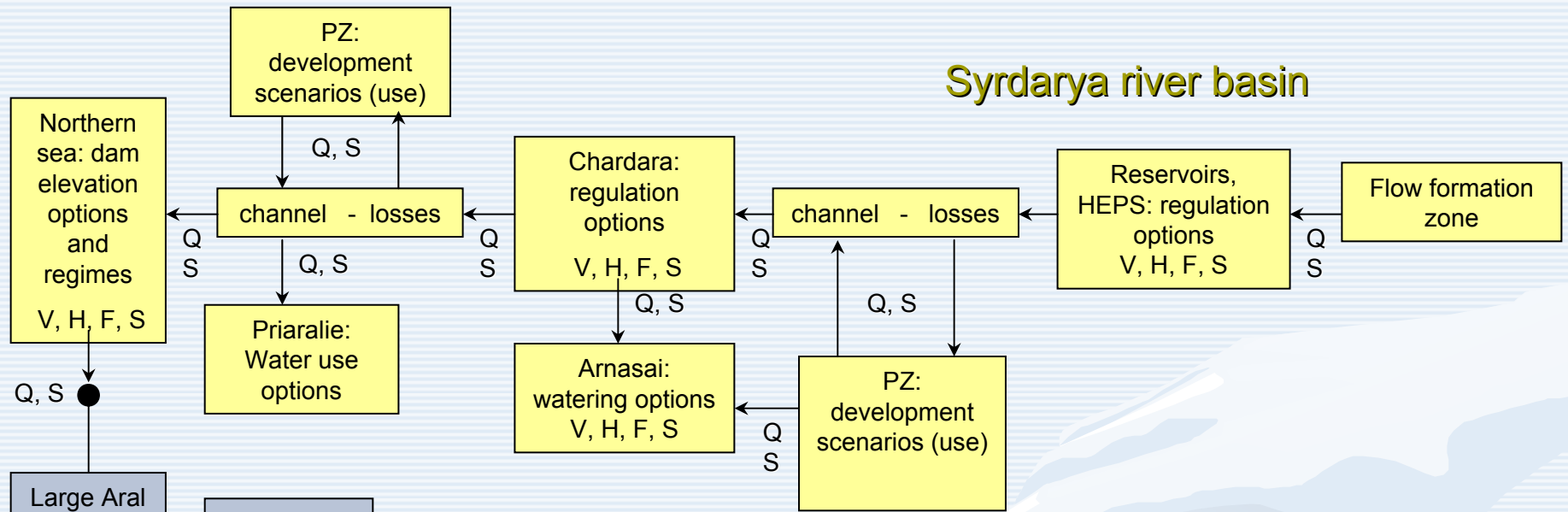
**Variant 2: Rogun, Nurek, Tuyamuyun**

## Our approaches

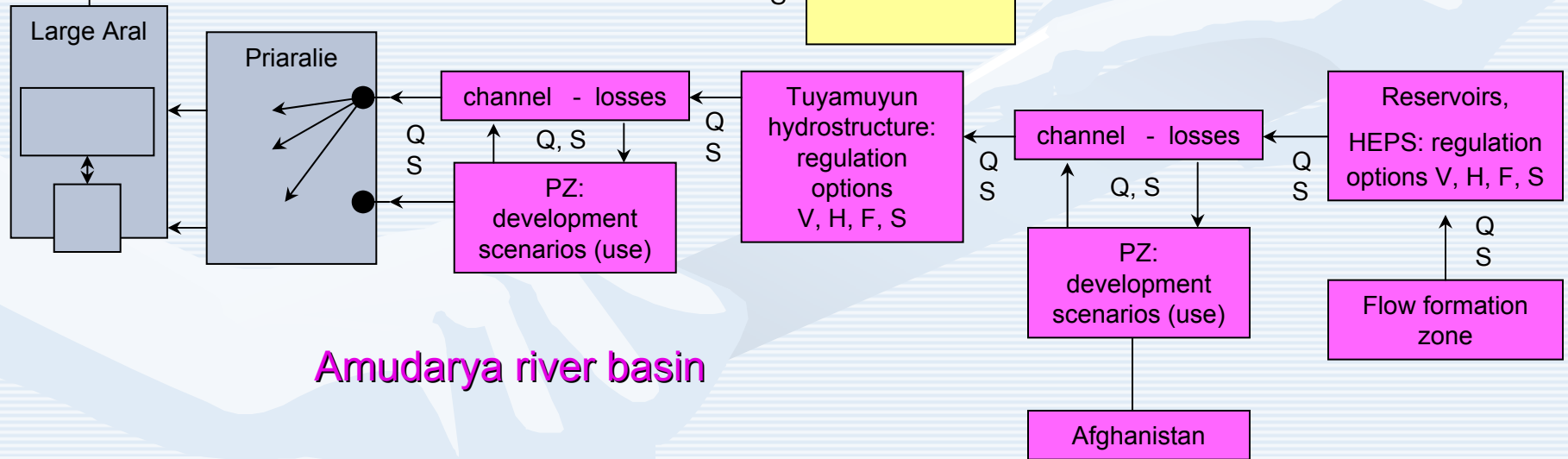
- To the modeling
- To analysis of Scenarios for Future Development of the Aral Sea Basin
- To search of the alternative decisions (consensus)

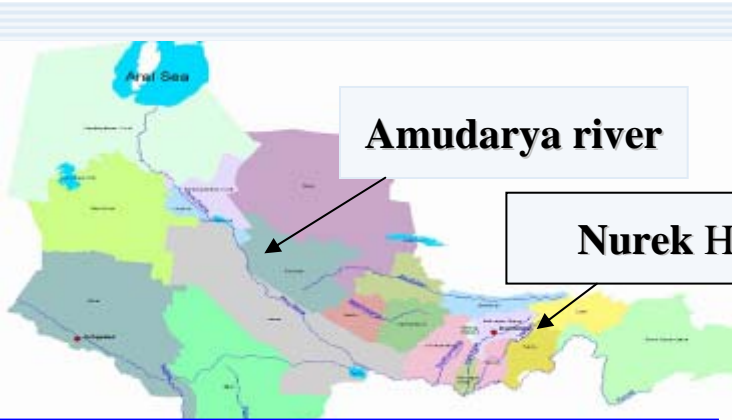


## Syrdarya river basin



## Amudarya river basin

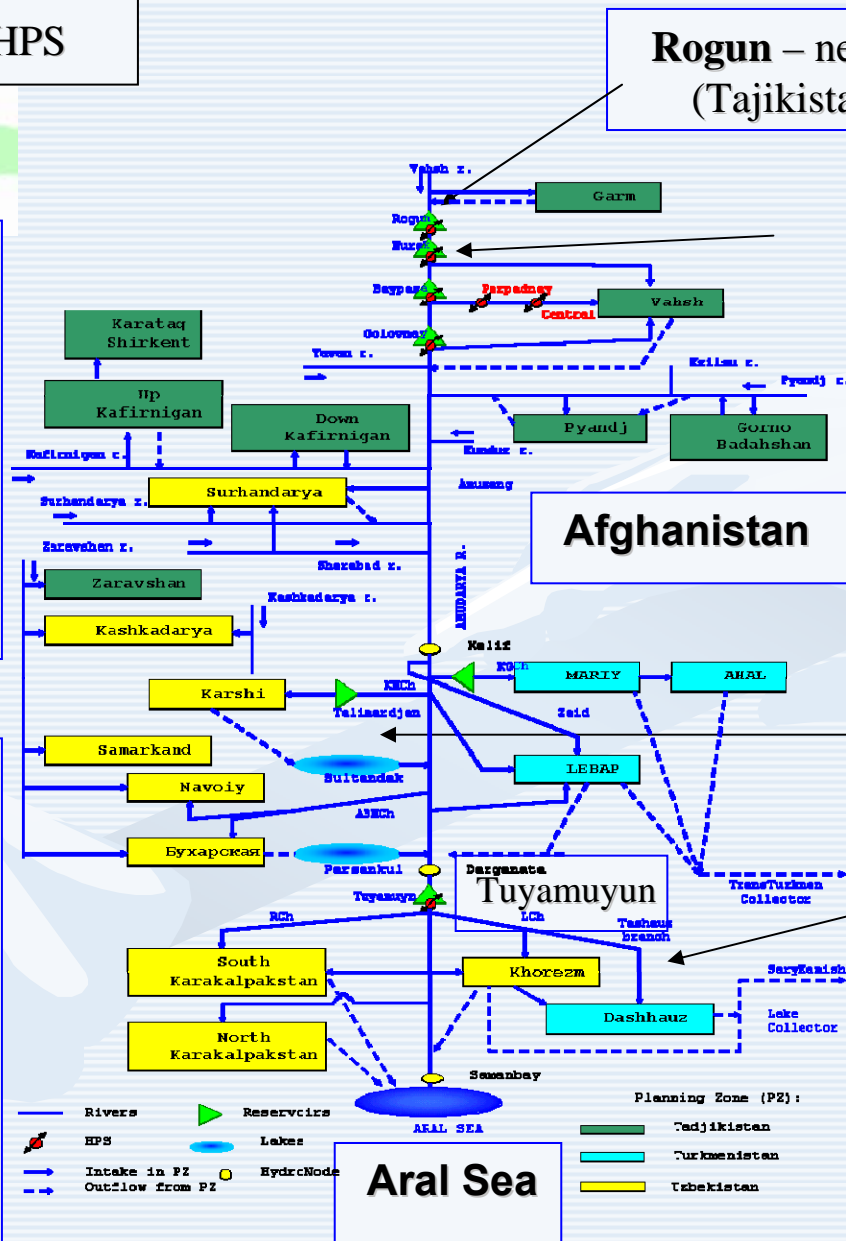




- Contradiction of water users (hydropower, irrigation, ecology),
- Climate change,
- New water users (Afghanistan),
- Losses of regulating capacity of reservoir (sedimentation),
- Uncertainty in water losses

- Long-term agreements, **joint planning and observance of HPS modes,**
- **Automation** and dispatching of hydrological stations, improvement of forecasts,
- On-line estimation of water availability and consequences of reservoir management.

# AMUDARYA RIVER BASIN

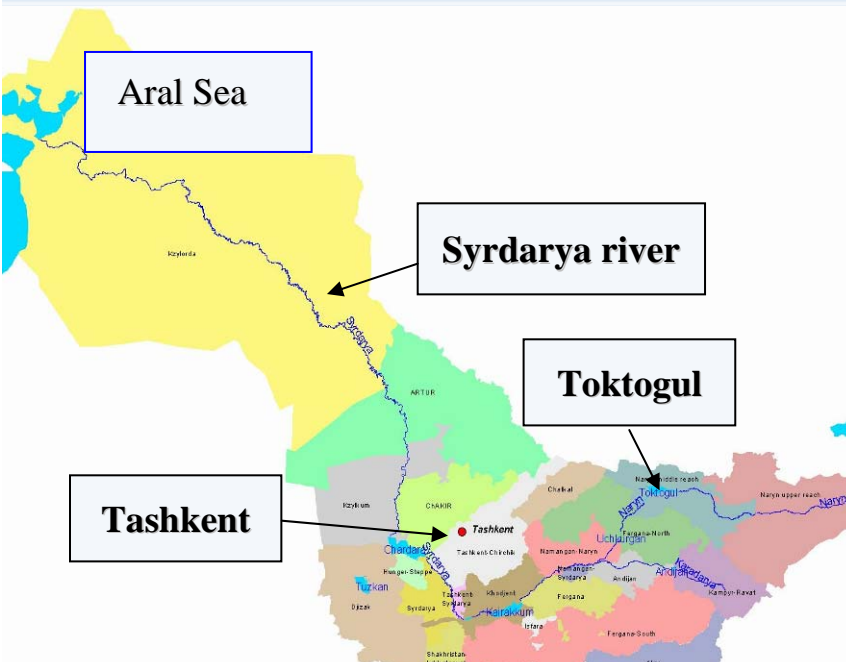


**Rogun – new HPS (Tajikistan)**

**Afghanistan**

**Decrease of water availability, mistakes (Turkmenistan, Uzbekistan)**

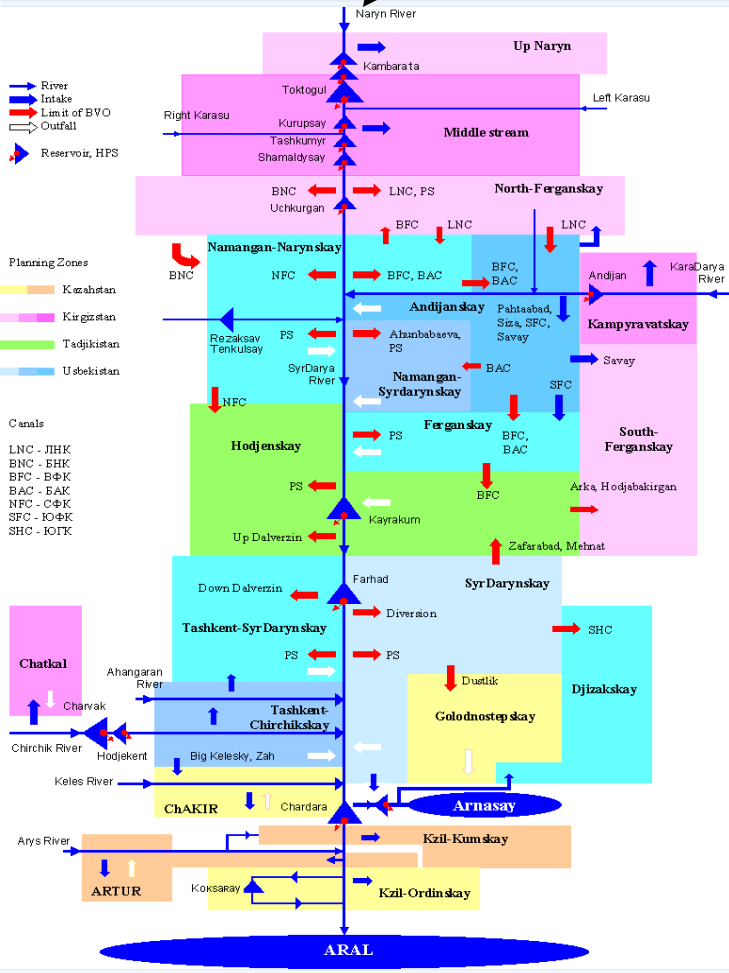
**Aral Sea**



# SYRDARYA RIVER BASIN

**Kambarata 1,2 – new HPS (Kyrgyzstan)**

**Toktogul HPS (Kyrgyzstan)**



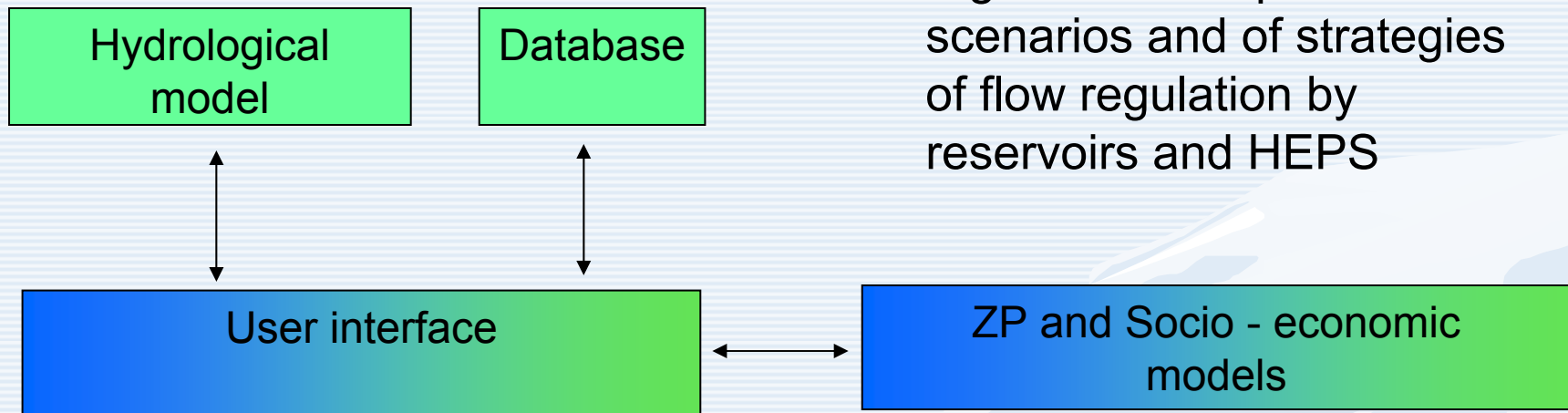
**Decrease of water availability, mistakes (Uzbekistan, Kazakhstan and Tajikistan)**

- Contradiction of water users (hydropower, irrigation, ecology),
- Climate change,
- **Lack of compensating reservoirs for irrigation purposes**

Risk of decrease in hydropower and water availability, **mistakes**

- Need for:
- Regional cooperation
  - IWRM decision support

## Development of a set of basin models



IWRM decision support

Evaluation of national and regional development scenarios and of strategies of flow regulation by reservoirs and HEPS

Water demands considered:

- population,
- ecosystems
- Aral Sea,
- irrigated agriculture,
- hydropower,
- industry

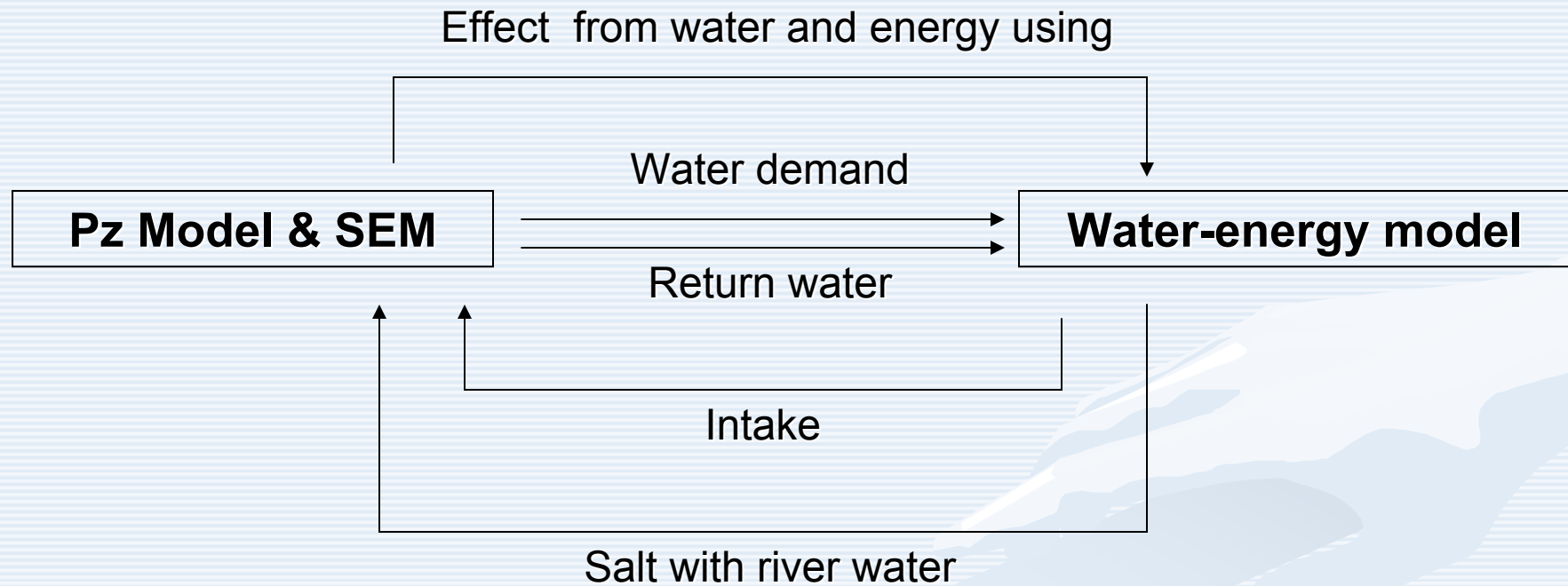
- Syrdarya basin
- Amudarya basin

Dedicated to special user audience

- decision makers
- researchers



# Connection between models



Check on conformity

**water-energy demand** ↔ **available water resource**



## How to decide task ?

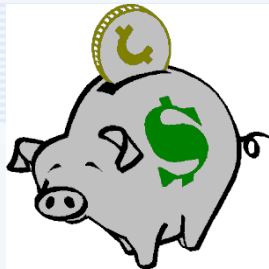
- The **integrated** approach + basin covering,
- A line of **criteria** + system of additional parameters,
- Hydro-**ecological** + **water-power** management,
- Orientation to **regional effect** + **minimization of damages** (in the countries, sectors).
- The compensatory mechanism

### **Pareto Principle:**

Any change of mode, which will not cause damage, but has at least one water user gets a benefit is improve of regime



The population growth rate tends to decrease and *for 2020* it will make *0.98 %/year*



**Rate of increase in Gross Domestic Product.**

- 6-8% 2000-2010
- 8-10% 2010-2015
- ~ 6% 2015-2020

**Large-scale regional integration**



Unit water consumption - *9,4* thousand m<sup>3</sup>/ha



Unit water consumption in KhBC - *0,08* thousand m<sup>3</sup>/man/year (*220 l/daily*)

**Optimistic scenario**

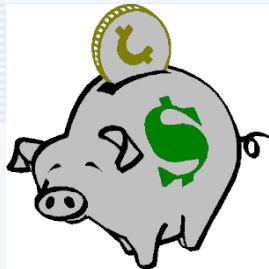
The population growth rate tends to decrease and *for 2020* it will make *1.9 %/year*



**Small-scale regional integration**



Unit water consumption – *12* thousand m<sup>3</sup>/ha



**Rate of increase in Gross Domestic Product:**

4-6% 2000-2010

6-5% 2010-2015

~ 5% 2015-2020

Unit water consumption in KhBC – *0,1* thousand m<sup>3</sup>/man/year (*280 l*/daily)



**Pessimistic Scenario**

### Northern Aral

Max level 47 m  
 $H_{2025} = 47 \text{ m}$   
 $S_{2025} = 10 \text{ g/l}$

Max level 42 m  
 $H_{2025} = 42 \text{ m}$   
 $S_{2025} = 11 \text{ g/l}$

$W_{\text{year}} = 1.6 \text{ km}^3$   
 $S_{\text{year}} = 4.0 \text{ g/l}$

$W_{\text{yr}} = 3.5 \text{ km}^3$   
 $S_{\text{yr}} = 3.6 \text{ g/l}$

### Syrdarya river

Priaralie water consumption  
 $W_{\text{yr}} = 1.5 \text{ km}^3$

### Inflow

2006-2025	Unit	mean	max	min	$\Delta$
$W_{\text{year}}$	$\text{km}^3/\text{yr}$	7.2	11.2	4.0	+2.0
$W_{\text{growing}}$		2.5	8.7	1.1	+1.7
$W_{\text{non-growing}}$		4.7	9.0	2.5	+0.3
$S_{\text{year}}$	$\text{g/l}$	1.03	1.4	0.8	-0.34

## OPTIMISTIC SCENARIO + MAX FLOW

### Amudarya river

### Inflow

2006-2025	Unit	mean	max	min	$\Delta$
$W_{\text{year}}$	$\text{km}^3/\text{yr}$	11.9	21.9	4.8	+2.4
$S_{\text{year}}$	$\text{g/l}$	0.95	1.58	0.71	-0.37

**Big Aral**

Priaralie

## **We can:**

- collect a regional **team** from the national experts and qualified experts in modeling,
- build the regional integrated **model**, necessary for all (with the agreed principles of management, target functions, regional restrictions – ecology, etc., and also with obligations to achieve the general development potentials – water conservation, energy saving, allocation of water for the environment, etc.),
- and create necessary **informational support**.

**THANK YOU for ATTENTION !**



[www.cawater-info.net](http://www.cawater-info.net)

**Aral sea. Evening**

