Water Management Examples - Vit Rver Case Study

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Strengthening of master curricula in water resources management for the Western Balkans HEIs and stakeholders

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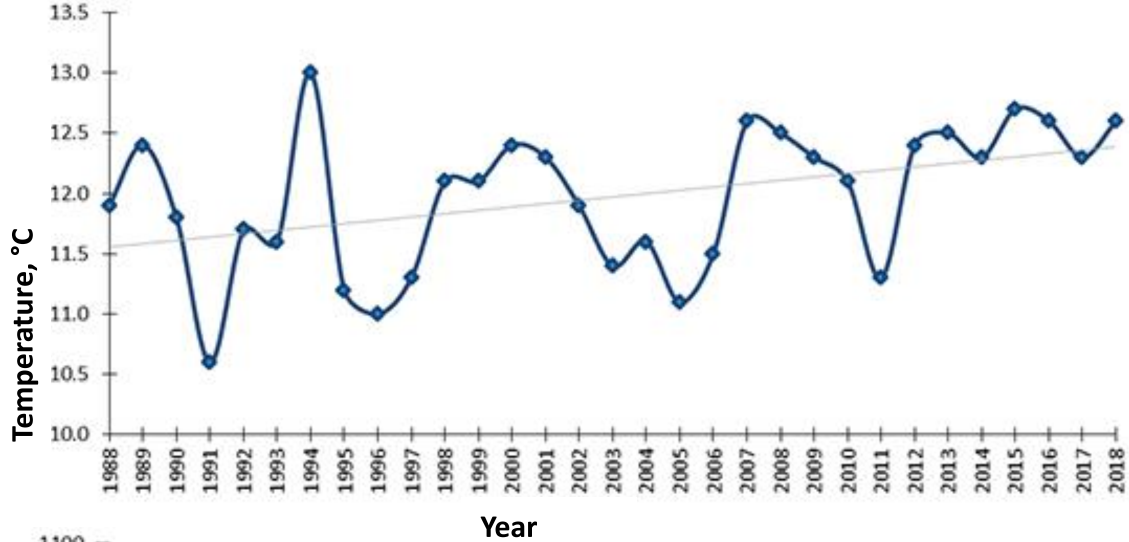
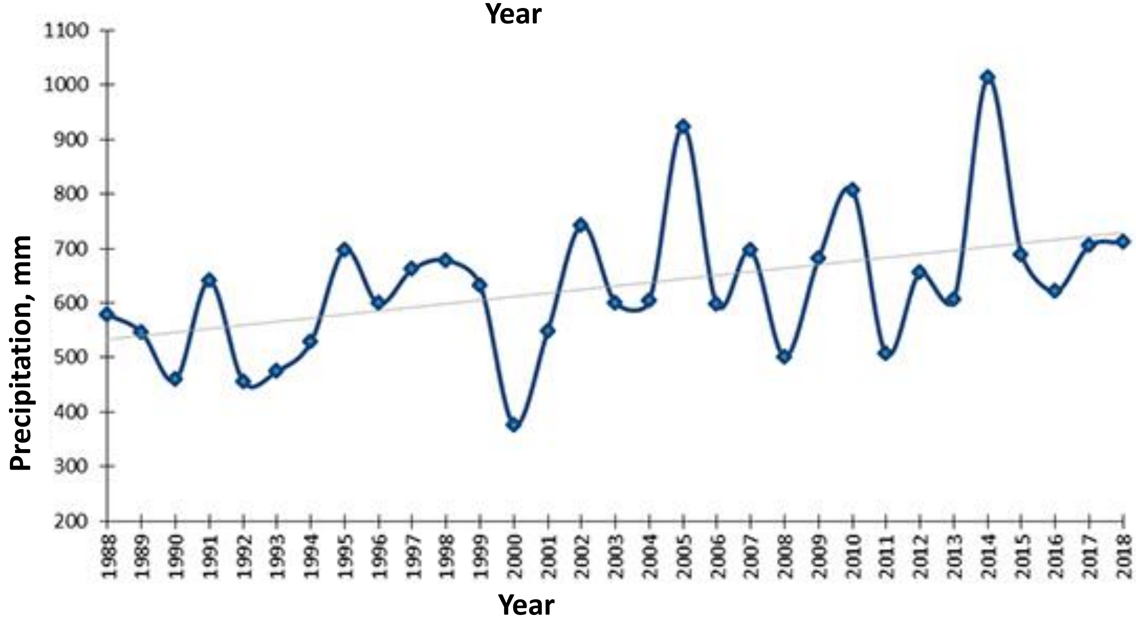
Introduction

Climate changes

Climate variable	Observed change	Expected change (without mitigation measures)
Precipitation	South and East Europe : 20% less precipitation	South Europe: Decrease in annual precipitation. 5% reduce in summer.
Temperature	Europe: an increase of 1.1 ° C, the increase is more in the winter than in the summer, the highest increase over the Iberian peninsula, Southeast Europe and the Baltic republics.	Europe: an average increase of 2.1-4.4 ° C to 2080 (range 2.0-6.2 ° C) with a larger increase in southern and eastern Europe.
Extreme events	Extreme temperatures are stronger and more frequent than previous decades. Considerably more wet days in central and northern Europe and less in southern Europe. More severe precipitations in most parts of Europe. Increase of consecutive dry days.	Increasing and more frequent hot flushes is expected. North Europe: more frequent summer droughts despite most intense rainfall this season. Южна Европа: more droughts through all seasons.

FORECAST VS REALITY





Legislation

Water Framework Directive (WFD) 2000/60/EC

River basins

Preventive action

- River basin management plans (per 6 years) – include the best combination of measures
- To achieve good status for all water bodies till 2015

Blueprint to safeguard Europe's Water Resources

About half of EU surface waters are unlikely to reach good ecological status in 2015

Proposing water accounting

Common implementation strategy

Water accounting and efficiency objectives at sectorial level

Guidance Document on the application of water balances for supporting the implementation of the Water Framework Directive (WFD)

- Accounting for future climate change scenarios
- Water balances can also be used as the basis for emergency plans in the case of water shortages
- based on the UN System of Environmental Economic Accounting for Water (SEEA-Water) and its 'Asset Accounts'
- Based on number of studies- one of them **ABOT project**

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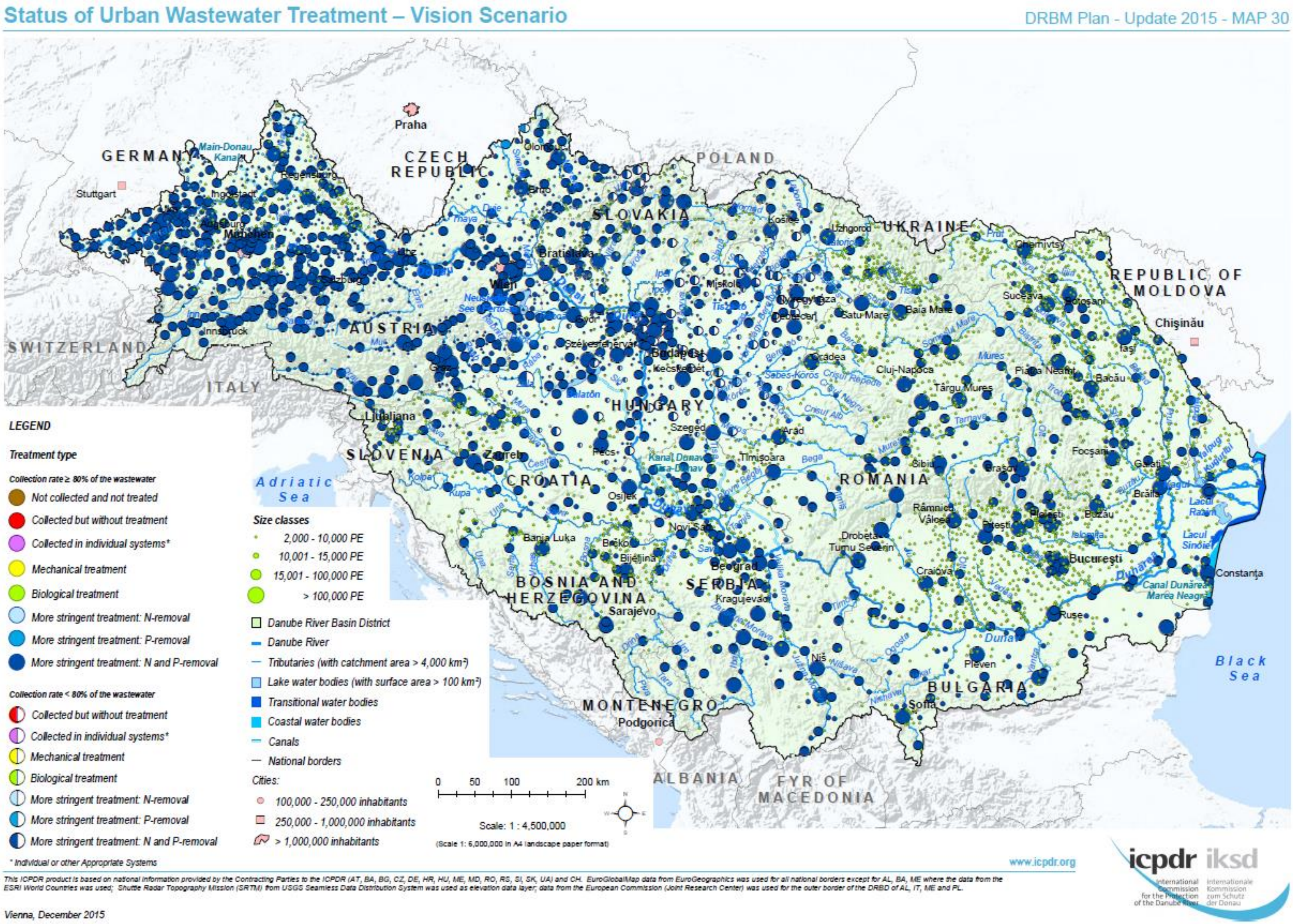
Waste water treatment plants



Scientific approaches to water management

Classic approach– water abstraction management

- Increasing water storage- 7000 large dams with capacity of 20% from the available water

Methods for assessment of water resources

- WaterGAP – global level of evaluation, for policy making
- Mapping - with endangered areas and sectors

Approaches to stakeholder relations

- Top-down – classic (aging)
- Bottom-up - modern

Approaches to prioritize a set of measures

- Lists in excel
- Analytical hierarchical process - 7 + 2 variables
- Multi-purpose optimization

Water balance system, type "accounting": SEEAWater

Main goal in the case study

To develop a combined approach to support decision-making in order to reduce the impact of droughts and water scarcity.

The approach should integrate river basin objectives with measures at local level and cover all sectors.

To forecast the effect of the measures, to take into account the climate changes and the change of the consumption.

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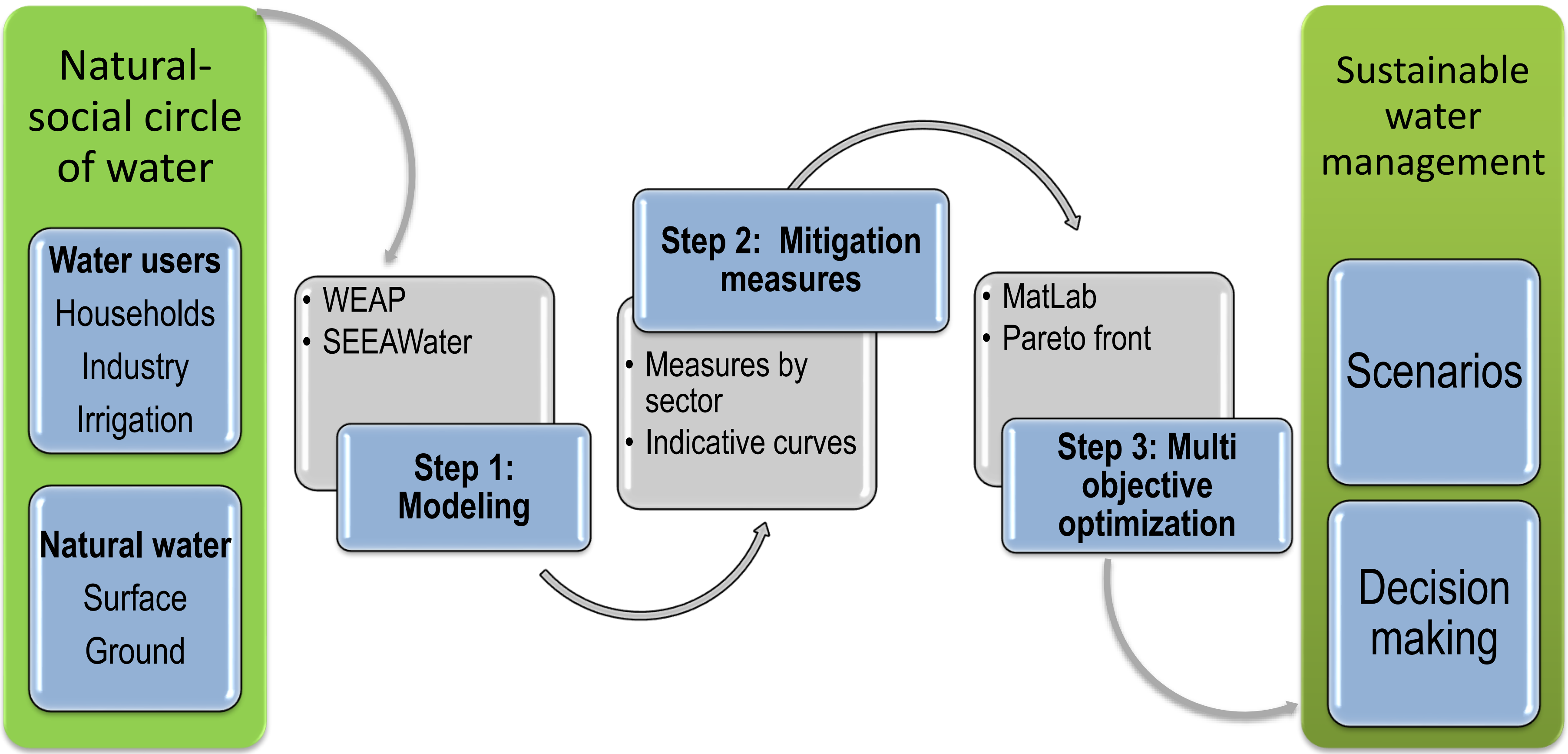
Tasks

1) Select river basin
2) To choose a model for determining the balance between available natural water and water consumption;
3) To identify the necessary set of input data and to propose a methodology for their analysis;
4) To select technical measures and construct indicative curves;
5) To propose an optimization algorithm to prioritize the measures according the goals;
6) Vulnerability - scenarios
7) Check the possibility of automatically filling in the tables of the European Commission SEEAWater and adding the necessary information, using modeling

Combine approach

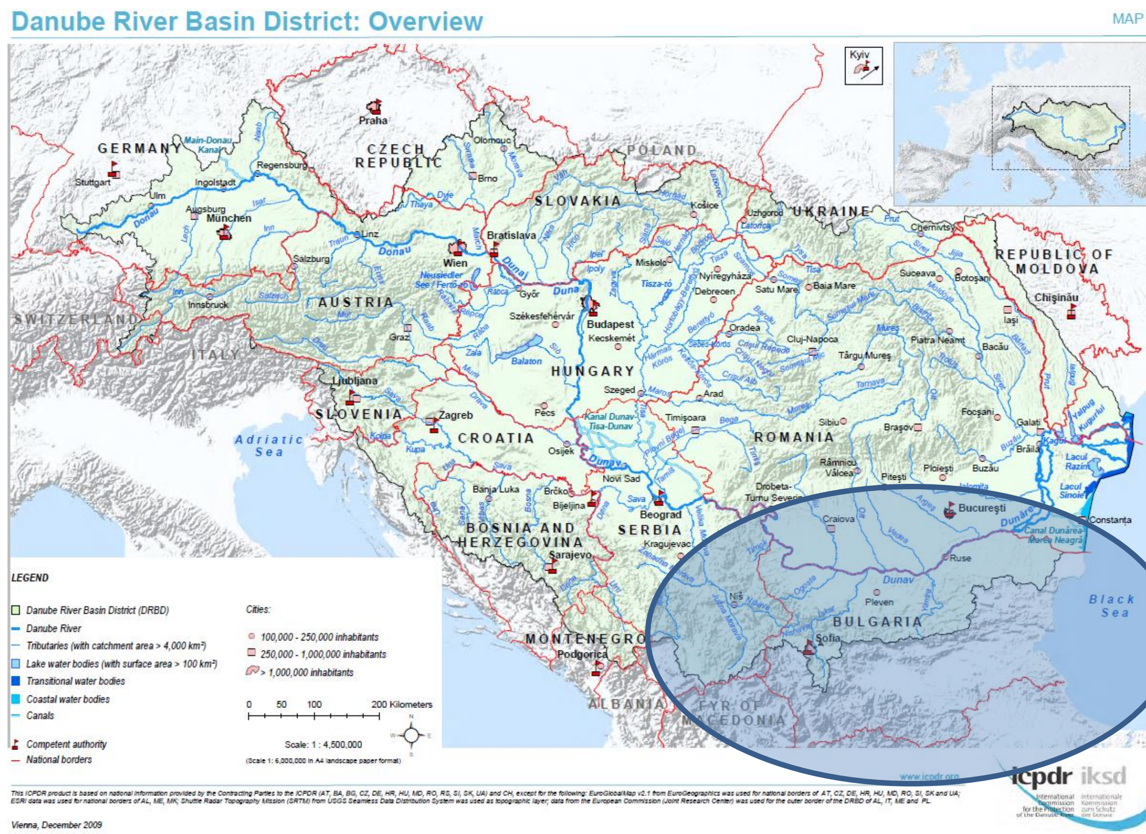


Vit watershed

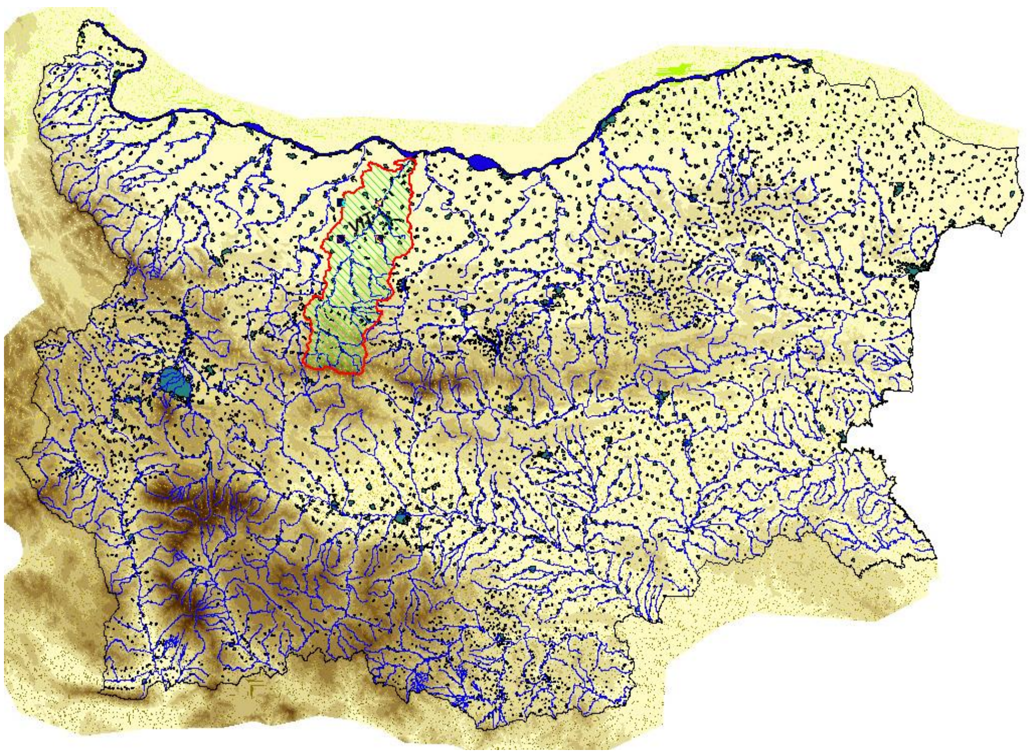
Assessment of water Balances and Optimisation based Target setting across EU River Basins (ABOT)

Water balance modeling in 4 pilot River Basins across Europe:

- Tiber (Italy),
- Mulde (Germany),
- Ali-Efenti Pinios (Greece),
- **Vit (Bulgaria).**



Vit river sub-basin



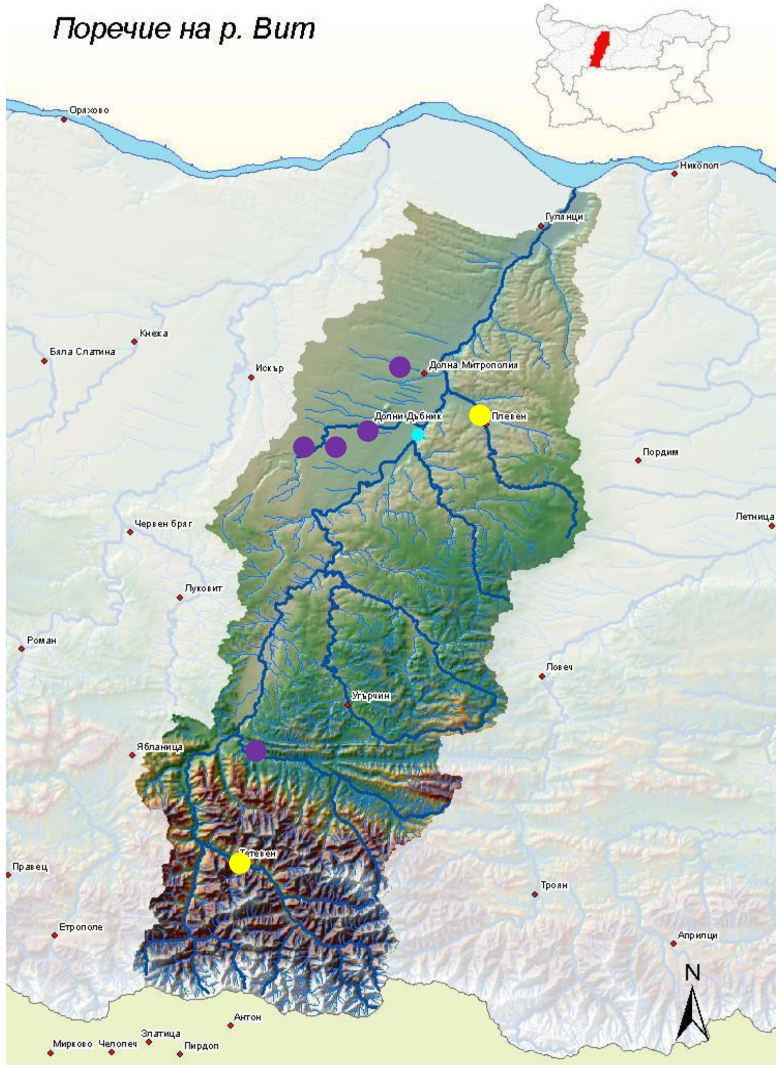
Vit river sub-basin on the map of Bulgaria

Vit River is located in the central part of Northern Bulgaria and is 189 km long.
The catchment area is 3220 km^2
The average slope of the river is 9.6 ‰.
The density of the river network is small - 0.5 km / km^2.
The average altitude is about 400 m

15 subbasins,
77 settlements,
8 groundwater bodies,
5 reservoirs,

Vit river sub-basin-monitoring

- River runoff monitoring
- Rain gauge
- Reservoir



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Vit river sub-basin-monitoring

Sopot - Reservoir on the river

Gorni dabnik, Dolni dabnik and Telish - Off river reservoirs
At river

Input data

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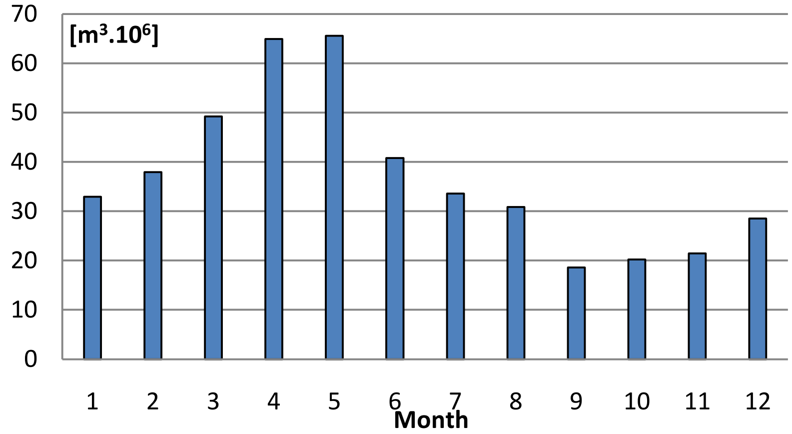
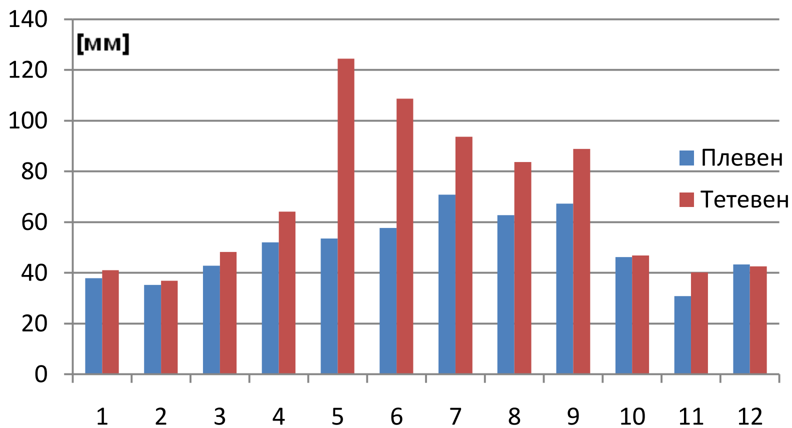
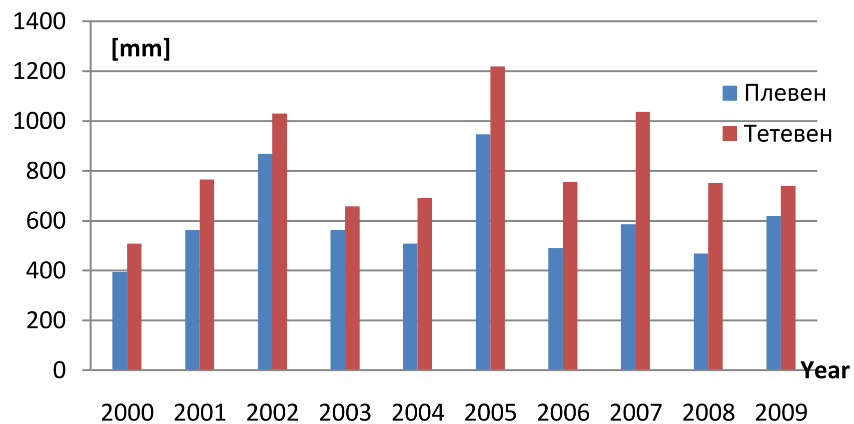
River runoff



Average monthly river flow at Tarnene station for the period 2000 – 2009 г. (NIMH)

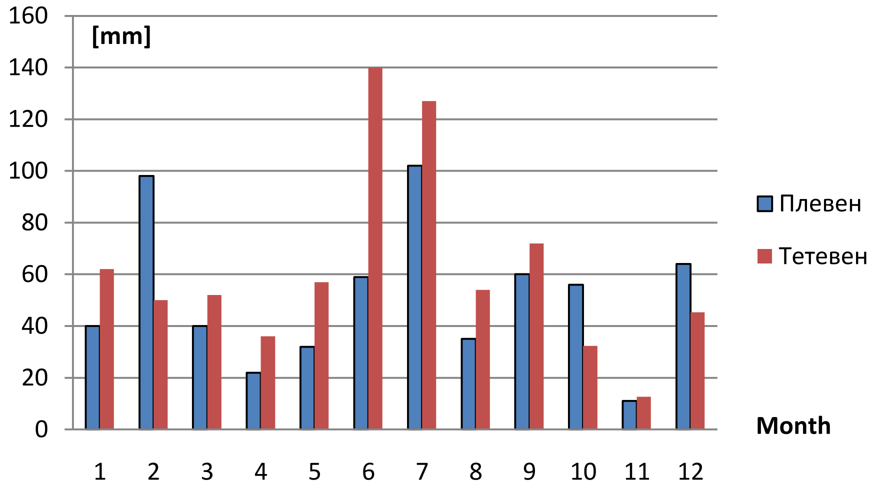


Average monthly precipitation for the period 2000 - 2009 г. (NIMH)

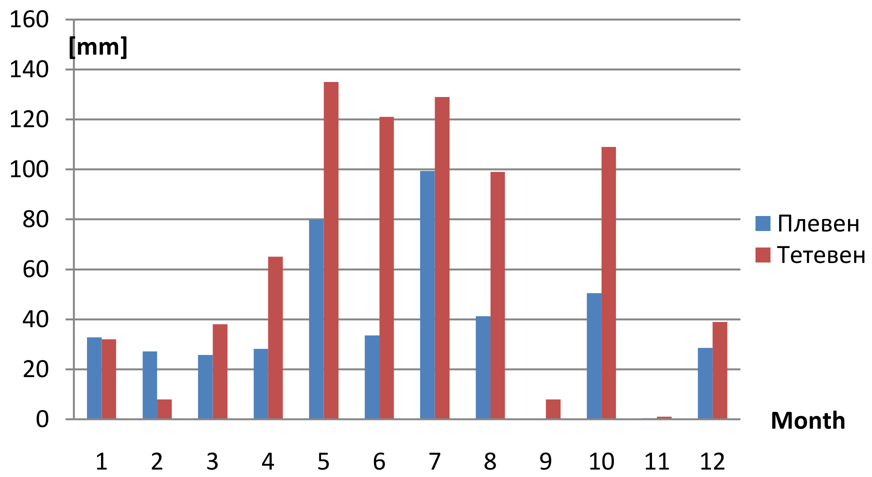


Annual precipitation for the period 2000 – 2009 г. (NIMH)

Precipitation

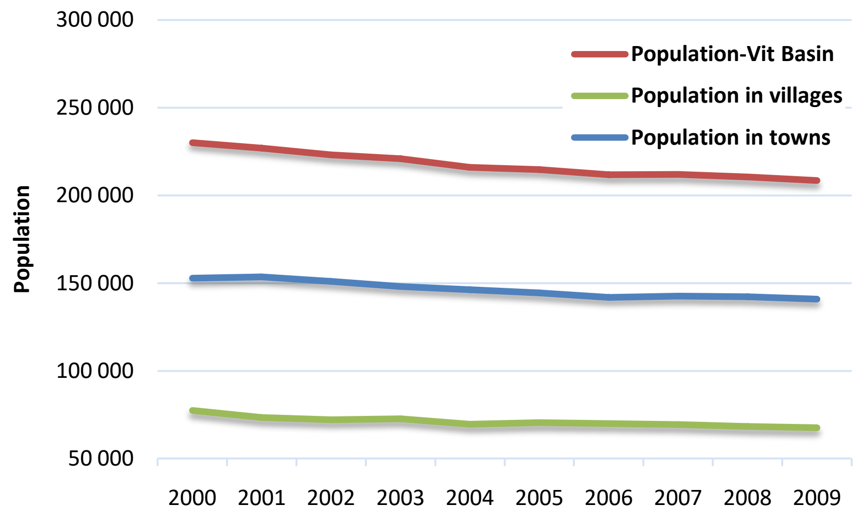


Monthly precipitation for 2009 (NIMH)

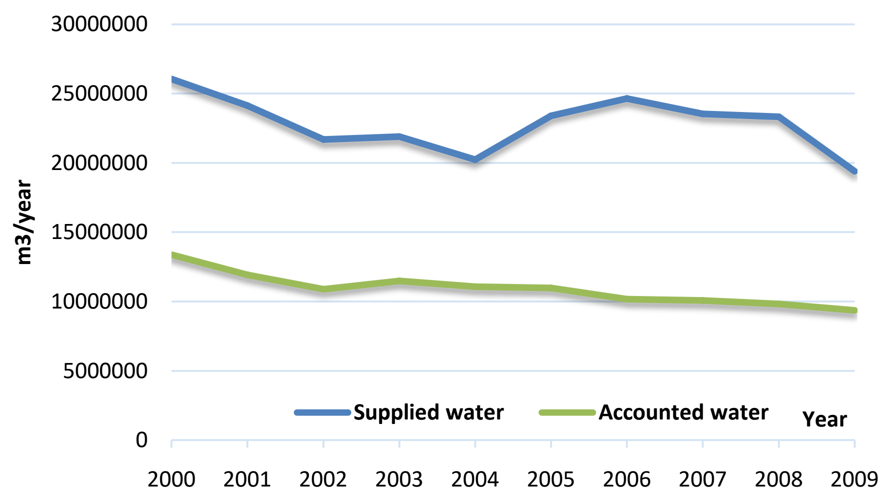


Monthly precipitation for 2011 (NIMH)

Settlements



Population in Vit river sub-basin (own processing of database from NSI)



General information on supplied and accounted water in Vit river sub-basin (own processing of database from NSI)

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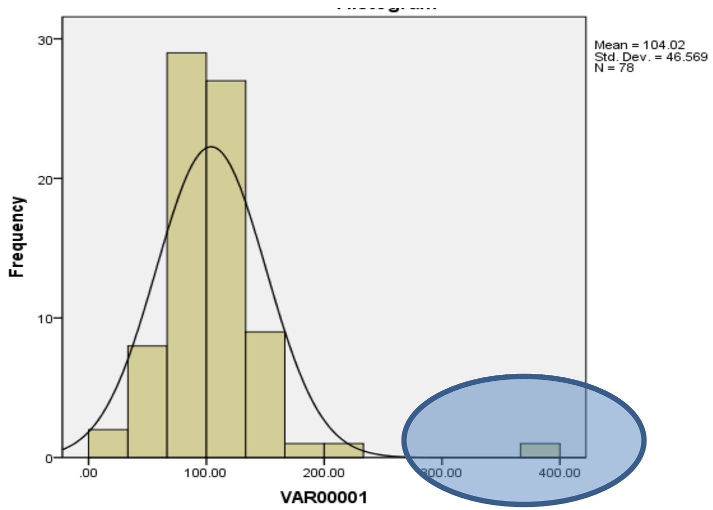
Evaluation of input information

All setlements

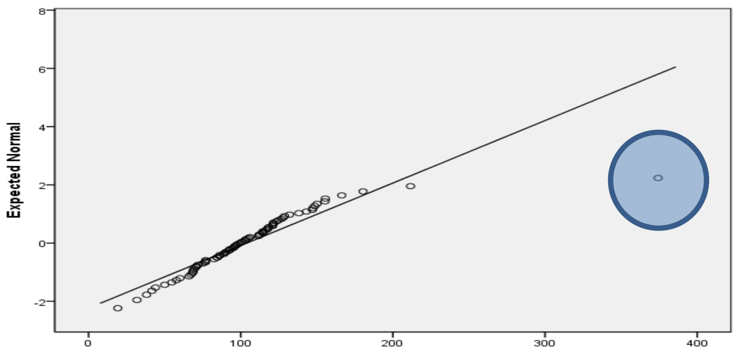
Main statistic parameters

Средна			104.0192
95%	Доверителен	Долна граница	93.5195
интервал за средната		Горна граница	114.5190
Медиана			99.4500
Стандартно отклонение			46.56941
Минимум			19.20
Максимум			374.30
Range			355.10
Асиметрия			2.613
Ексес			13.957

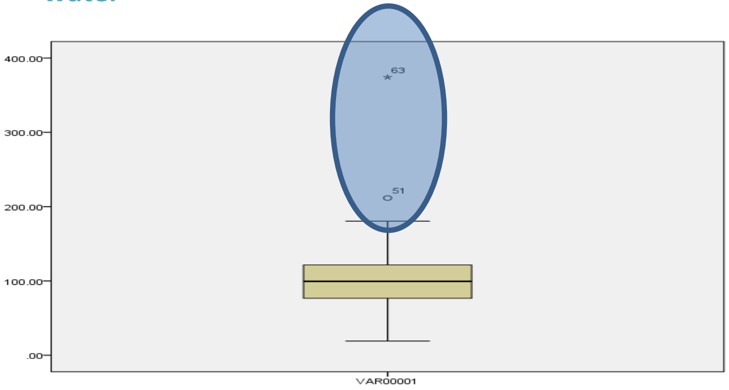


Histogram and theoretical curve of normal distribution- accounted water

Distribution is not normal!



Normal Q-Q plot – accounted water



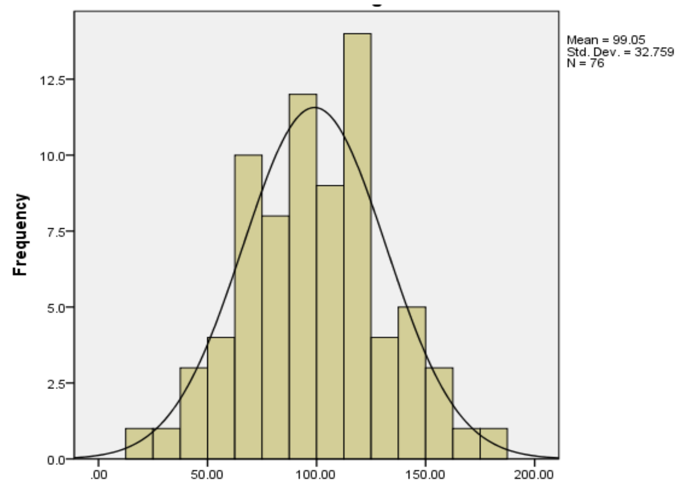
Detrended normal Q-Q plot

Evaluation of input information

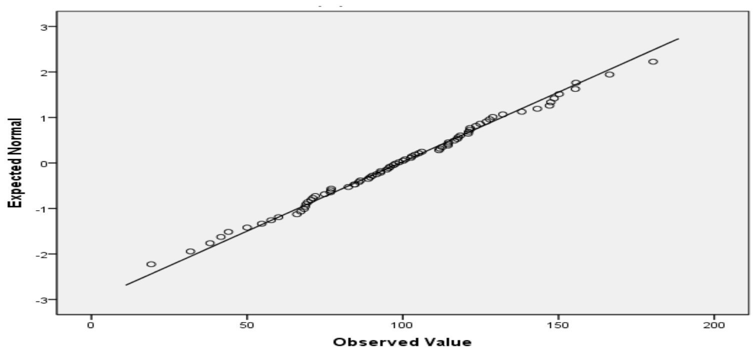
Main statistic parameters

Average		99.0474
95% confidence interval	Lower boundary	91.5616
	Upper boundary	106.5331
Median		98.2000
Standard variation		32.75906
Min		19.20
Max		180.40
Range		161.20
skewness		0.007
kurtosis		-0.128

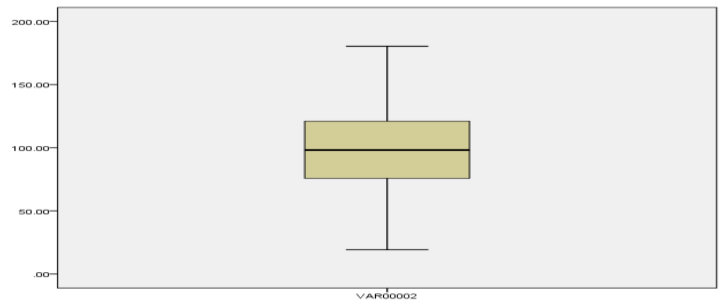
Distribution is normal with value of the null hypothesis Sig(P)=0.995!



Histogram and theoretical curve of normal distribution- accounted water



Normal Q-Q plot – accounted water



Detrended normal Q-Q plot

WEAP Modeling

Modelling

WEAP-Water evaluation and planning

Solves a wide range of problems

Can be applied at the river basin level, several river basins as well as the lower level

Appropriate for analyzing various scenarios of what-if type

Adaptive to farming practices

Suitable for detailed modeling of water demand

WEAP can work as COM Automation Server

WEAP

Hydrology and irrigation in the method "Precipitation runoff (simplified method with coefficients)"

$Pav_{LC} = q_{HU} A_{LC} Pef_{LC}$ -rainfall that can be used by plants

$ETp_{LC} = ETref_{HU} Kc_{LC} A_{LC}$ -potential evapotranspiration

$Psh_{LC,I} = Max(0, ETp_{LC} - Pav_{LC})$ -insufficient rainfall

$Sreq_{LC,I} = \left(\frac{1}{\eta_{IRR_{LC,I}}} Psh_{LC,I}\right)$ -necessary water for the irrigation field

$Sreq_{HU} = \Sigma_{LC,I} Sreq_{LC,I}$ -total water required for the irrigation field

$S_{LC,I} = S_{HU}\left(\frac{Sreq_{LC,I}}{Sreq_{HU}}\right)$ - delivered water for the irrigation field

$ETact_{LC,NI} = Min(ETp_{LC,NI}, Pav_{LC,NI})$ -actual evapotranspiration for the non-irrigated area

$ETact_{LC,I} = Min(ETp_{LC,I}, Pav_{LC,I}) + S_{LC,I}\eta_{IRR_{LC,I}}$ -actual evapotranspiration for irrigated area

$EF_{LC} = \frac{ETact_{LC}}{ETp_{LC}}$ -part of the satisfied potential evapotranspiration

WEAP

Modeling of settlements

$Qan_{DS} = \Sigma N_{BR} Q_{WUR,BR}$ - required amount of water per year

N_{BR} - number of users in branch

$Q_{WUR,BR}$ - required amount of water for one user for this branch

$Qm_{DS} = k_m Q_{ADJAN,DS}$ - required amount of water per month

k_m - coefficient of monthly irregularity

$Q_{ADJAN,DS}$ - adjusted amount of water per year

$$Qmsr_{DS} = \frac{Qm_{DS}(1-Rr_{DS})(1\text{-}DSMs_{DS})}{1-L_{DS}}$$ - required amount of water per month

$DSMs_{DS}$ - percentage of reduction of used water as a result of the applied measures

L_{DS} - percentage taking into account the losses of water from the settlement water

Rr_{DS} – reused water

100*10%losses=110 l/p/d
20% WSM
80*10%losses=88 l/p/d
100+10%losses=110 l/p/d
20% WSM
80+10%losses=90 l/p/d

WEAP

Annual Activity Level | Annual Water Use Rate | Monthly Variation | Consumption

Annual water use rate per unit of activity

Bivolare	2009	Scale	Unit	
demand	31		m^3	/person
losses	25		m^3	/person

Consumed water Qc_{DS} is calculated as follows:

$Qc_{DS} = Qi_{DS.}C$

Qi_{DS} – the incoming water in the node

$C= (Q_{hh.}c+Q_L)/(Q_{hh}+ Q_L)$

c - % of actual consumption (in case of sewerage it is reported as 10%, ie 90% is returned to the sewerage network);

C - % of consumption introduced into the model;

Q_{hh} – used water in households;

Q_L – leaks (introduced as used water).

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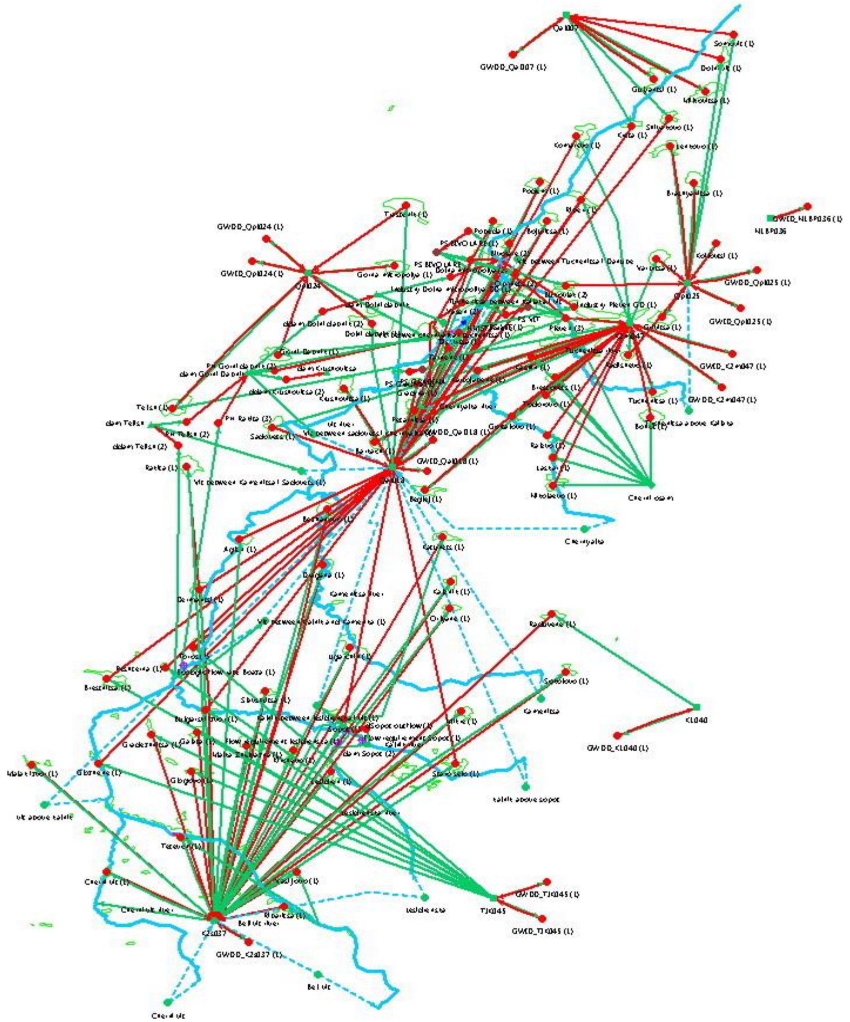
Developing the model structure



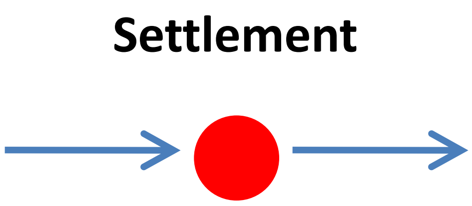
Modeling scheme of Vit river sub-basin

- 15 sub catchments;
- 104 design nodes:
    - •77 simulating settlements, of which 47 in Pleven WO and 30 Lovetch WO;
    - •15 simulating private and public water user using ground water by drills води.
    - •12 for reservoir management, for PH, industry, WWTP and pumping stations.
- -5 reservoirs with economic significance
- 8 simulating ground water bodies
- 3 controlling minimal river runoff
- 1 other type water supplier
- 1 for hydrometric station at Tarnene

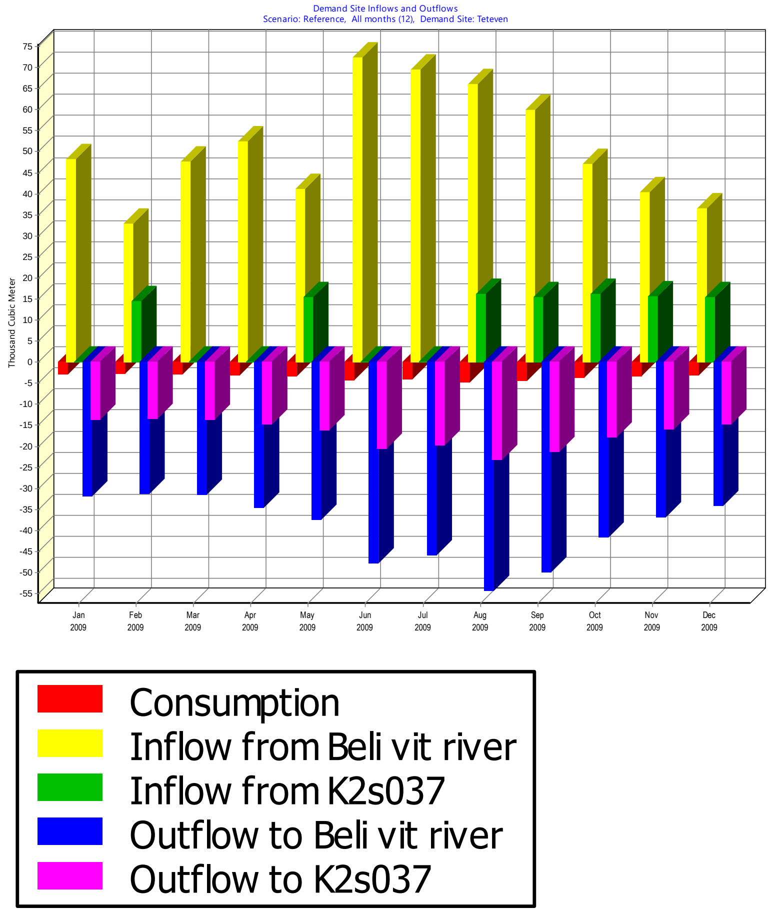
Modelling of settlements

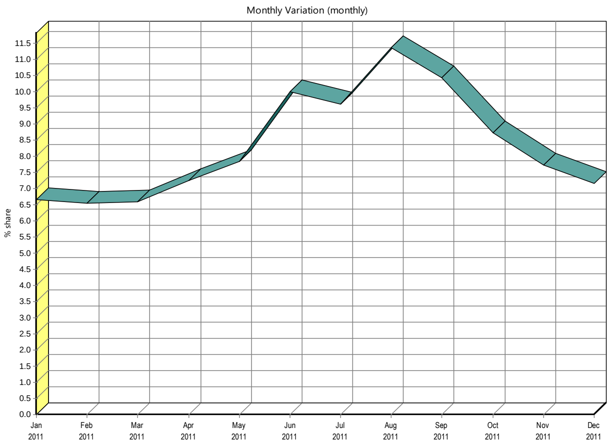
Input data

- ➢Population
- ➢Average water use
- ➢Water losses (non-revenue water)
- ➢Coefficient of monthly variation



Water balance



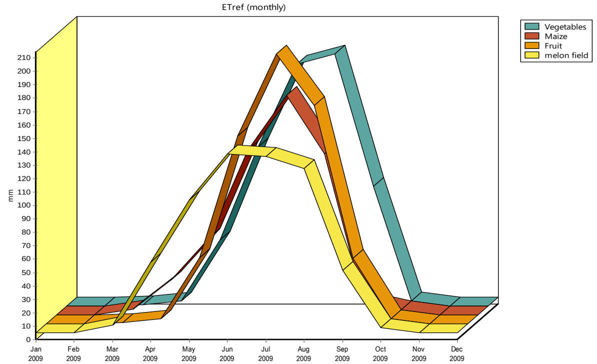


Modelling of sub-catchments

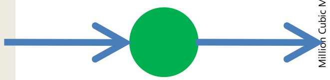
Input data

Rainfall Runoff method

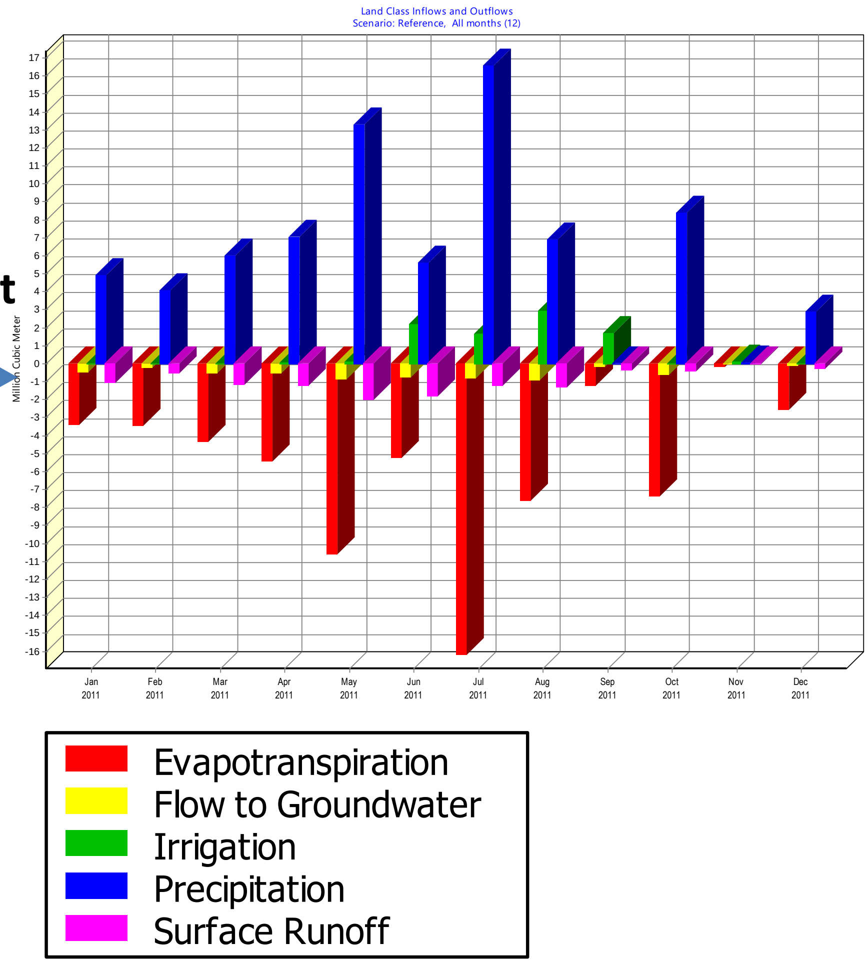
- Area
- Irrigated and non irrigated areas
- Crops
- Crop coefficient
- Effective precipitation
- Precipitation
- Irrigation efficiency
- Evapotranspiration



Sub-catchment



Water balance

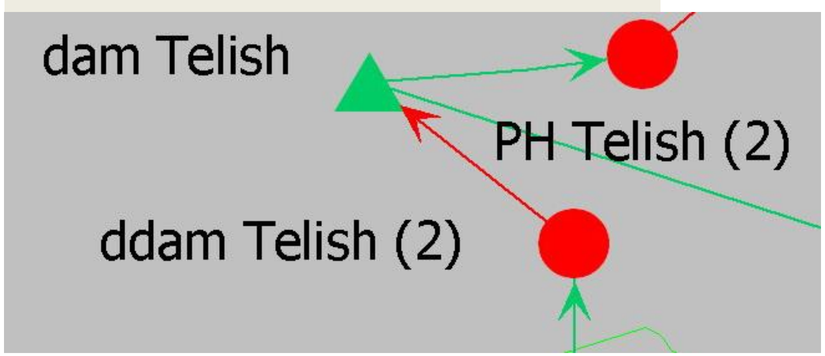


Modelling of reservoirs

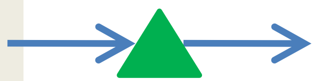
Water balance

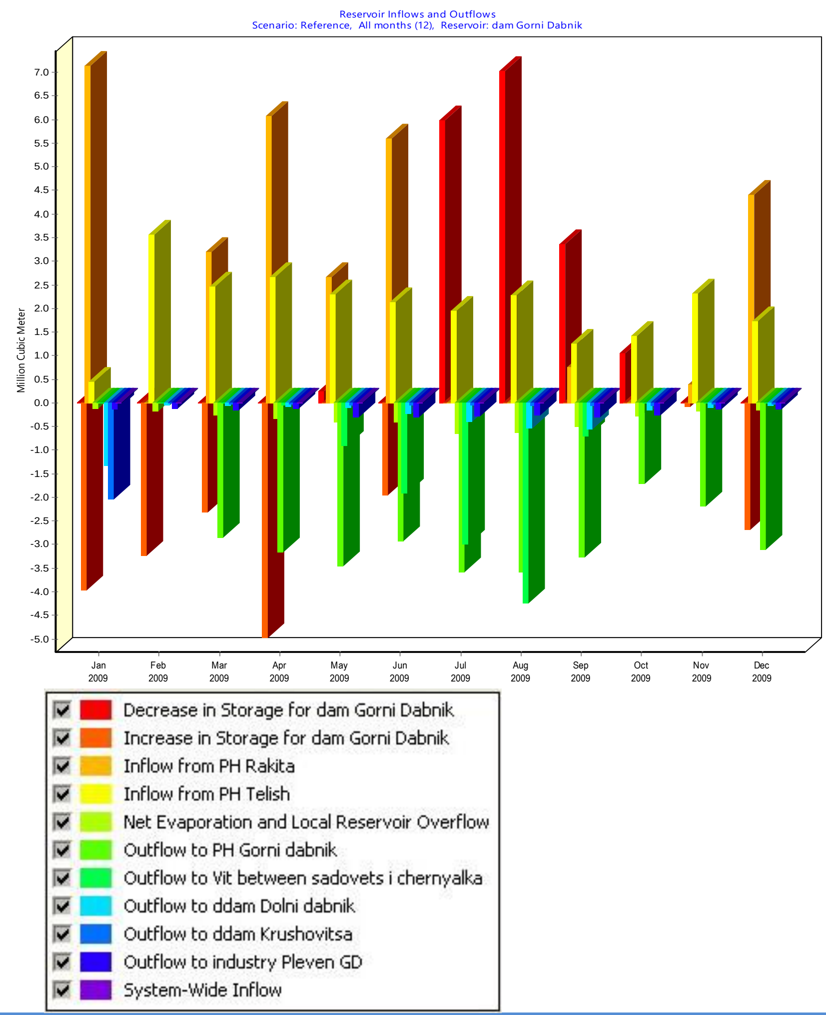
Input data

- Inflow
- Total volume
- Initial volume
- Key curve
- Transpiration
- Water losses to GWB
- Volume
- Technical specifications- working volume, dead volume and others.



Reservoir

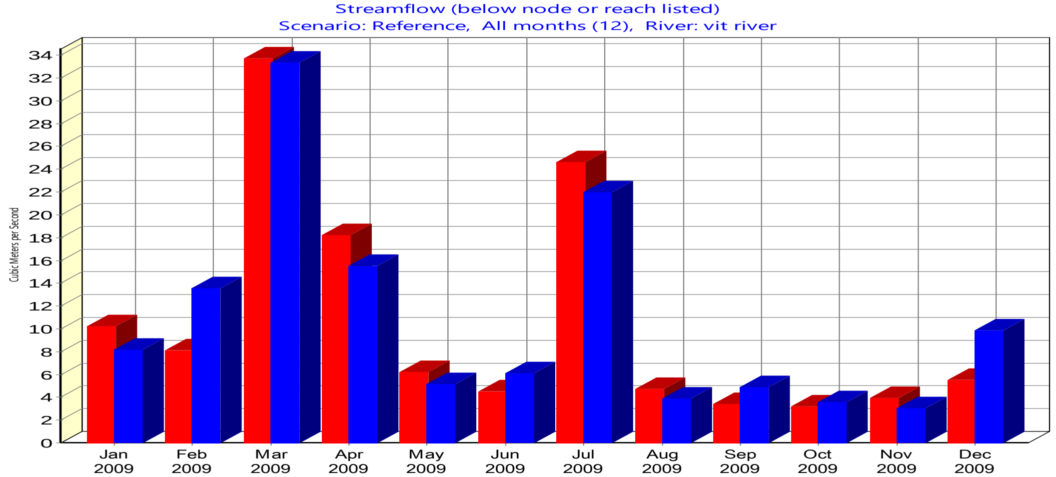




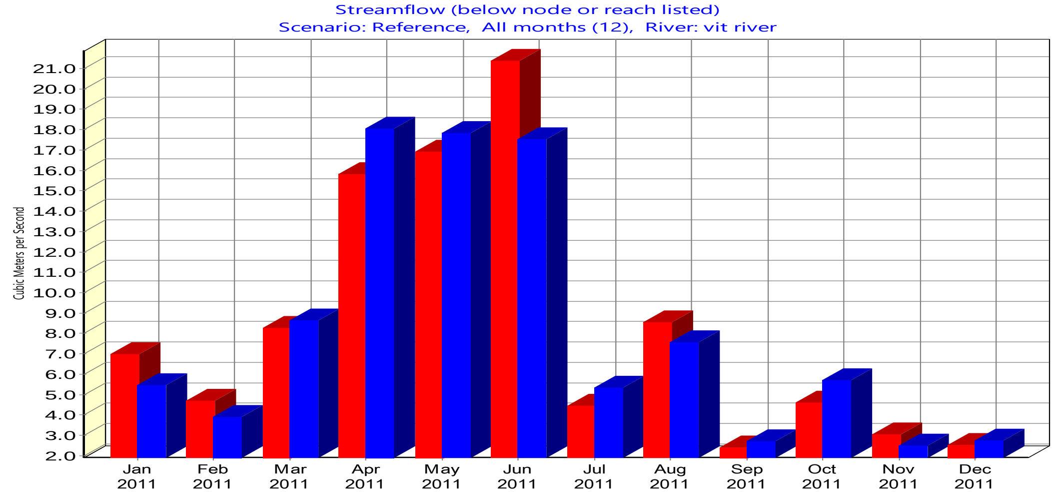
Results

(flow rates at Tarnene HMS)

2009 for calibrating
Annual difference of +2.1%



2011 for validating
Annual difference of -1.77%

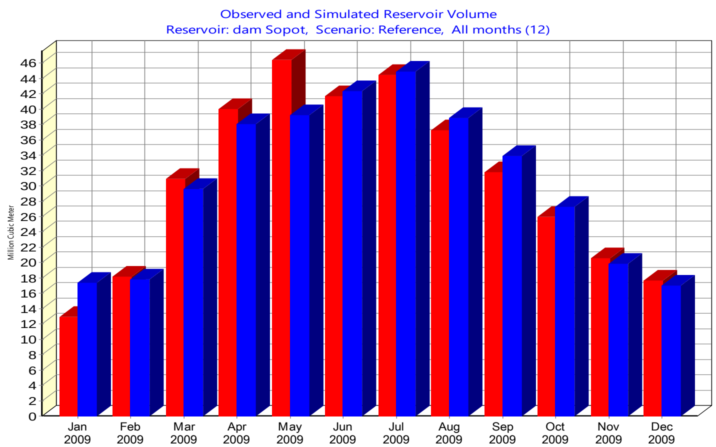


Red- observed flow rate
Blue- simulated flow rate

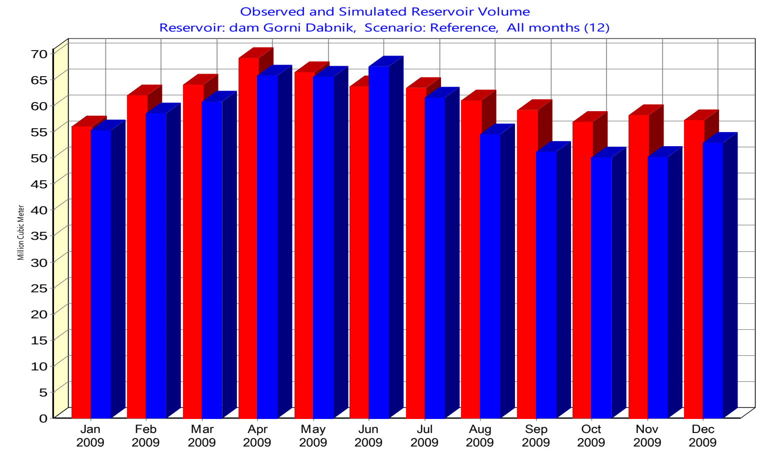
Results

(stored water volumes in reservoirs in 2009)

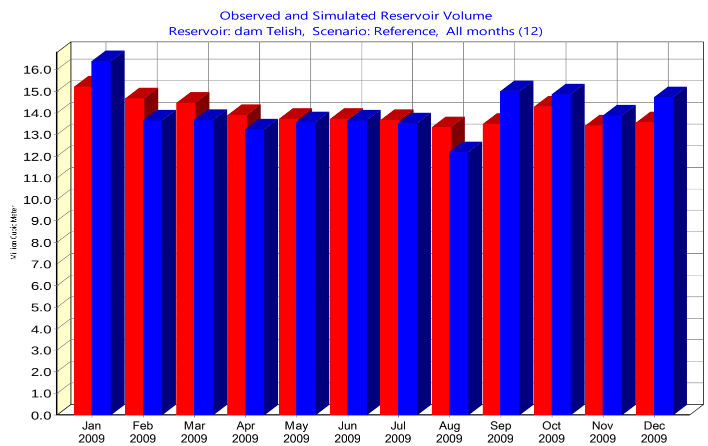
Sopot reservoir- annual diff. of -0.45%



Gorni dabnik reservoir- annual diff.of -5.93%



Telish reservoir- annual diff. of +0.45%



Red- observed flow rate
Blue- simulated flow rate

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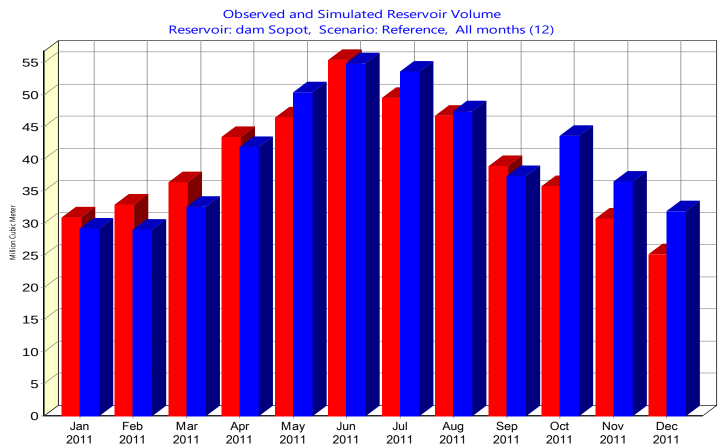
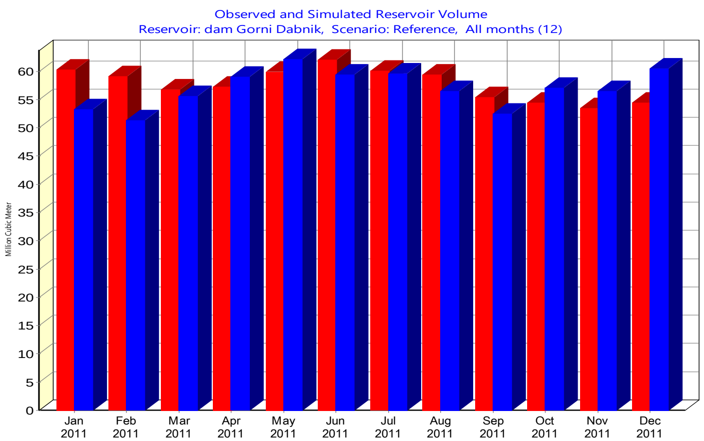
Results

(stored water volumes in reservoirs in 2011)

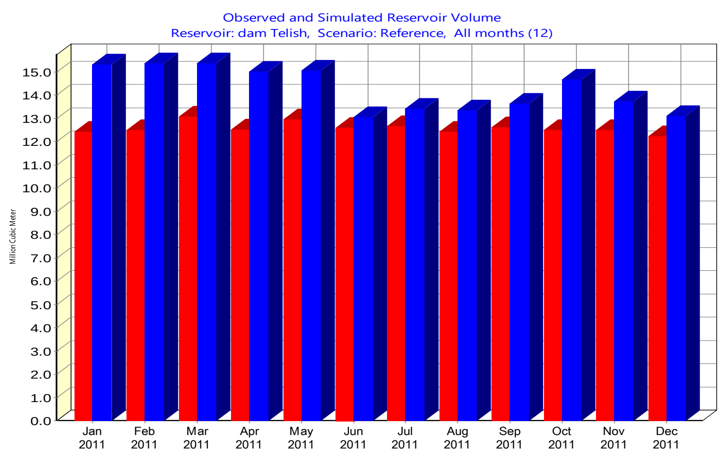
Sopot reservoir- annual diff. of +3.23%



Gorni dabnik reservoir- annual diff.of -1.48%



Telish reservoir- annual diff. of +13.31%



Red- observed flow rate
Blue- simulated flow rate

Optimization measures

Indicative curves

Represents the relationship between the effect of certain measure and investment.

During the development of RBMPs forecast for water demand can be used.

Type of water use	Used water m^3/year
Public water supply	19 394 283
Agriculture	8 651 636
Industry	2 231 000
HPP	147 071 938

The group of measures aim to reduce:
-physical losses by the water networks;
-inefficient water use by end users.

The development of the indicative curve should be done at lower scale-business plans by water operators, industry, municipalities etc.

Different approach is used to develop the individual curves and shown in next slides.

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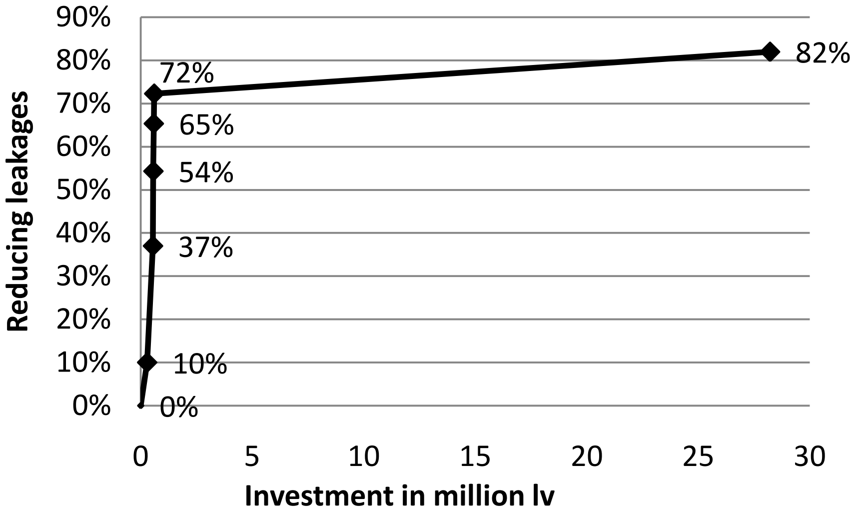
Reducing physical leakages in Pleven



Steps:

1st – Pressure management

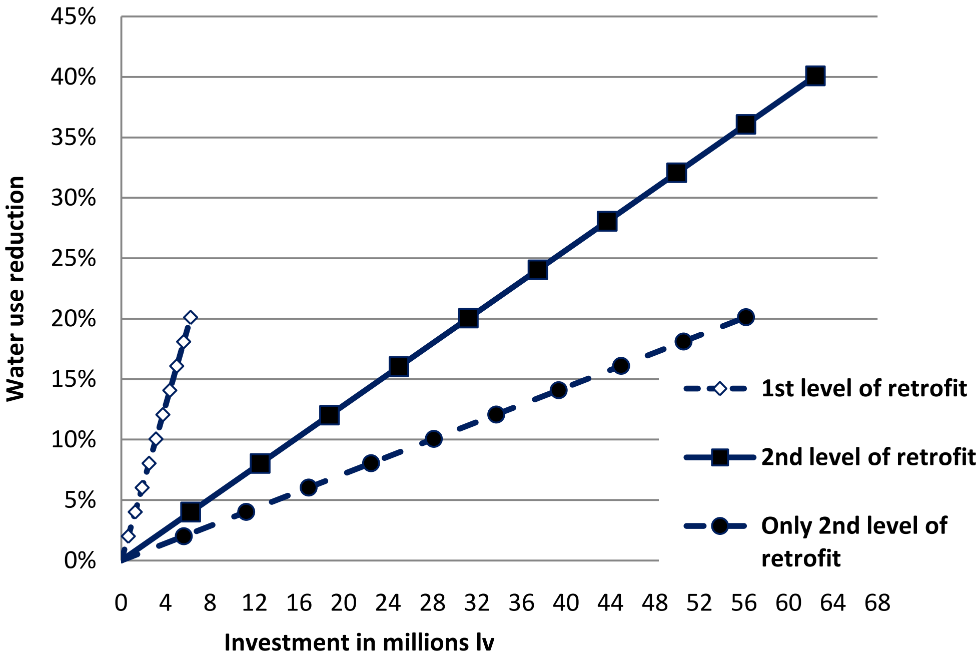
2nd – Active leakage control– in 4 steps

3rd – Replace part of the network

Parameters of the complex indicative curve for reducing water losses in the town of Pleven

Measure	Physical leakages reduction on annual basis	Physical losses	Cumulative reduction in losses on an annual basis	Effect on leakage reduction	Investment	Cumulative price
	m^3/year	m^3/year	m^3/year	%	lv/measure	lv
BAU		4,950,902				
Step 1: Pressure management	495,090	4,455,812	495,090	10%	280,000	280,000
Step 2.1	1,336,743	3,119,068	1,831,834	37%	263,250	543,250
Step 2.2	2,194,487	2,261,324	2,689,577	54%	281,250	561,250
Step 2.3	2,740,324	1,715,487	3,235,414	65%	299,250	579,250
Step 2.4	3,084,201	1,371,610	3,579,292	72%	317,250	597,250
Step 3. Network replacing	1,371,400		4,950,691	82%	27,349,370	28,226,620

Improve water use efficiency in Pleven



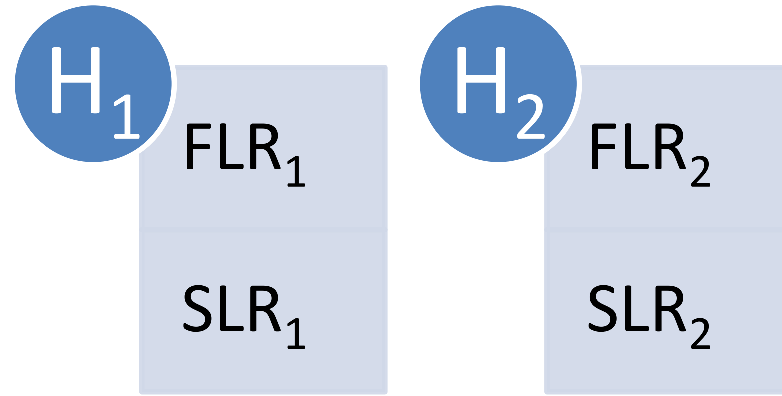
Single indicative curves for water use reduction in the town of Pleven

Reduction of daily water use [Sh., et al., 2009]

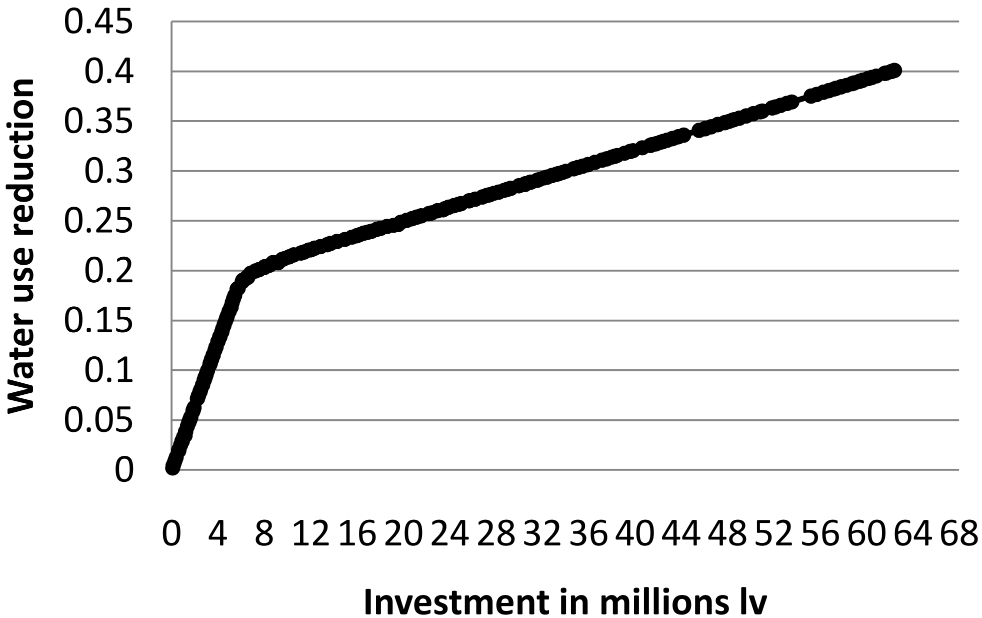
Measure	No change of level of comfort		Price per capita
	l/cap/day	% of reduction	lv
Business as usual	150	0	0
1st level of retrofit – water fixtures	120	20%	30-70
2nd level of retrofit- best sanitary appliances and water appliances	90	40%	200-600
Water reuse- not applied	75	50%	2400-4000

Improve water use efficiency in Pleven

2 measures – split the population in 2 groups (H1 и H2). And apply the measure (2) for each group. Total of 6 variables



Computational scheme for the development of complex indicative curve for water use reduction in the town of Pleven



Complex indicative curve for water use reduction in the town of Pleven (results from optimization by Matlab)

Improve irrigation efficiency

Percentage distribution of irrigation crops by type of irrigation system for 2009 (according to data by Irrigation company)

Type of crops	N	Drip	Sprinkler	Furrow	Sum	Percent of totally irrigated areas
		%	%	%	%	
Vegetables/ strawberries	1	0.9	90.9	8.2	100	67.9
Maize/ sunflower	2	0.0	22.3	77.7	100	14.9
Melon	3	0.4	69.3	30.3	100	13.3
Fruits	4	55.6	0.0	44.4	100	0.3
Tabaco		0.0	0.0	100.0	100	3.6
					Σ	100.0

Type of crops	Areas				Coefficient of efficiency			
	Drip	Sprinkler	Furrow	Sum				
	ha	ha	ha	ha	Drip	Sprinkler	Furrow	Weighted average
Vegetables/ strawberries	1.1	117.6	10.643	129.34	0.94	0.79	0.65	0.780
Maize/ sunflower	0	6.3	21.995	28.295	0.94	0.79	0.65	0.681
Melon	0.1	17.575	7.7	25.375	0.94	0.79	0.65	0.748
Fruits	0.3	0	0.24	0.54	0.94	0.79	0.65	0.811
Tabaco	0	0	6.8	6.8	0.94	0.79	0.65	0.650
			Σ	190.35			Weighted average =	0.756

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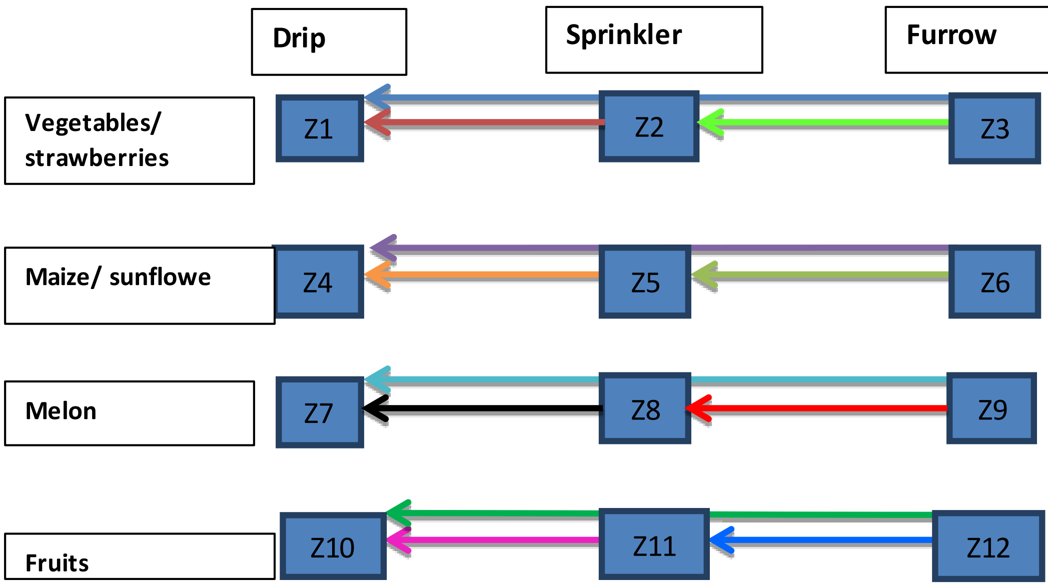
Improving irrigation efficiency



Computation scheme for developing indicative curve for improving irrigation efficiency

Each arrow represents variables in the optimization process

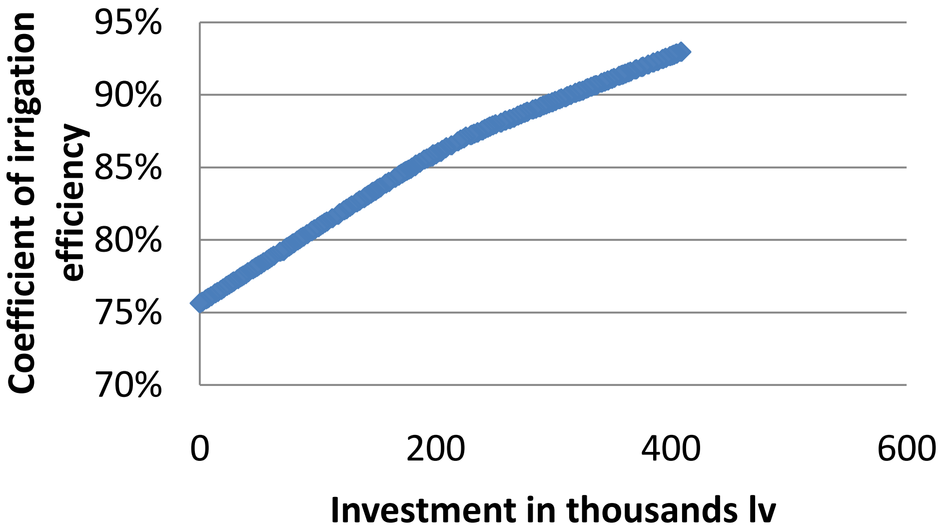
Objectives:

To reduce water demand → Improving irrigation efficiency

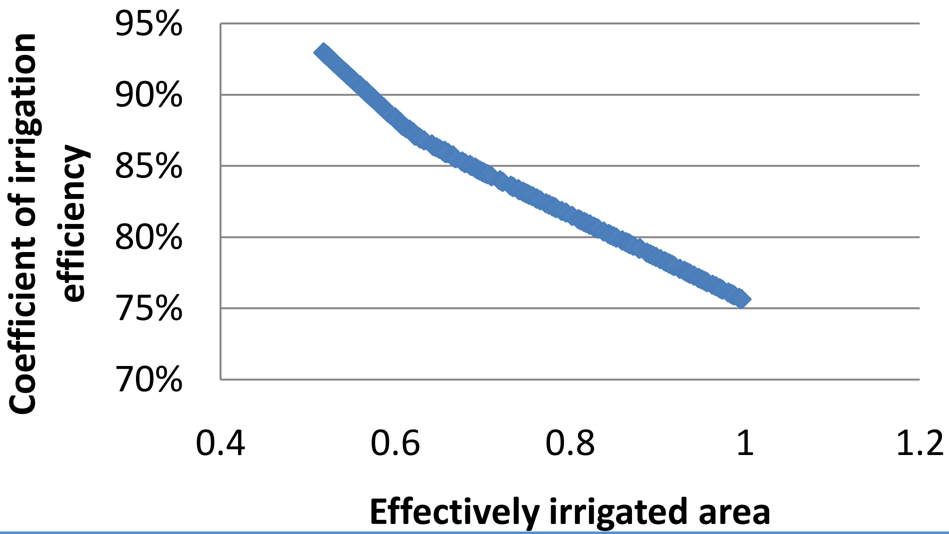
Minimal investment → Reducing effectively irrigated area

The results are Z1 – Z12, representing areas of different crops and irrigation type

Improving irrigation efficiency



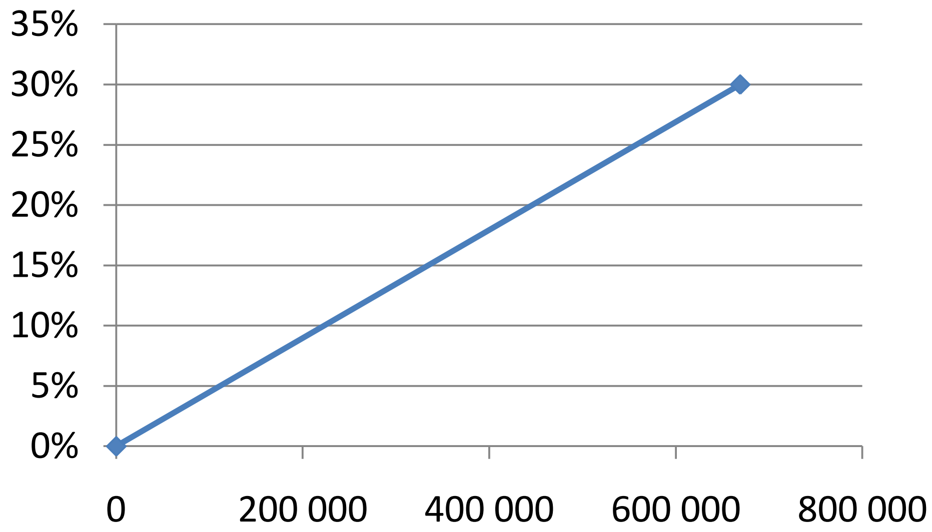
Indicative curve for improving irrigation efficiency (results from optimization in Matlab)



Relationship between coefficient of efficiency and effectively irrigated area (results from optimization in Matlab)

Improving irrigation efficiency

Reduction of channel losses



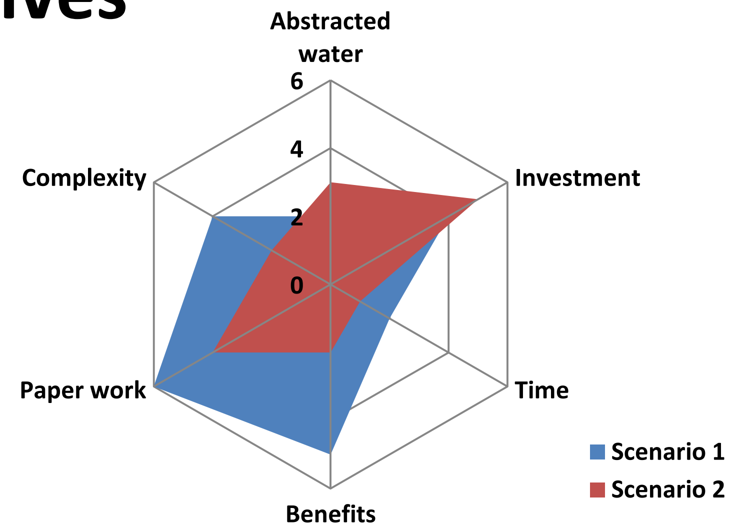
Indicative curve for reducing water losses from the irrigation network

Information used by Irrigation Systems

Optimization

Objectives

Many goals



Minimal number of goals

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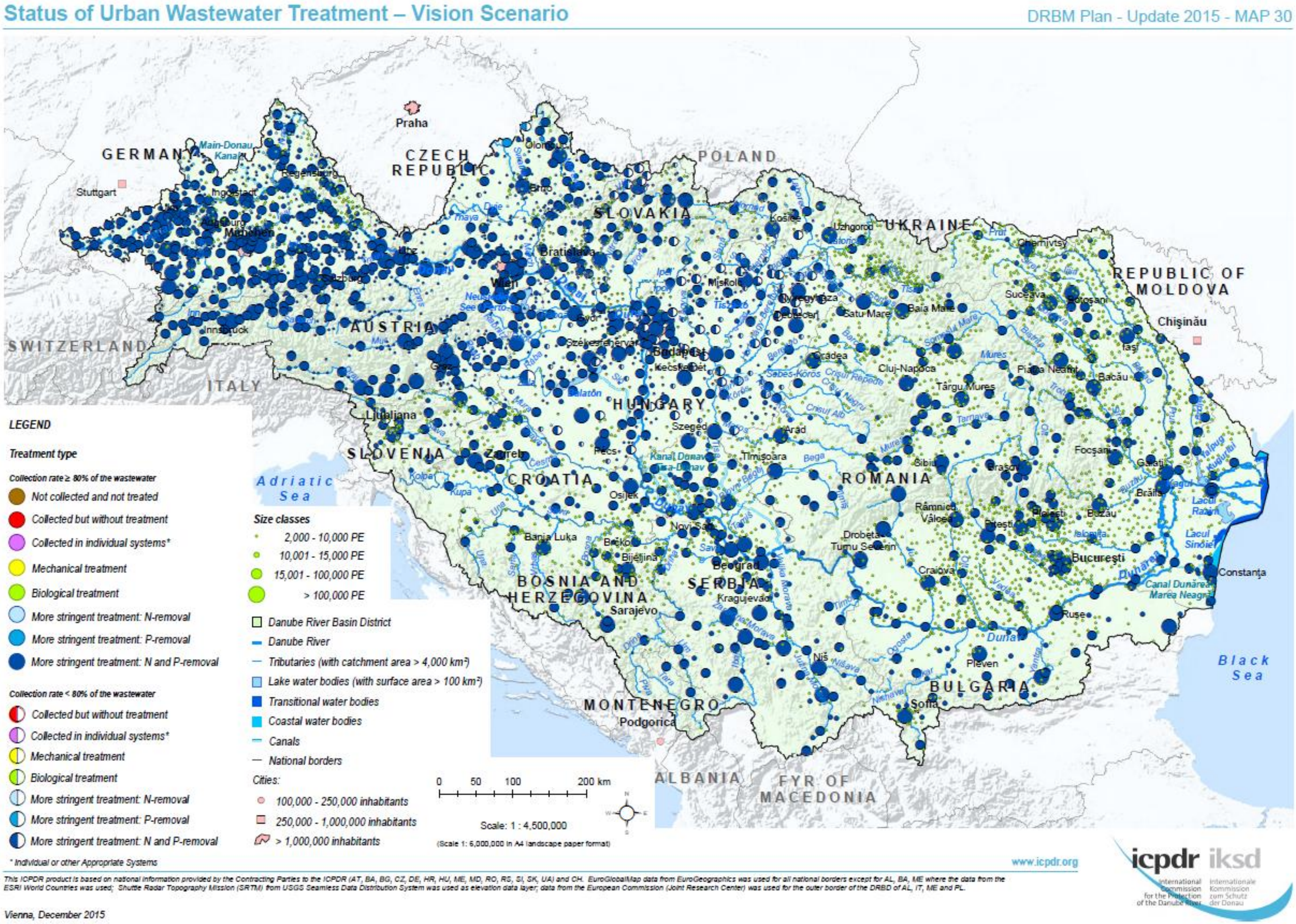
Waste water treatment plants

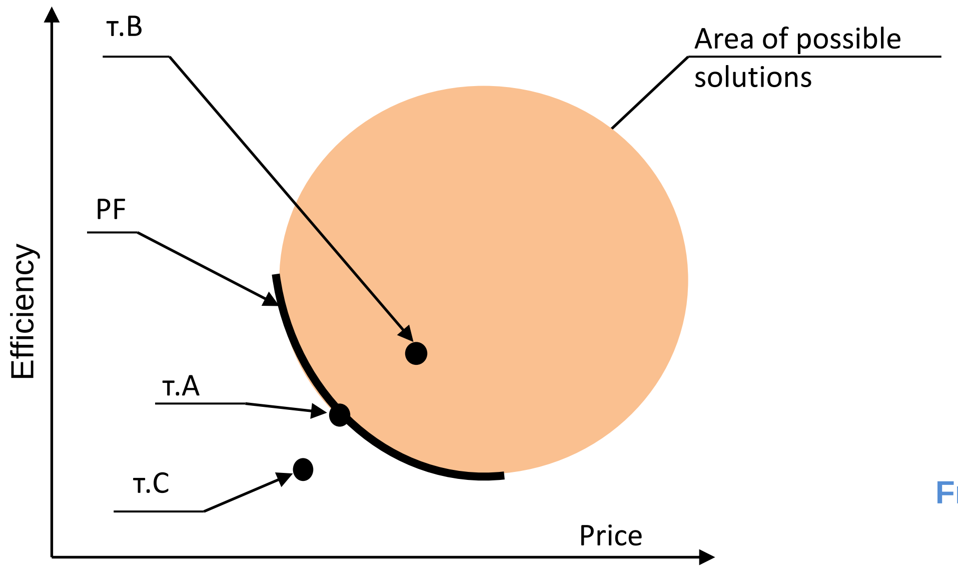


Optimization algorithm

Multi objective optimization– there is no single solution

Evolutionary algorithms are using

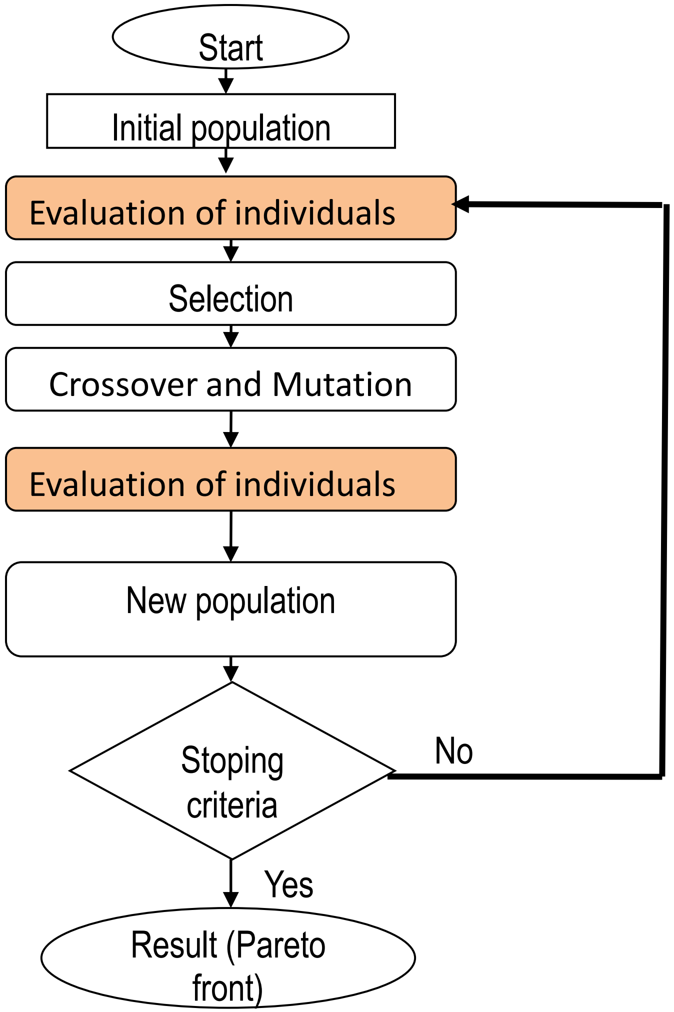
- The principal of evolution – reduced computation time
- Very good balance between the use of best solutions and the search of space
- Create multiple solutions at each computational step



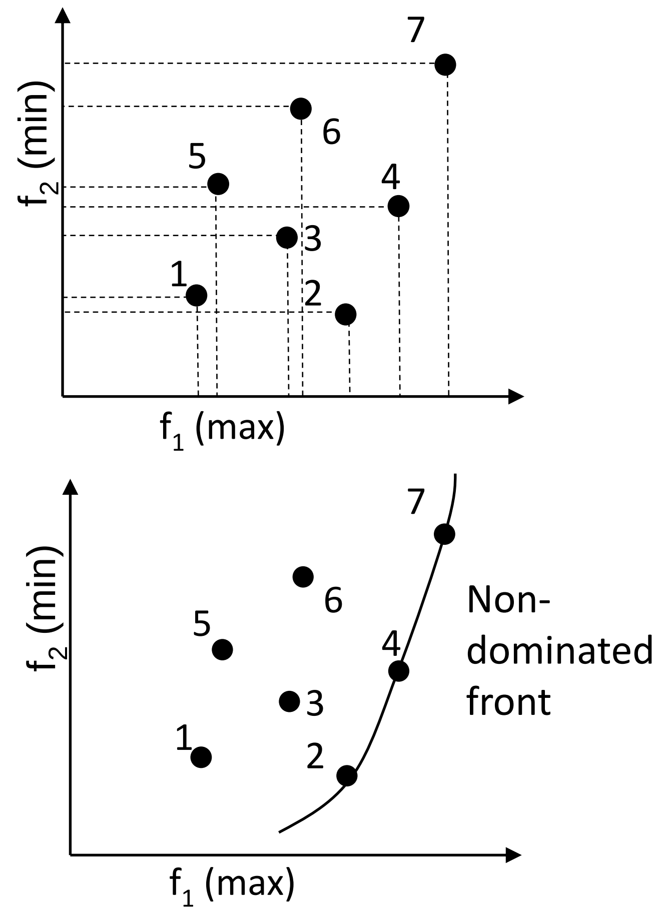
PF- Pareto front
т.A- non-dominant point
т. B- dominant point
т.C- unexciting point

Front Pareto in multi objective optimization

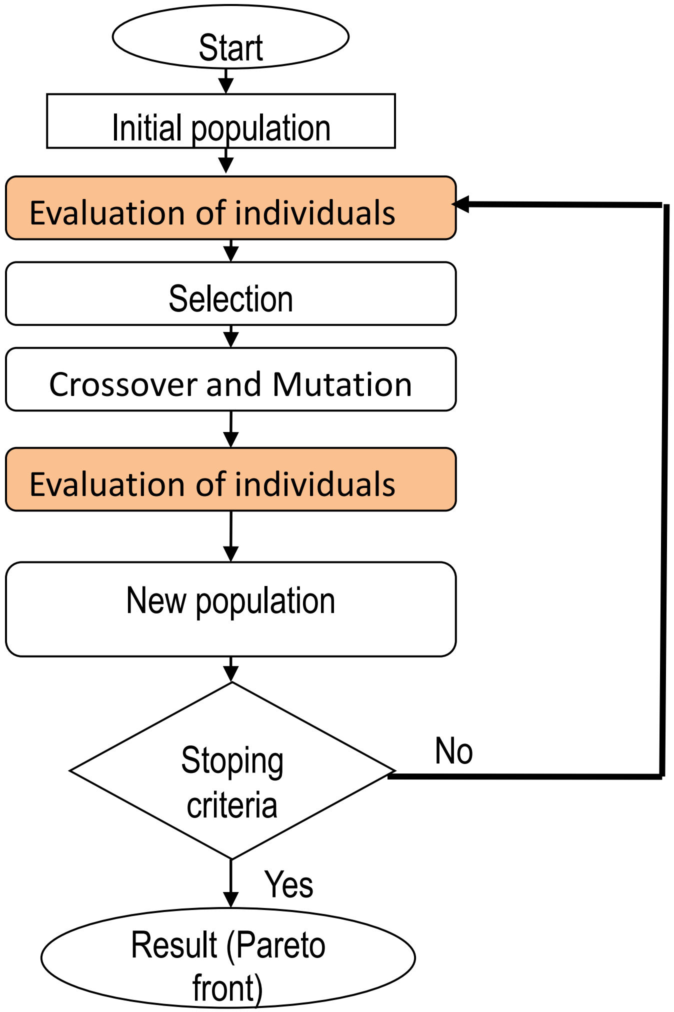
Elite non-dominant sorting genetic algorithm



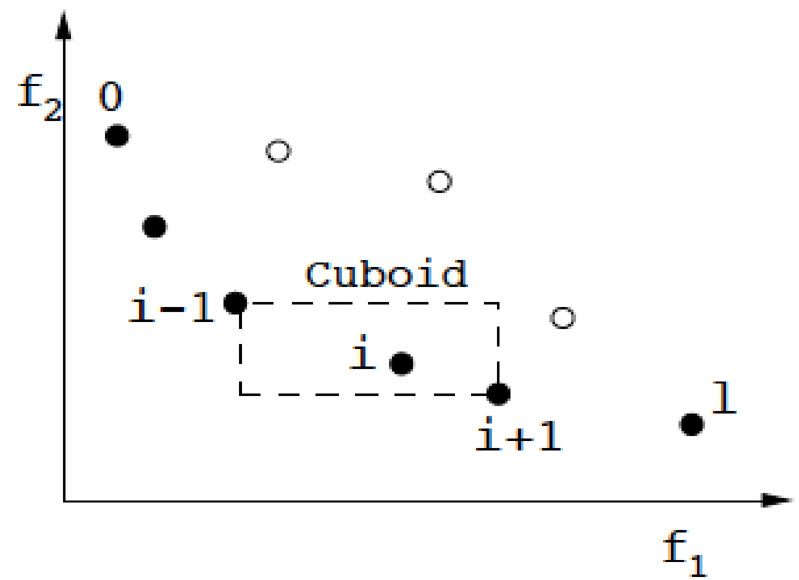
Evaluation - Non-dominance



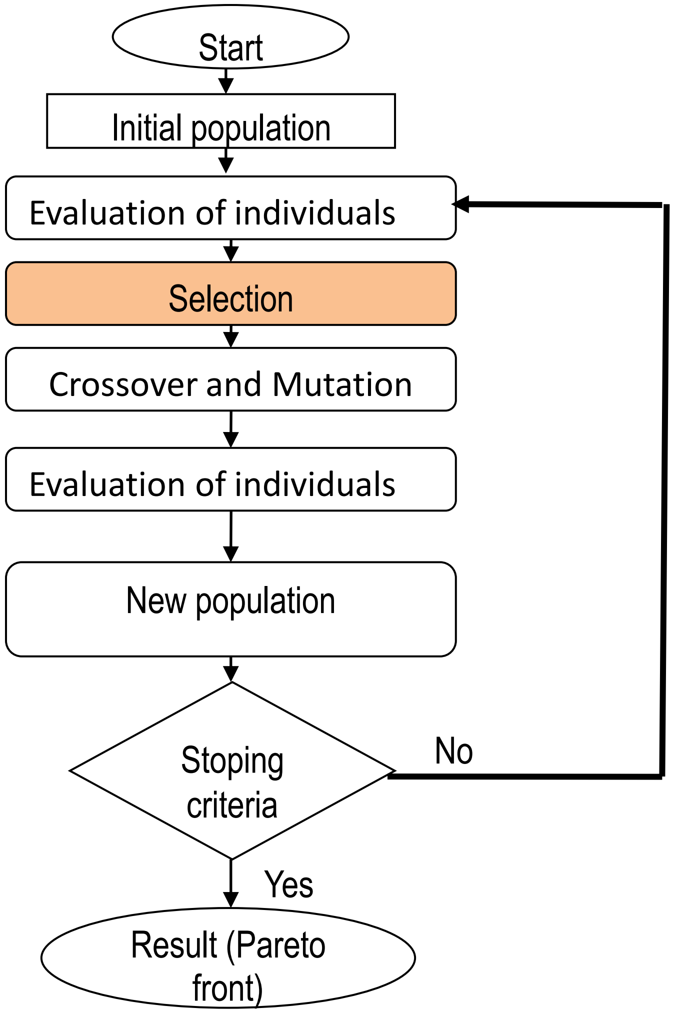
Elite non-dominant sorting genetic algorithm



Evaluation - Cluster distance



Elite non-dominant sorting genetic algorithm



Tournament selection

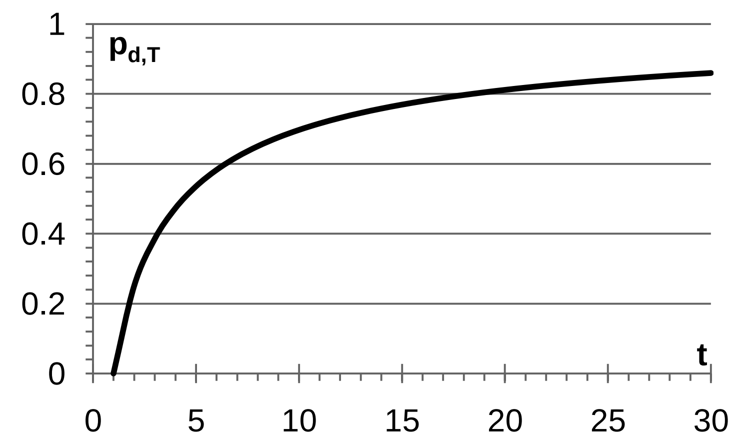
- Recombination

$$\bar{R}_T(f) = t\left(\frac{\bar{S}(f)}{N}\right)^{t-1}$$

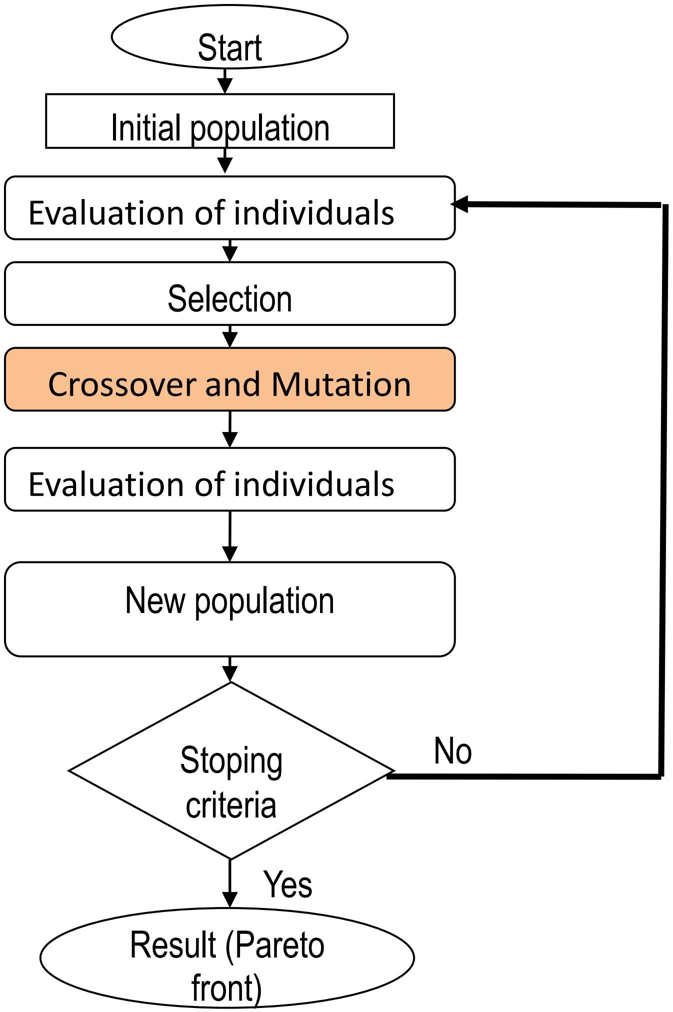
$\bar{S}(f)$ – Cumulative distribution of individuals with force f or less

- The loss of diversity

$$p_{d,T}(t) = t^{-\frac{1}{t-1}} + t^{-\frac{t}{t-1}}$$



Elite non-dominant sorting genetic algorithm



Crossing

- arithmetic crossing
- heuristic crossing
- Intermediate crossing

$C = P_1 + b\alpha(P_2 - P_1)$

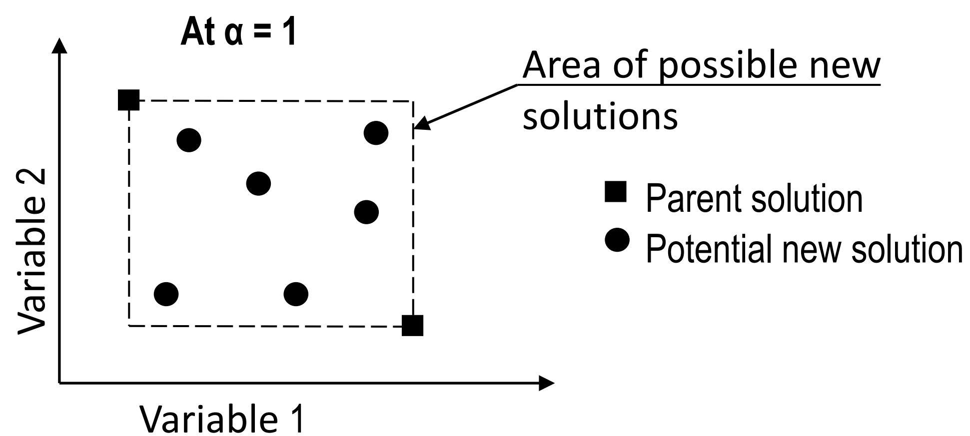
C – new solution

P_1 – first parent

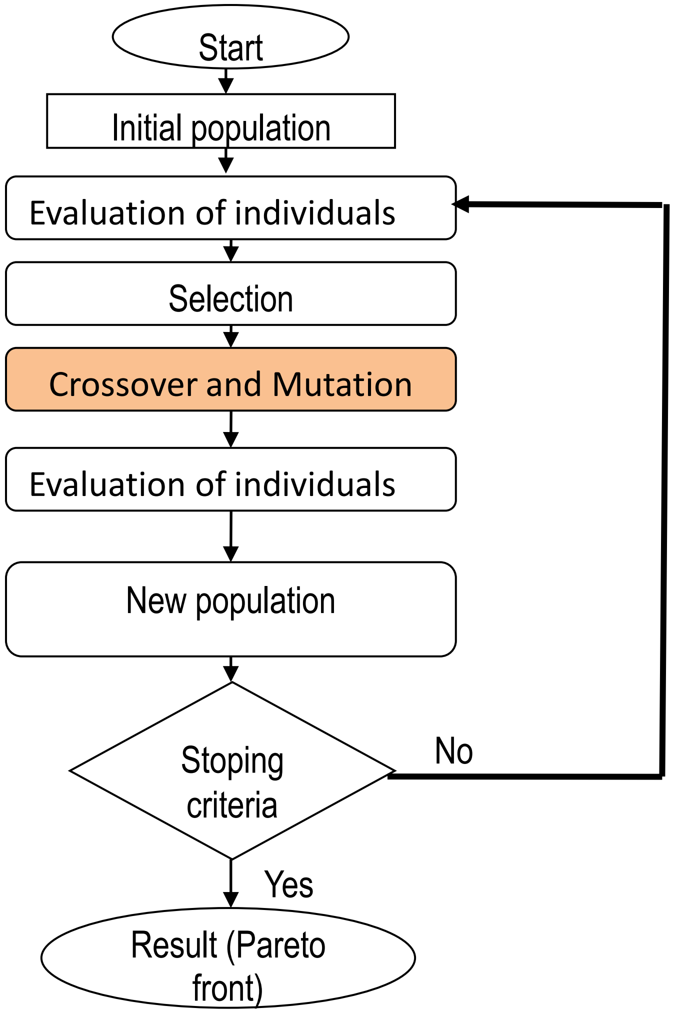
P_2 – second parent

$\alpha = 0 \div 1$– exploration coefficient

$b = 0 \div 1$– random number



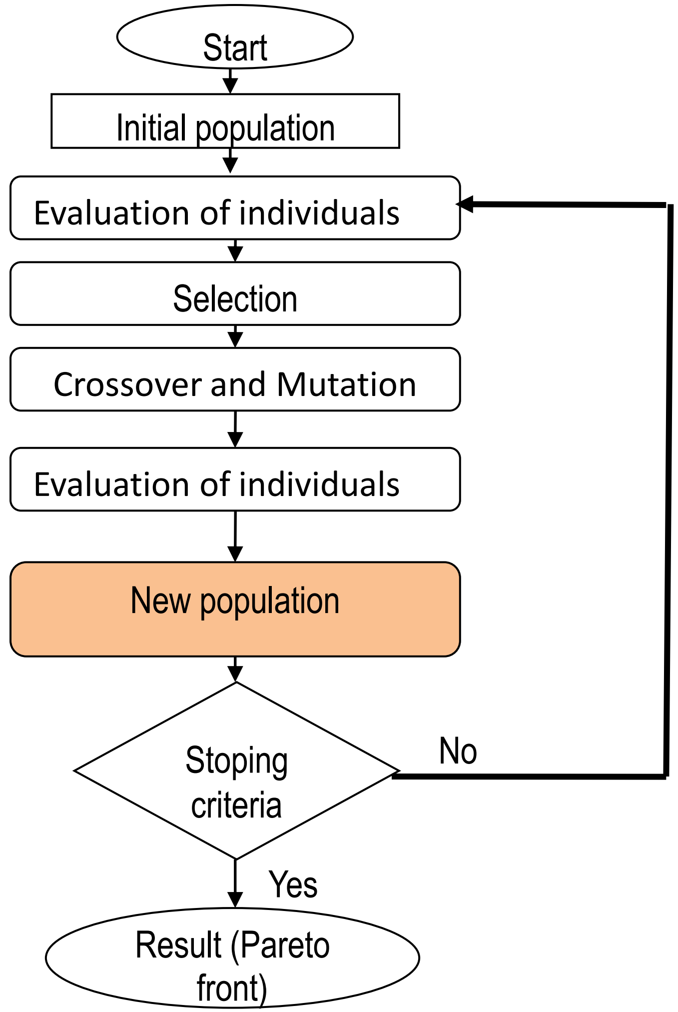
Elite non-dominant sorting genetic algorithm



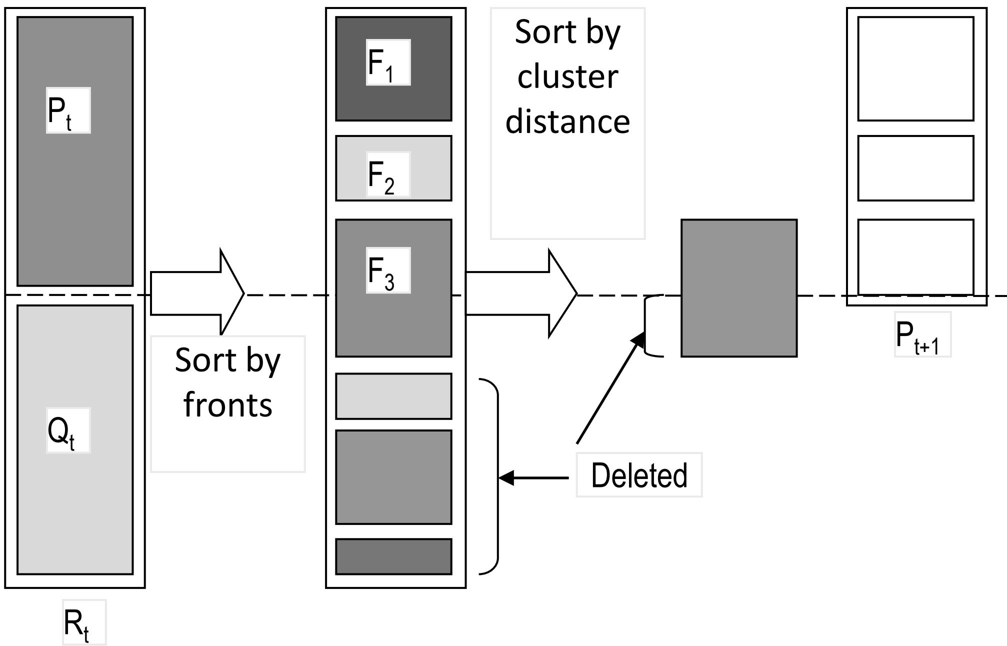
Mutation

- For linear constraints and limits - The adaptively applicable operator
- It randomly generates directions that are adaptable to the last successful or unsuccessful generation

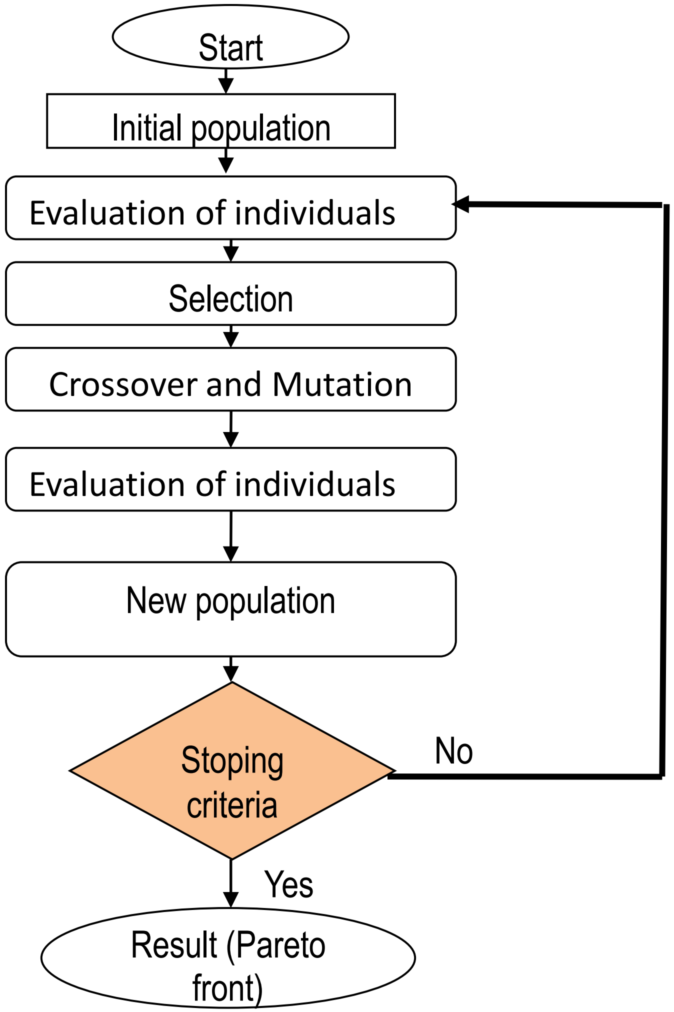
Elite non-dominant sorting genetic algorithm



Creating a new generation



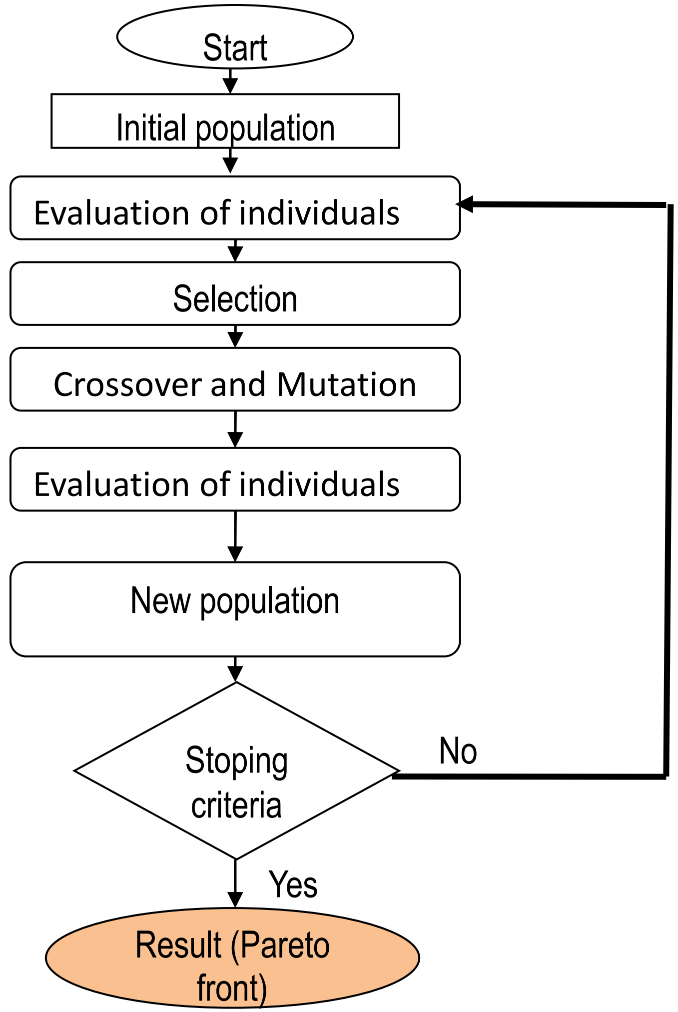
Elite non-dominant sorting genetic algorithm



Stopping criteria

- Maximum number of generation
- Calculation time limit
- Power limit
- Stable populations
- Function tolerance

Elite non-dominant sorting genetic algorithm



PF- Pareto front
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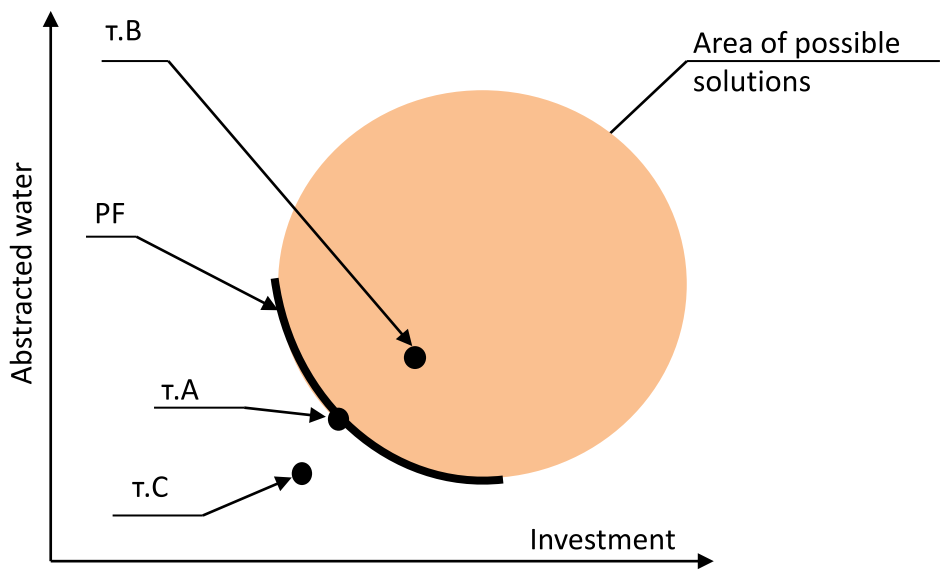
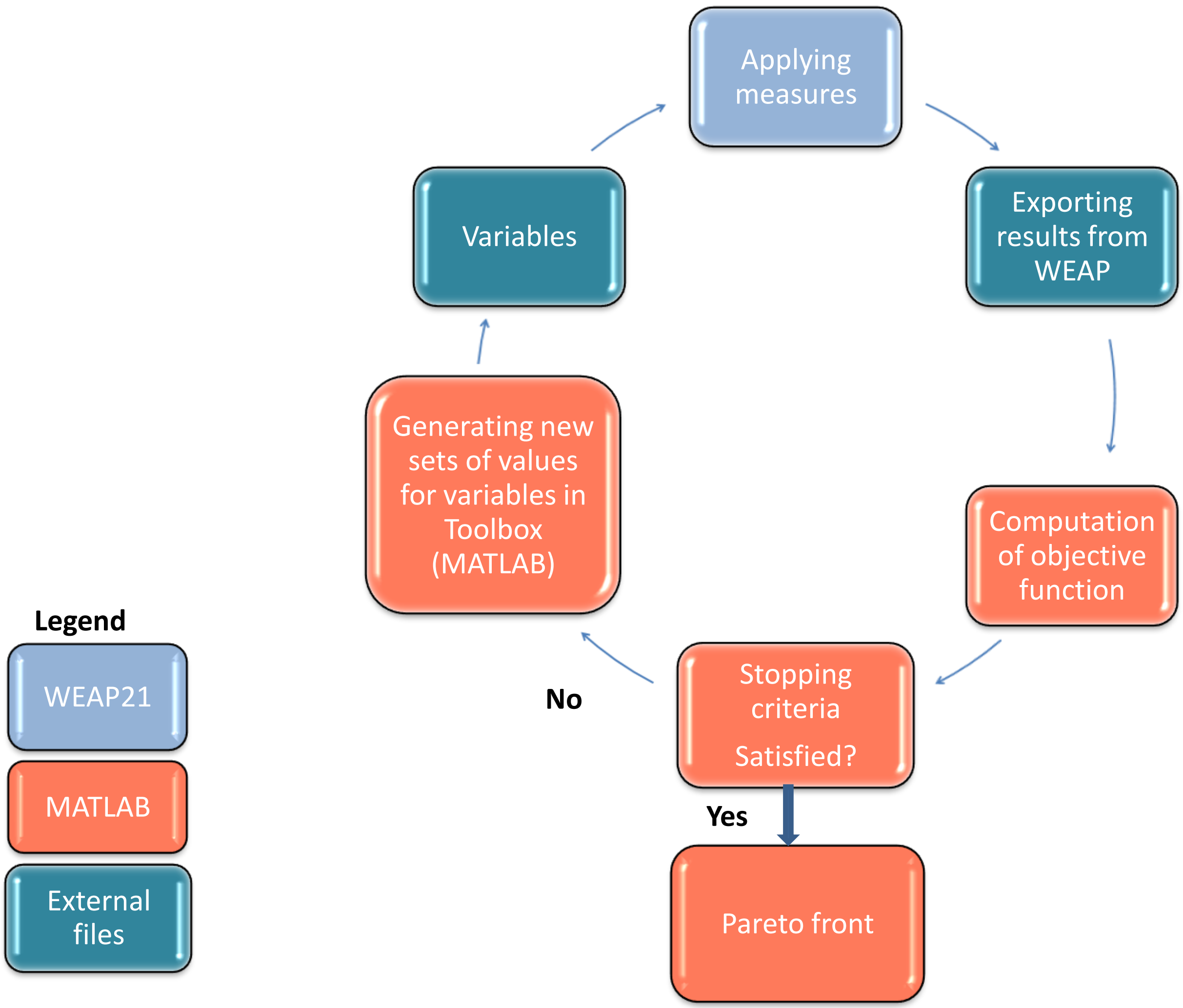
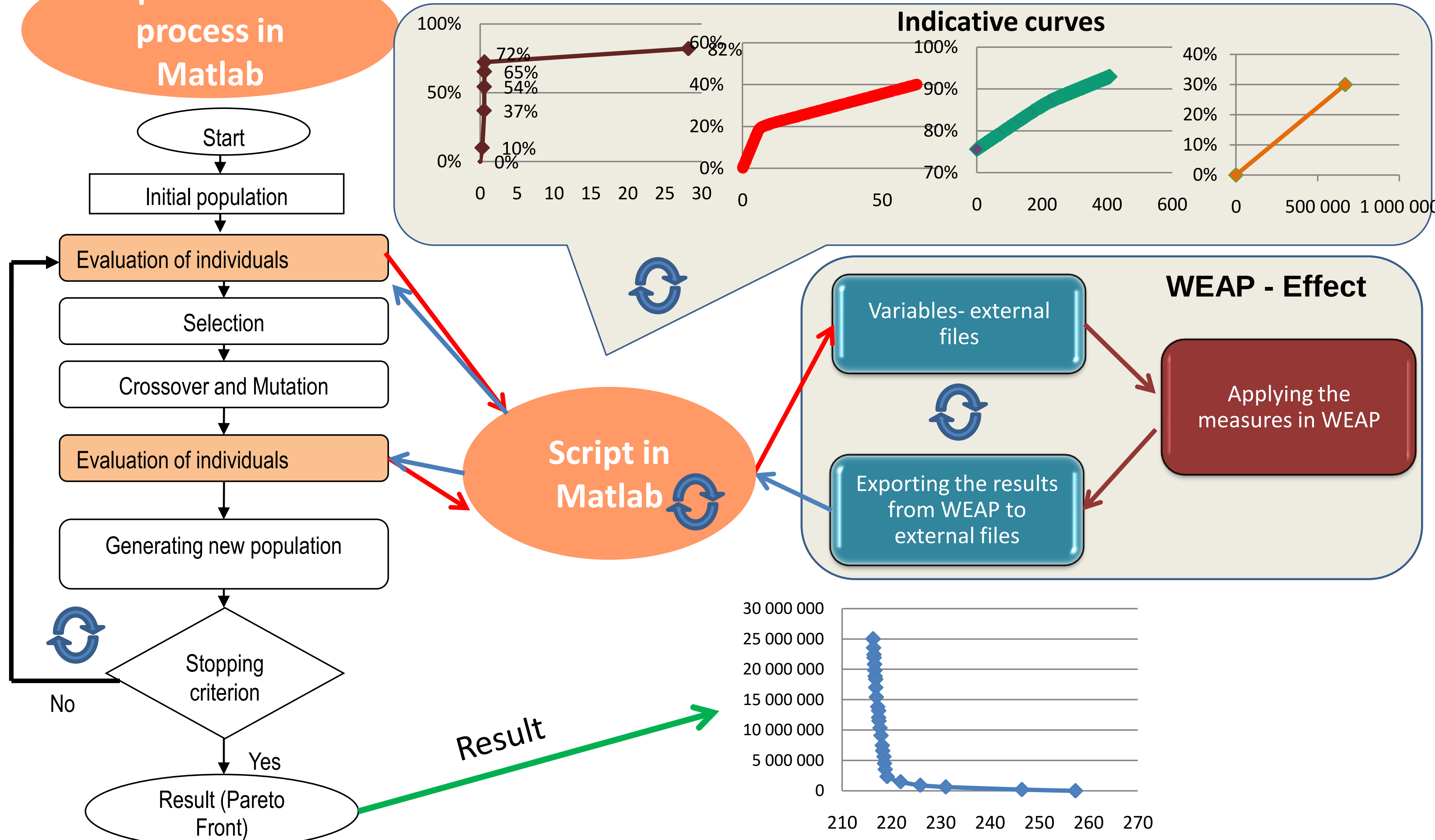


Front Pareto in multi objective optimization

Simultaneous calculations in WEAP and Matlab



Optimization process in Matlab



Simultaneous calculations in WEAP and Matlab

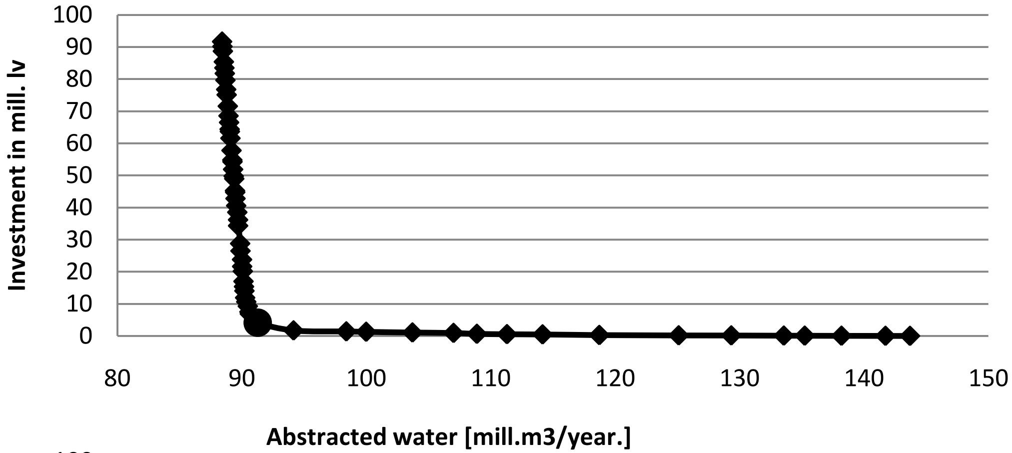
Restrictions

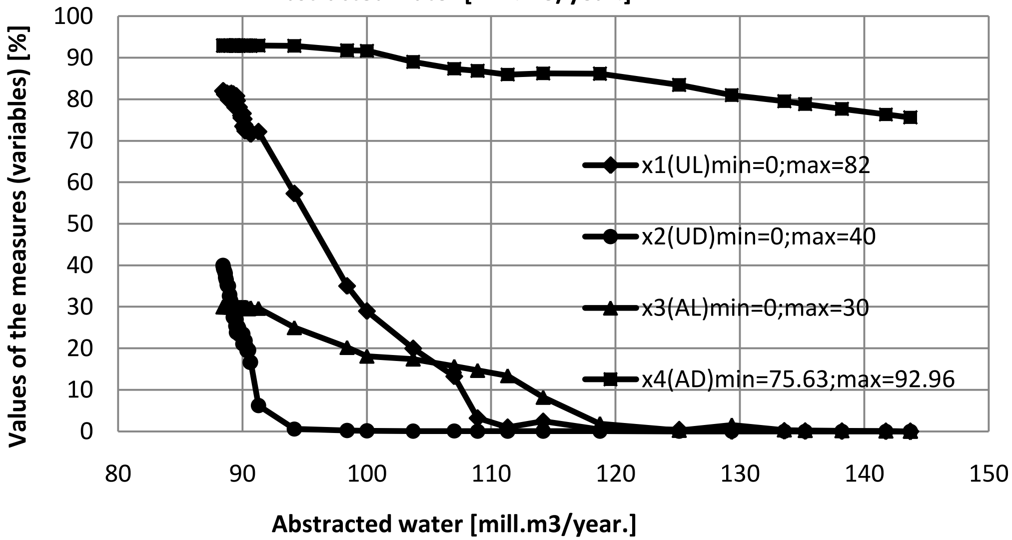
Optimization variable	Name	In Matlab			Modeled in WEAP	
		Min %	Max %	Optimization variable	in key assumptions	in the elements of the model
UL	v1	0	82	x_1	$a=1- x_1/100$	a*losses
UD	v2	0	40	x_2	$b=1-x_2/100$	b*demand
AL	v3	0	30	x_3	$c=1-x_3/100$	c*losses
AD	v4	75.6	92.96	x_4	$d=x_4$	d=a

Goals

- Minimum total investment – Σ Total investment cost
- Minimal abstracted water from nature– Σ Water abstraction

Optimization results for 2009



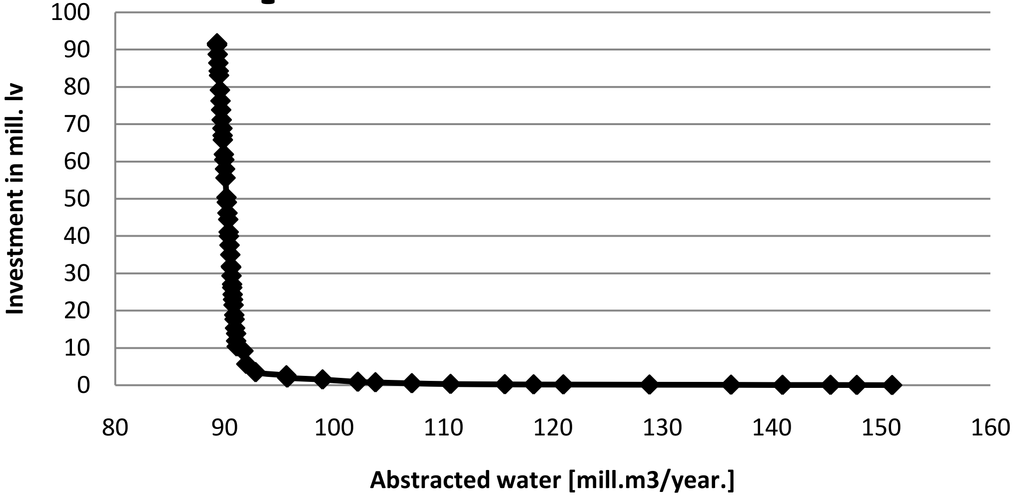


Population size of 60. Results after 102 generations and computational time of 15 hours.

Pareto Front for Vit river sub-basin for 2009 (results from optimization in Matlab)

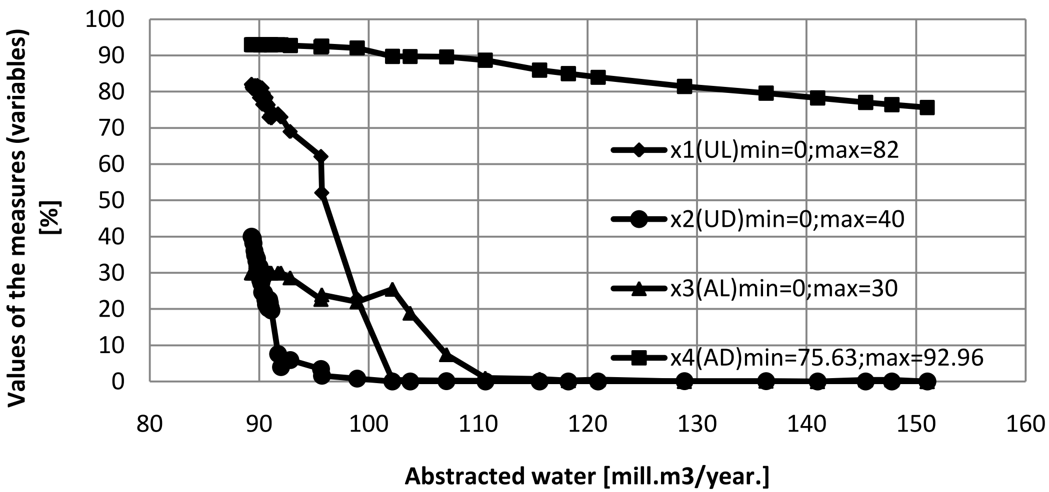
Relationship between values of the optimization variables (measures) and abstracted water for 2009 (results from optimization in Matlab)

Optimization results for 2011

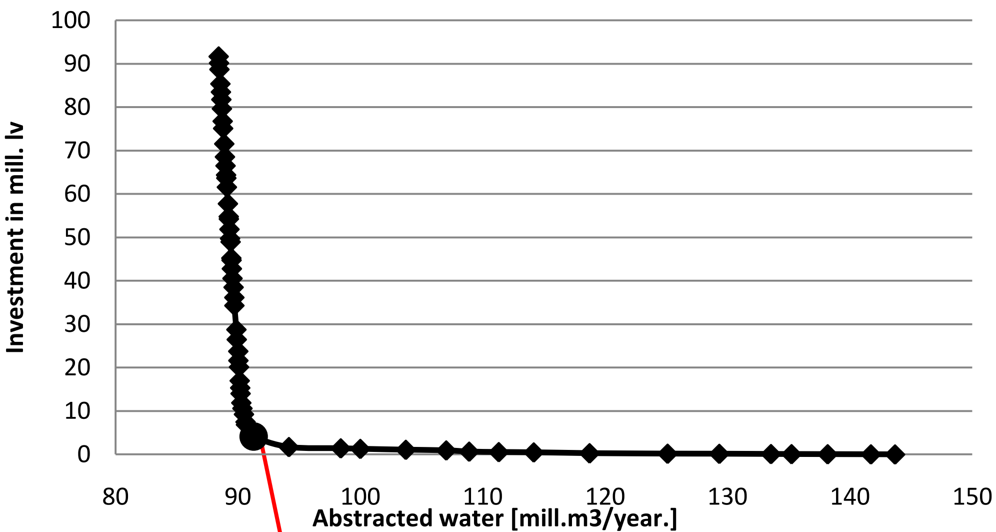


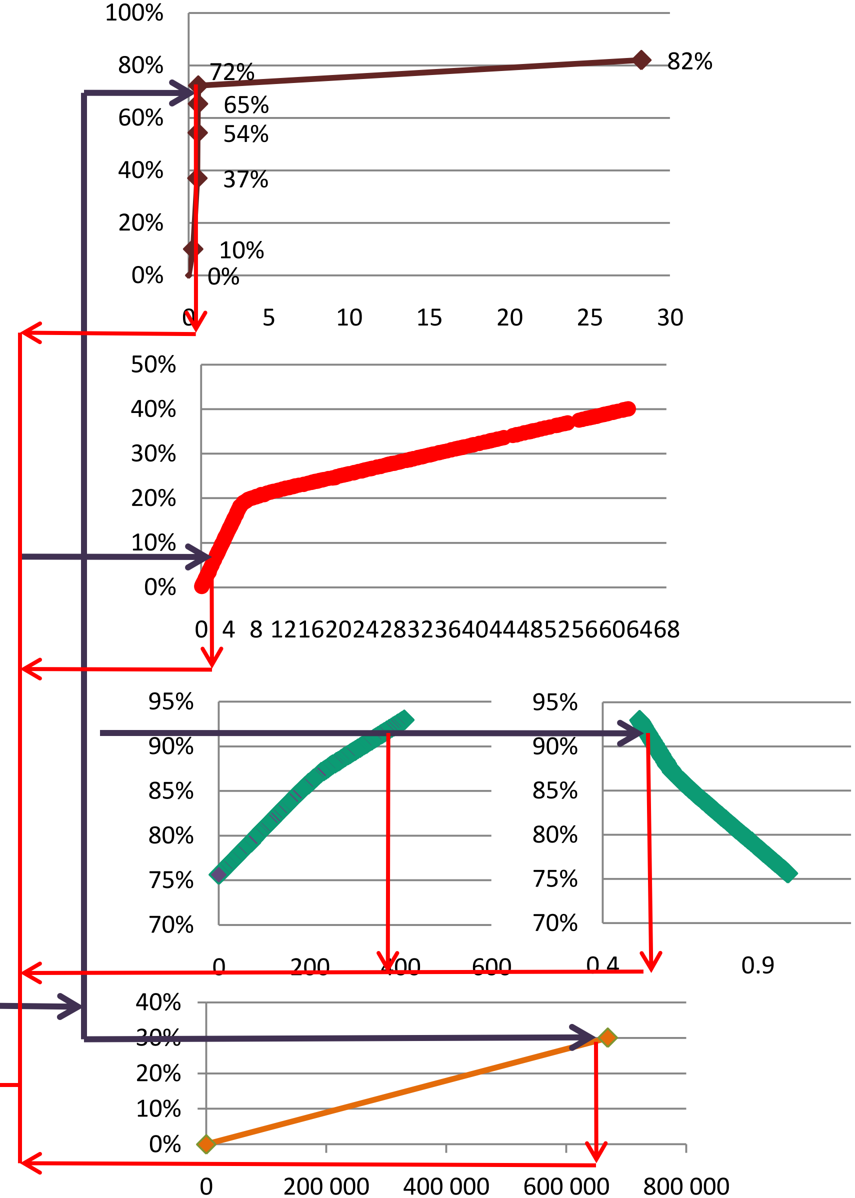
Population size of 60. Results after 102 generations and computational time of 15 hours.

Pareto Front for Vit river sub-basin for 2011 (results from optimization in Matlab)



Relationship between values of the optimization variables (measures) and abstracted water for 2009 (results from optimization in Matlab)





	UL reduction	UD reduction	AL reduction	AD reduction
Degree of application of the measure	72.19	6.21	29.67	92.94
Price				

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Scenarios and scenarios optimization

Scenarios

Climate change- increase in evapotranspiration and reduction in precipitation

Economic – increase in irrigated areas

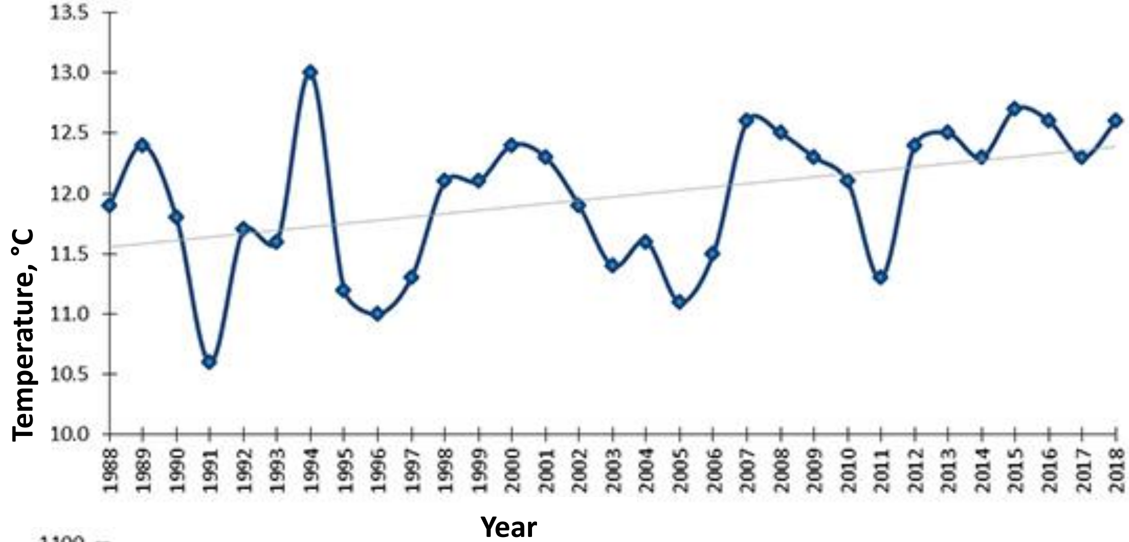
Combined- moderate combination between climate change and economic scenarios

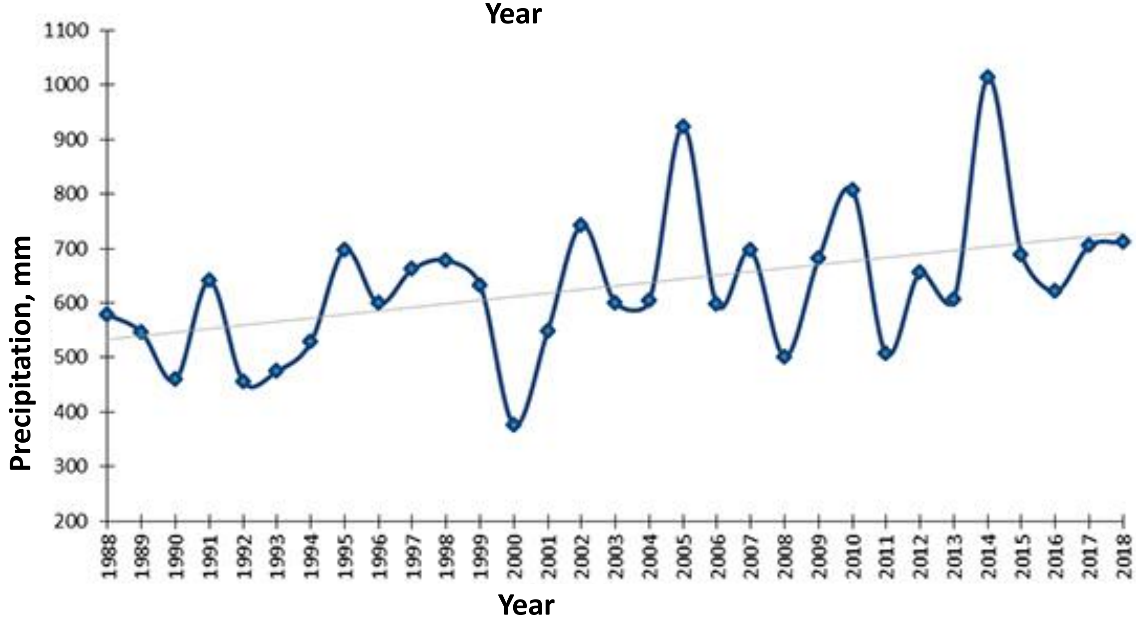
 10% reduction in precipitation
 10% increase in evapotranspiration
 Increase in irrigated areas 10 times

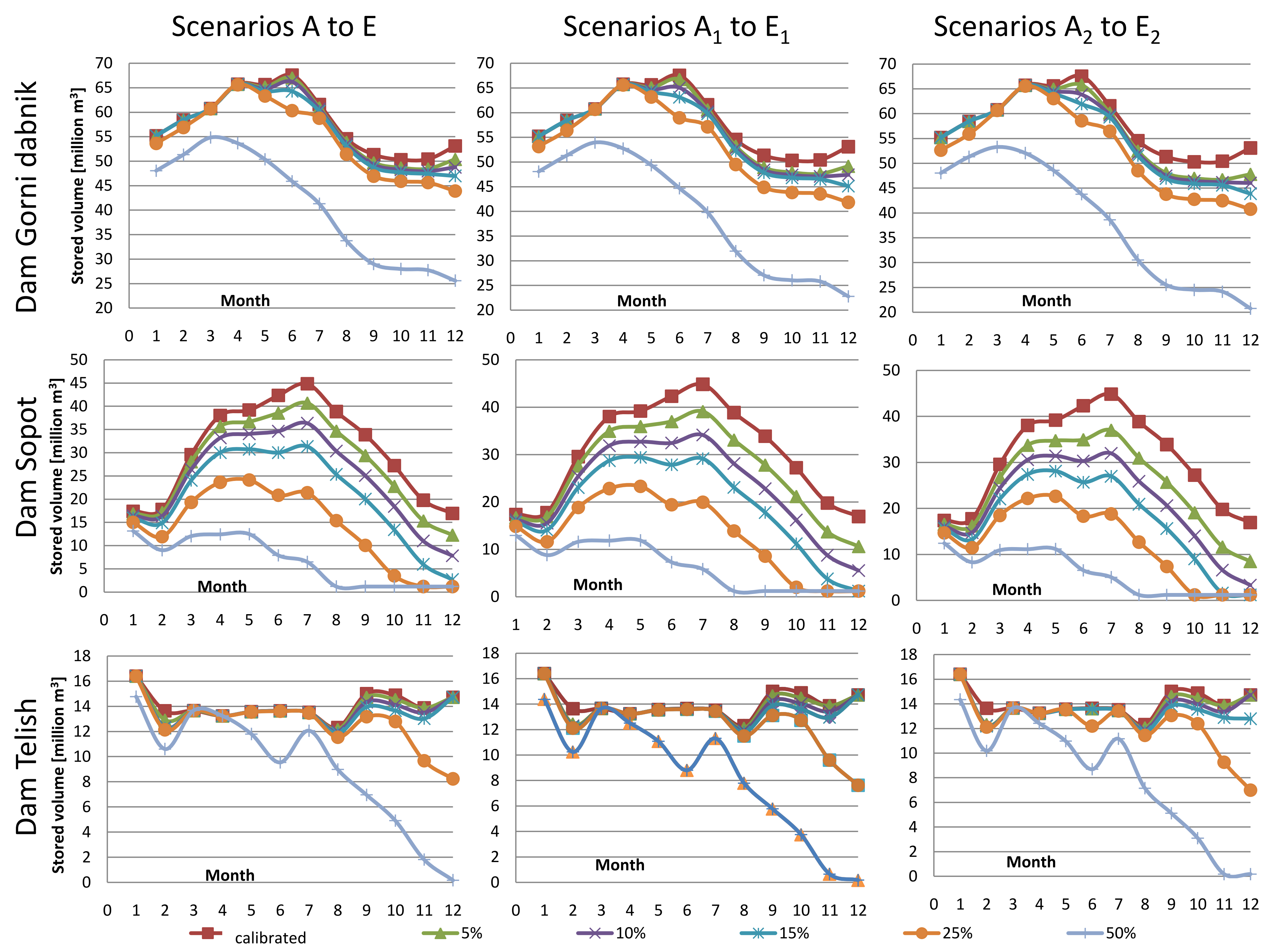
Scenarios

Name of sub - scenario	Climate change reported in the sub - variant						
	Reduction of precipitation					Increased evapotranspiration	
	5%	10%	15%	25%	50%	5%	10%
A	√	x	x	x	x	x	x
B	x	√	x	x	x	x	x
C	x	x	√	x	x	x	x
D	x	x	x	√	x	x	x
E	x	x	x	x	√	x	x
A_1	√	x	x	x	x	√	x
B_1	x	√	x	x	x	√	x
C_1	x	x	√	x	x	√	x
D_1	x	x	x	√	x	√	x
E_1	x	x	x	x	√	√	x
A_2	√	x	x	x	x	x	√
B_2	x	√	x	x	x	x	√
C_2	x	x	√	x	x	x	√
D_2	x	x	x	√	x	x	√
E_2	x	x	x	x	√	x	√

FORECAST VS REALITY

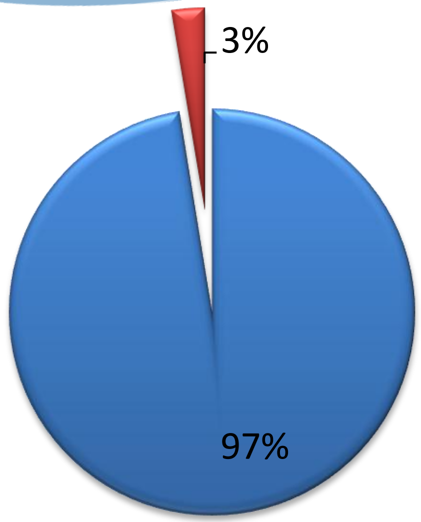






Scenarios A to E
Scenarios A$_1$ to E$_1$
Scenarios A$_2$ to E$_2$
Dam Gorni dabnik
Dam Sopot
Dam Telish
Stored volume [million m^3]
Month
calibrated
5%
10%
15%
25%
50%

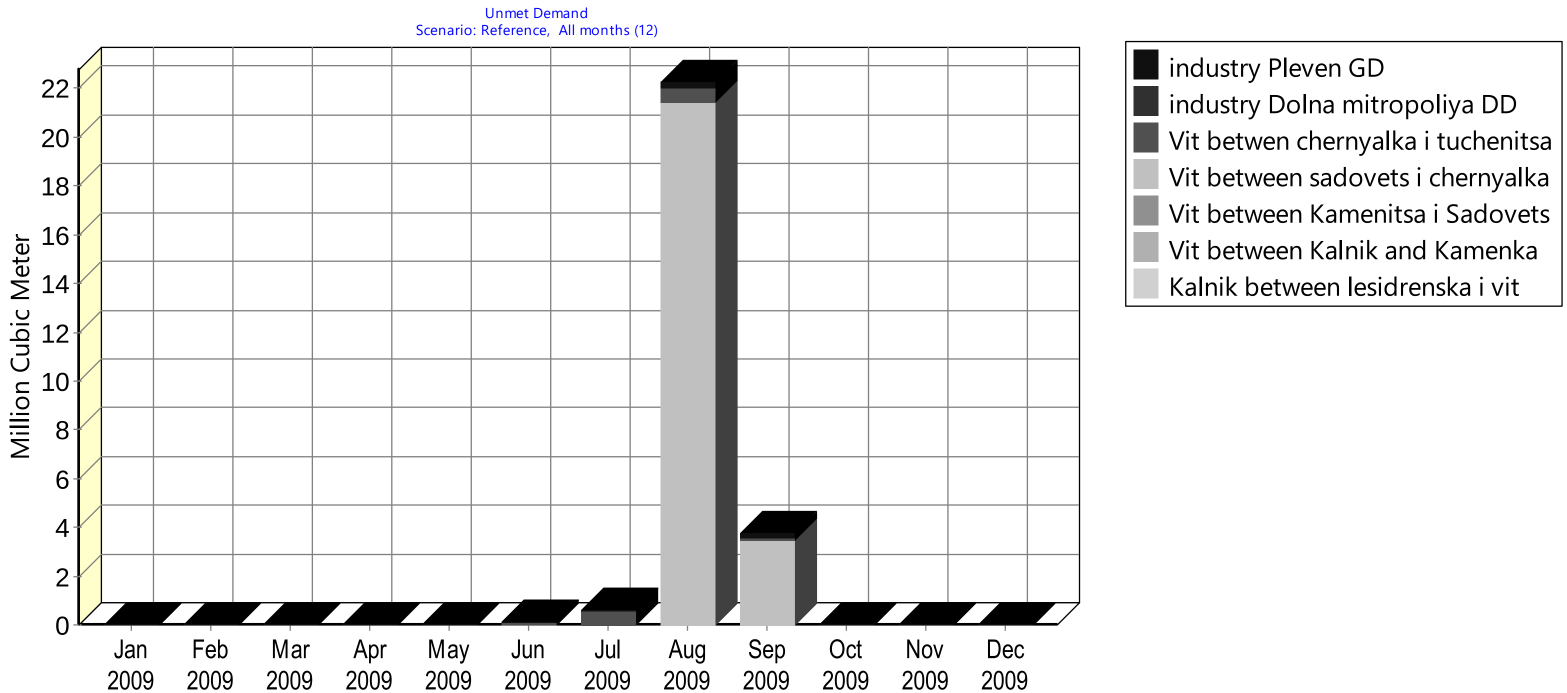
Economic scenario



Irrigated areas (designed and current), according to data by Irrigation company

Dam	Parametar	Unit	Irrigated area		Increase of the irrigated areas compared to 2009		
			Designed	Actual in 2009	2.5	5	10
Gorni dabnik	irrigated area	км²	434	16	40	80	160
	% from designed	%	100%	4%	9%	18%	37%
Telish	irrigated area	км²	217	1	4	7	15
	% from designed	%	100%	1%	2%	3%	7%
Sopot	irrigated area	км²	60	1	3	7	13
	% from designed	%	100%	2%	5%	11%	22%

Economic scenario



Water scarcity for the Vit river catchment in the economic scenario - increase of the irrigated lands 10 times

Lack of water for the irrigated areas of the dams Gorni and Dolni Dabnik, as well as for the industrial zones of Pleven and Dolna Mitropolia, supply by them!

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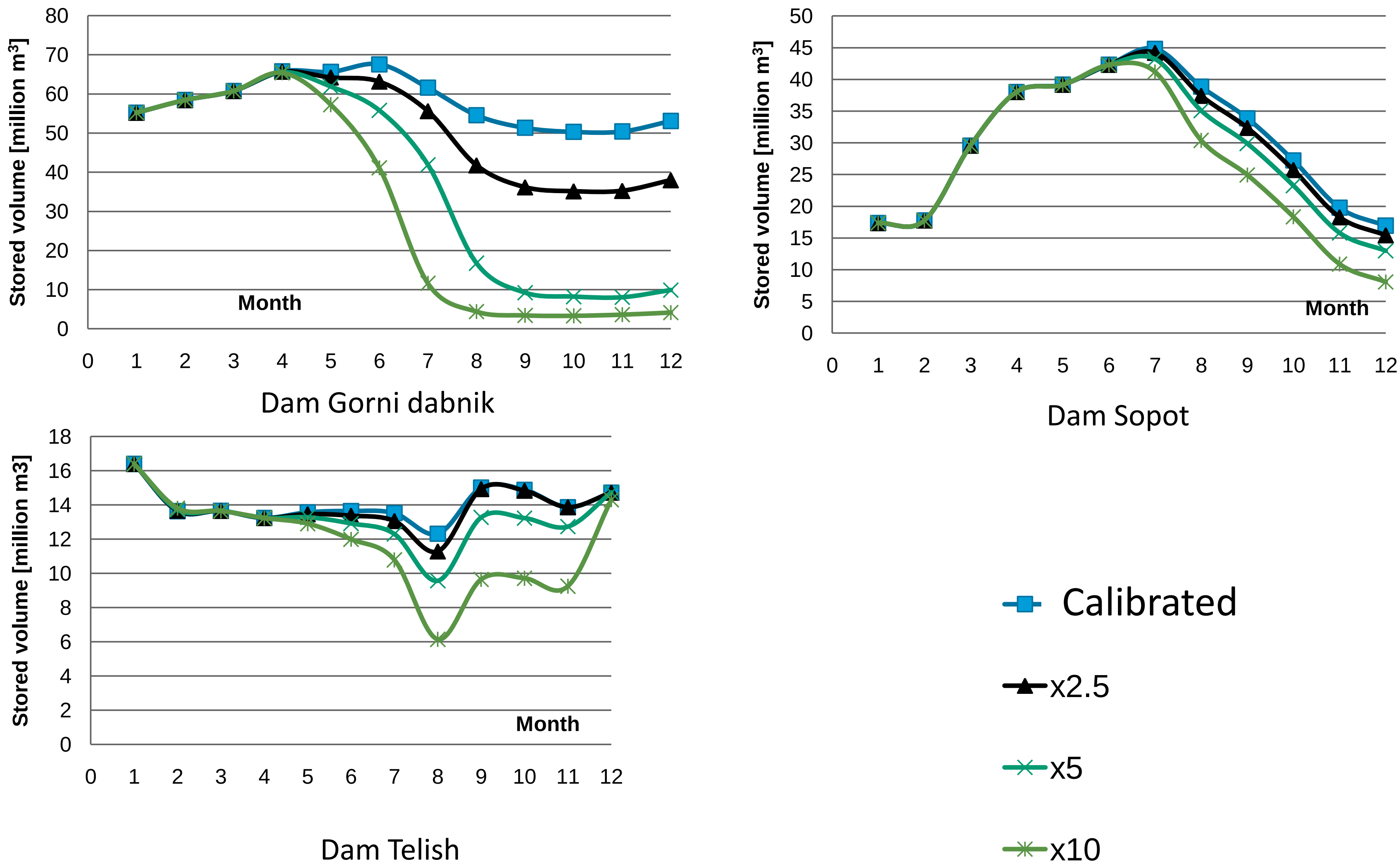
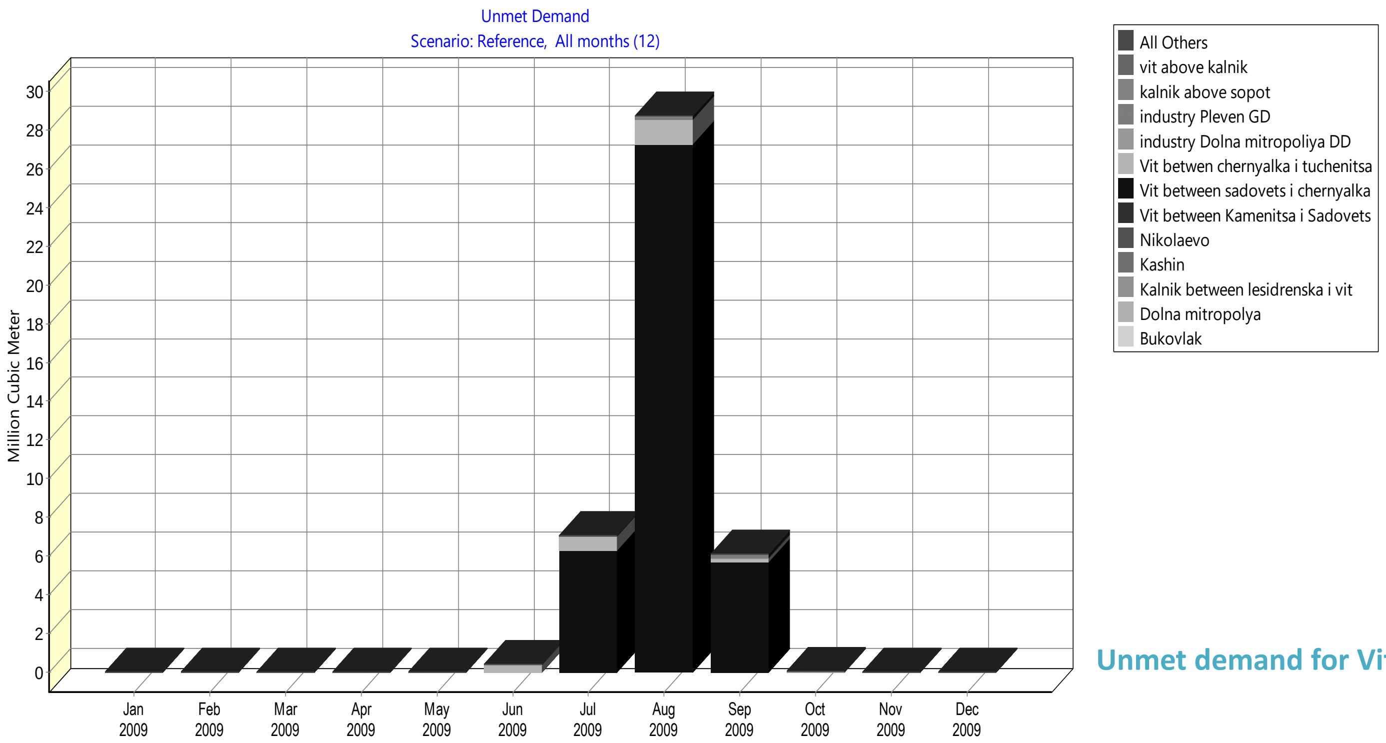
Monthly values for water volumes in dams



Combined scenarios

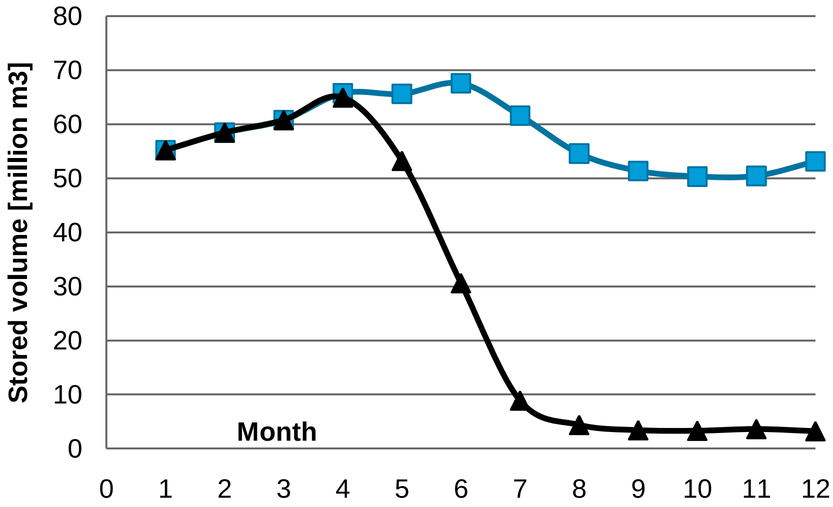
Reduce rainfall with 10%
Increased evapotranspiration by 10%
Increase the irrigated areas 10 times



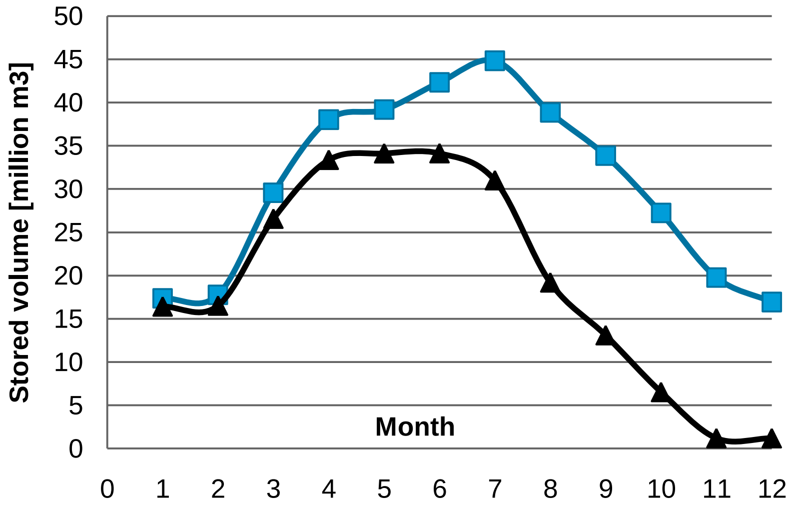
Unmet demand for Vit river sub-basin

The unmet demand occur for water user supplied by Gorni dabnik and Dolni dabnik reservoirs. These are irrigated fields and indrustrial areas in the towns of Pleven and Dolna mitropolia.

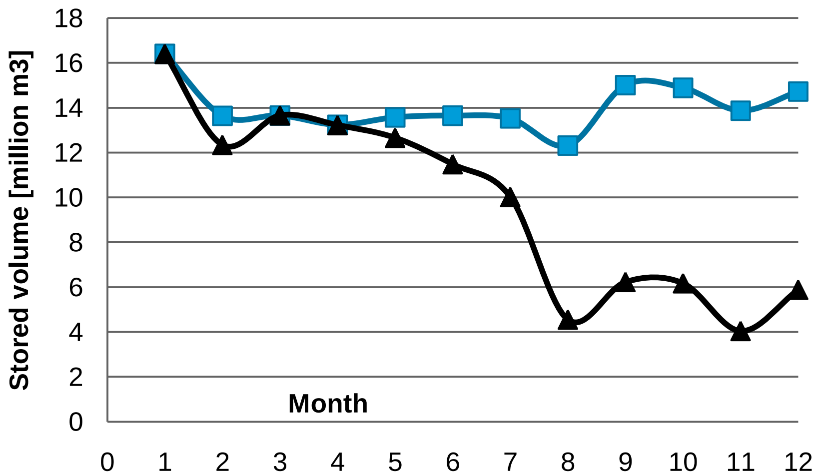
Combined scenarios



Dam Gorni dabnik



Dam Sopot



Dam Telish

Calibrated

x10

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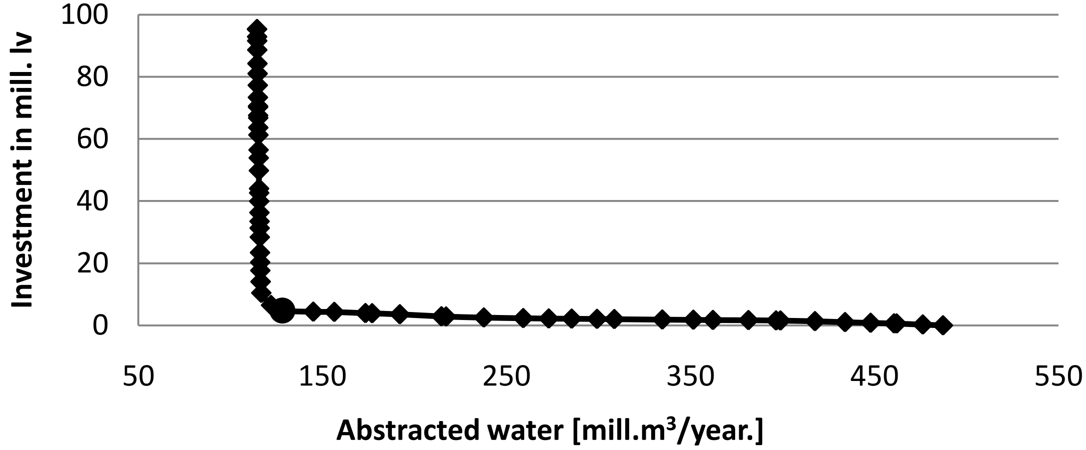
Combined scenarios

Simulated abstracted water is 487 million m^3/year

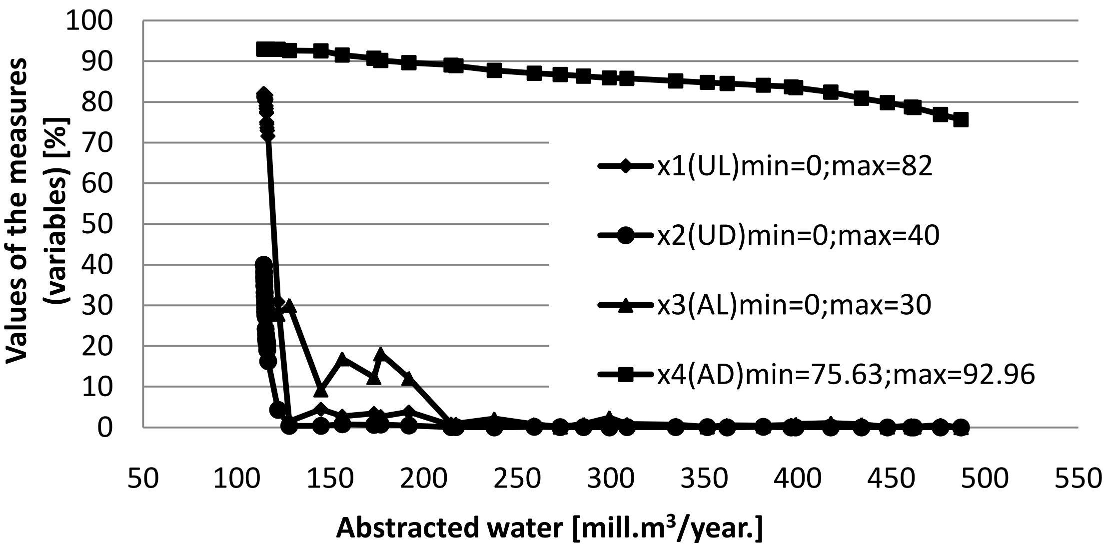
Compare with 143 million m^3/year in the reference 2009

Optimization results for combined scenario



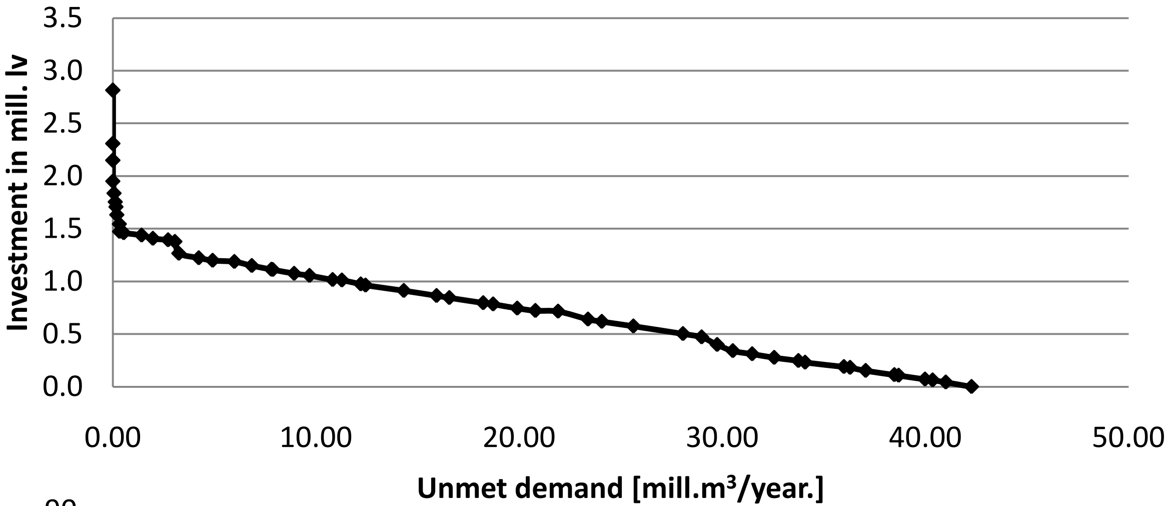
Objectives:
Reduce abstracted water at minimal investments

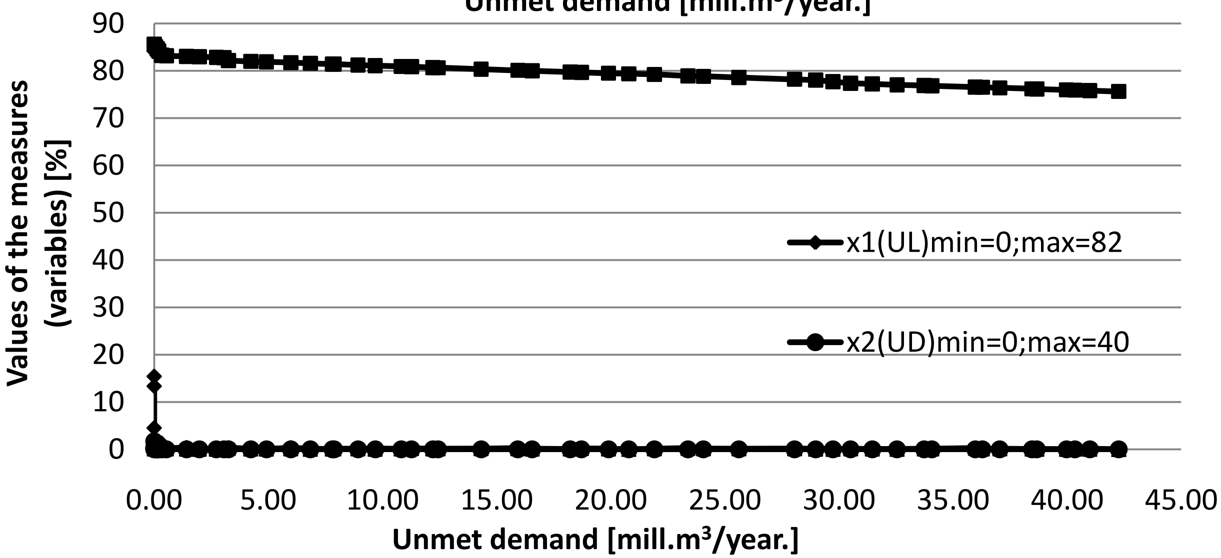
Pareto Front for Vit river sub-basin for combined scenario (results from optimization in Matlab)



Relationship between values of the optimization variables (measures) and abstracted water for combined scenario (results from optimization in Matlab)

Optimization results for combined scenario



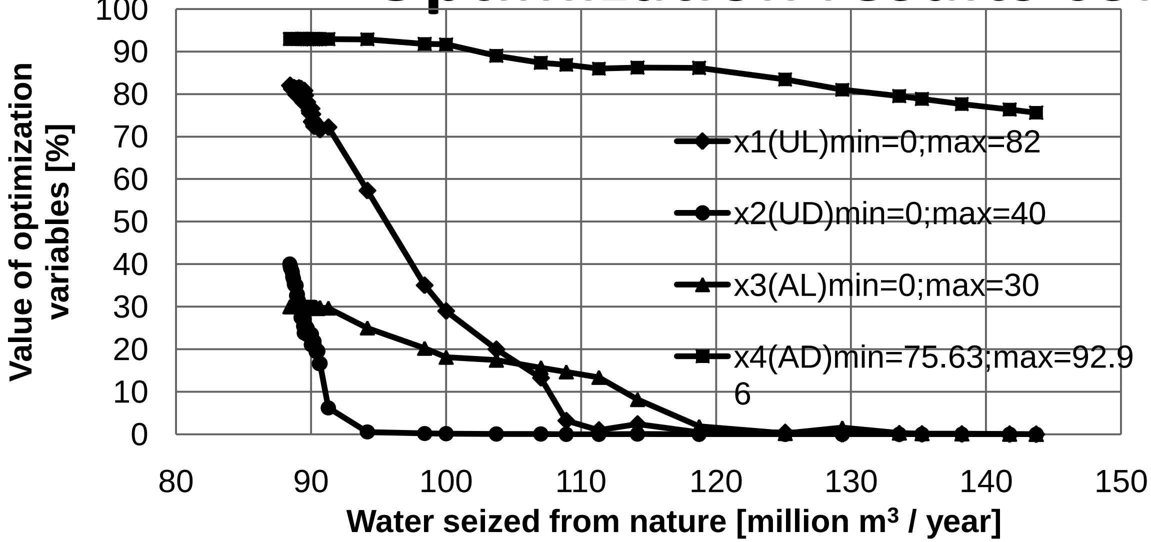


Objectives:
Reduce unmet demand at minimal investments

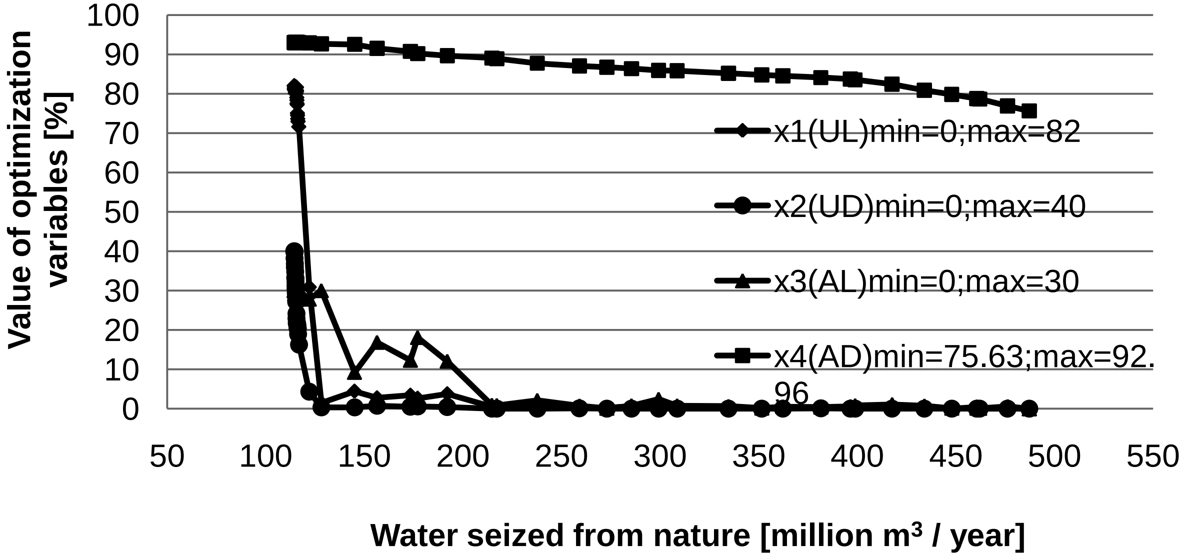
Pareto Front for Vit river sub-basin for combined scenario (results from optimization in Matlab)

Relationship between values of the optimization variables (measures) and abstracted water for combined scenario (results from optimization in Matlab)

Optimization results comparison



Value of the optimization variables in relation to the seized water from nature for 2009 (results from optimization with Matlab)



Value of the optimization variables in relation to the seized water from nature for combined scenario (results from optimization with Matlab)

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Water account tables

System of Environmental-Economic Accounting for Water (SEEAWater)

SEEAWater

Category 1: Physical supply and use tables and emission accounts.

This category of accounts brings together, in a common framework using definitions and classifications of the standard economic accounts of the 2008 SNA, hydrological data on the volume of water used and discharged back into the environment by the economy, as well as the quantity of pollutants added to the water. Bringing the physical information on water into the accounting framework introduces checks and balances into the hydrological data and produces a consistent data system from individual sets of water statistics often collected independently by different line ministries responsible for designing targeted policies.

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Category 2: Hybrid and economic accounts.

This category of accounts aligns physical information recorded in the physical supply and use tables with the monetary supply and use tables of the 2008 SNA. These accounts are referred to as “hybrid” flow accounts in order to reflect the combination of different types of measurement units in the same accounts. In these accounts, physical quantities can be compared with matching economic flows, for example, linking the volumes of water used with monetary information on the production process, such as value added, and deriving indicators of water efficiency.

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Category 3: Asset accounts.

This category of accounts comprises accounts for water resource assets measured mostly in physical terms. Asset accounts measure stocks at the beginning and the end of the accounting period and record the changes in the stocks that occur during the period. They describe all increases and decreases of the stock due to natural causes, such as precipitation, evapotranspiration, inflows and outflows, and human activities, such as abstraction and returns. These accounts are particularly useful because they link water abstraction and return to the availability of water in the environment, thus enabling the measurement of the pressure on physical water induced by the economy.

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Category 4: Quality accounts.

This category of accounts describes the stock of water in terms of its quality. It should be noted that the quality accounts are still experimental. Quality accounts describe the stocks of water resources in terms of quality: they show the stocks of certain qualities at the beginning and the end of an accounting period. Because it is generally difficult to link changes in quality to the causes that affect it, quality accounts describe only the total change in an accounting period, without further specifying the causes.

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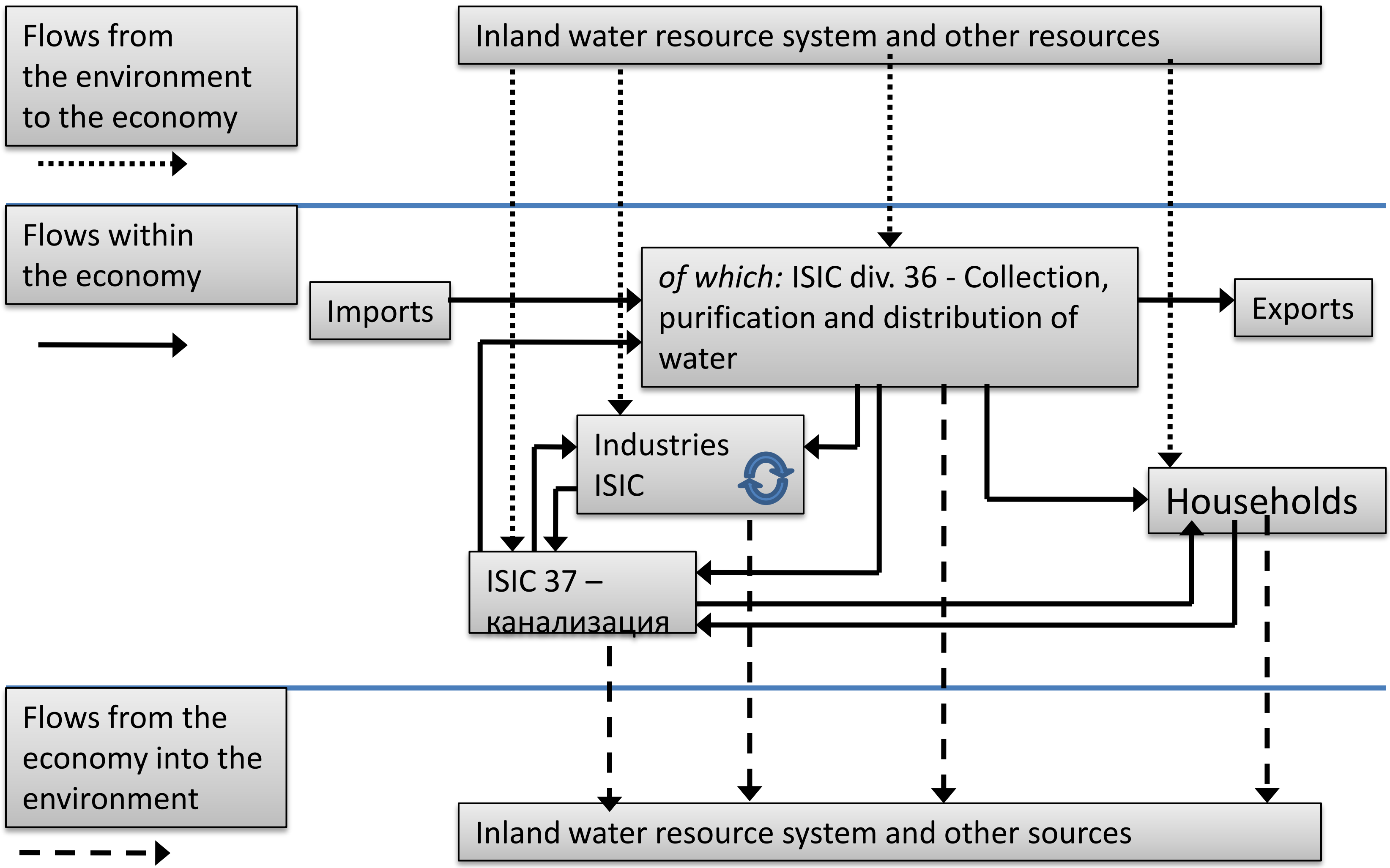
Category 5: Valuation of water resources.

The final category of the SEEA-Water accounts comprises the valuation of water and water resources. With regard to the quality accounts, this category of accounts is still experimental; there is still no agreement on a standard method for compiling them.

SEEA-Water

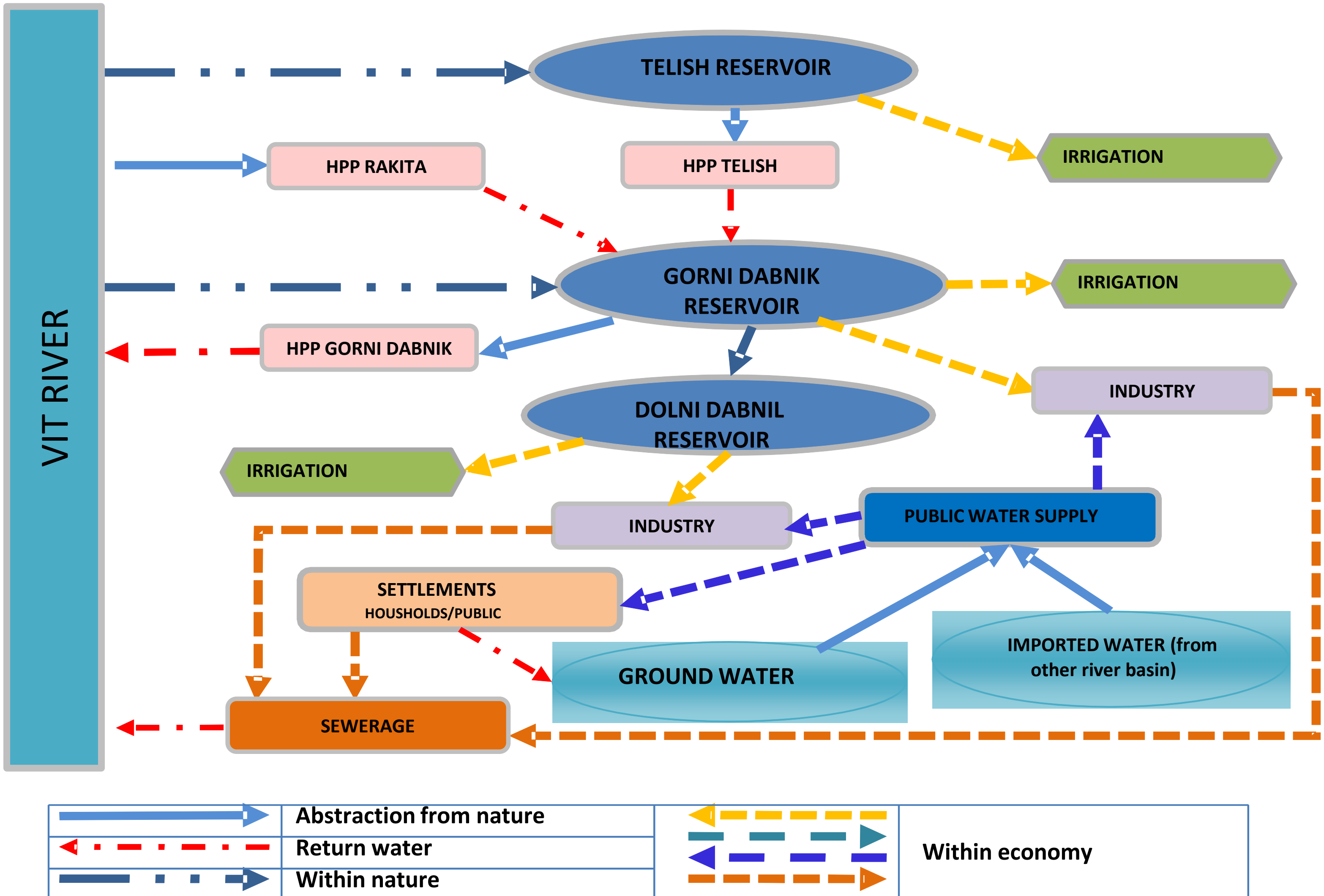

Flows from the environment to the economy
Inland water resource system and other resources
Flows within the economy
Imports
of which: ISIC div. 36 - Collection, purification and distribution of water
Exports
Industries ISIC
Households
ISIC 37 – канализация
Flows from the economy into the environment
Inland water resource system and other sources

Combined use of WEAP and SEEAWater

Completing the standard tables requires the use of additional modeling, as the information is often:

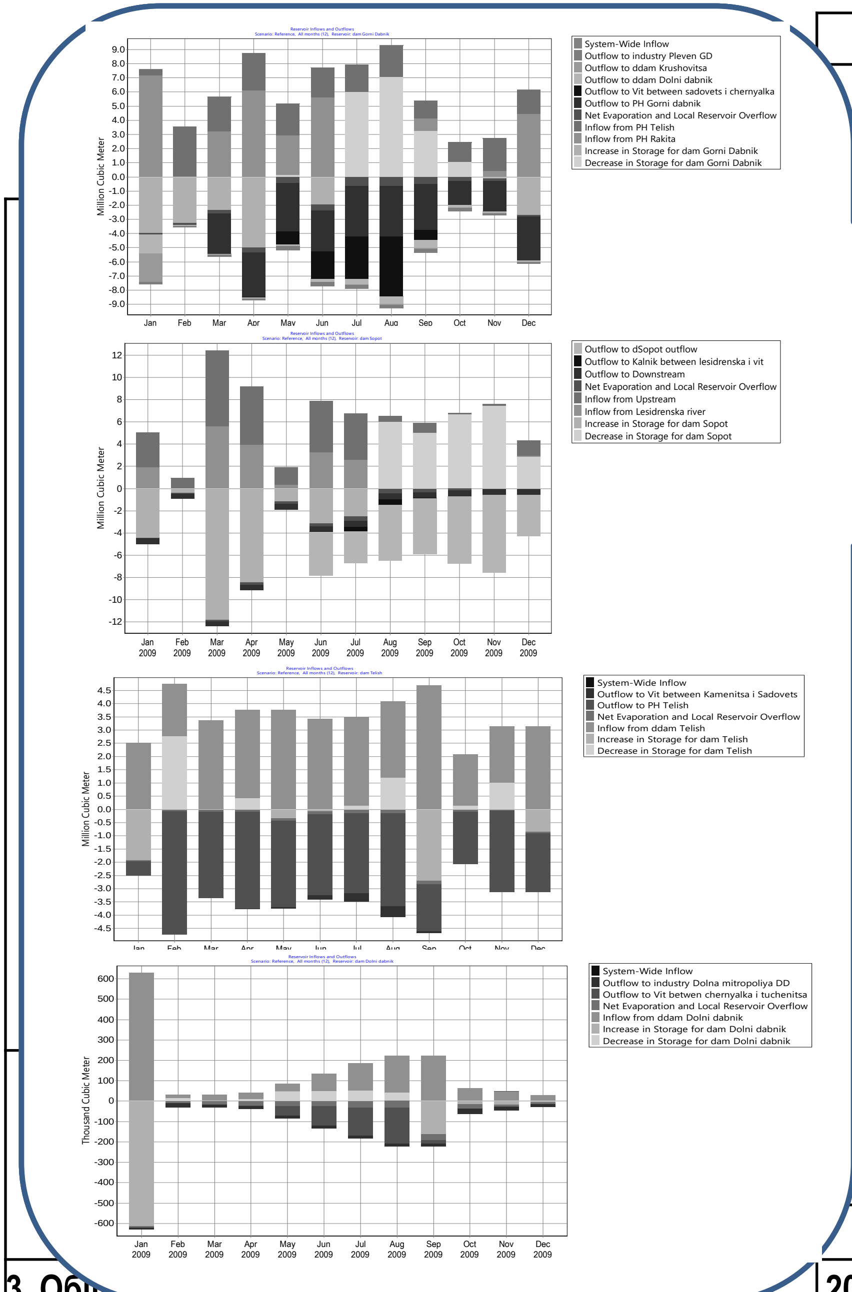
- Insufficiently complete
- Shifted in time
- Some parameters cannot be measured directly

Application of SEEA-Water



Used water

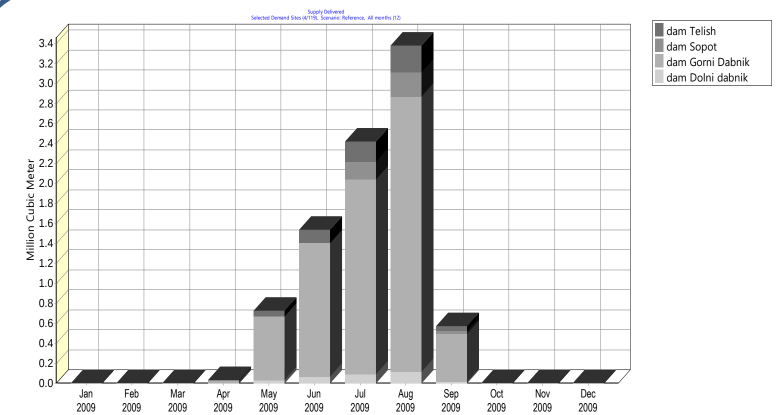
Units:Mill. m^3



	Industries (by ISIC category)									
	…-3	5-33, 41-43	35	36	37	38,39, 45-99	Total	House holds	Rest of the world	Total
	…66	**6.02**	**63.87**	**73.40**	**0**	**0**	**155.24**	**0.24**		**155.49**
			63.87				**81.84**	0		**81.84**
			0	73.40			**73.40**	0		**73.40**
			63.87	**73.40**	**0**	**0**	**155.24**	**0.24**		**155.49**
			…3.87	66.32	0		**130.19**	0		**130.19**
				50.39						
				2.65						
				13.28						
			63.87							
	…00	6.02	0.00	7.08	0	0	**13.10**	0		**13.10**
				7.08				0.24		
		6.02								
	…25	0	0	0		0	**12.25**	0		**12.25**
	0	**0**	**0**	**0**	**0**	**0**	**0.00**			**0.00**
	0	0	0	0	0	0	**0.00**	0		
	0	0	0	0	0	0	**0.00**	0		
	…65	2.23	32.32	12.30	9.99	2.39	**67.56**	7.00	0	**74.55**
3. Общ…	**20.90**	**8.25**	**96.19**	**85.70**	**9.99**	**2.39**	**223.5**	**7.24**	**0**	**230.34**

Physical use table (according to the model in SEEA-Water)

units: million m^3



		Indust…									
		1-3	5-33, 41-43								
From the environment	**1. Total abstraction (=1.a+1.b = 1.i+1.ii)**	**12.66**	**6.02**								
	1.a. Abstraction for own use	12.66	6.02								
	1.b. Abstraction for distribution		0								
	1.i. From inland water resources:	**12.66**	**6.02**								
	1.i.1 Surface water	0									
	From Vit river to HPP Rakita										
	-from reservoirs to industry										
	-from reservoirs to irrigation				13.2						
	-from reservoirs to HPPs			63.87							
	1.i.2 Groundwater	0.00	6.02	0.00			0	**13.10**	0		**13.10**
	For public water supply								0.24		
	For industry		6.02								
	1.i.3 Soil water	12.25	0		0		0	**12.25**	0		**12.25**
	1.ii. From others:	**0**	**0**		**0**	**0**	**0**	**0.00**			**0.00**
	1.ii.1 Collection of precipitation	0		0	0	0	0	**0.00**	0		
	1.ii.2 Abstraction from the sea	0	0	0	0	0	0	**0.00**	0		
Within the economy	**2. Use of water received from other economic units**	8.65	2.23	32.32	12.30	9.99	2.39	**67.56**	7.00	0	**74.55**
	2.a. Reused water										
	2.b. Wastewater to sewerage										

swarm

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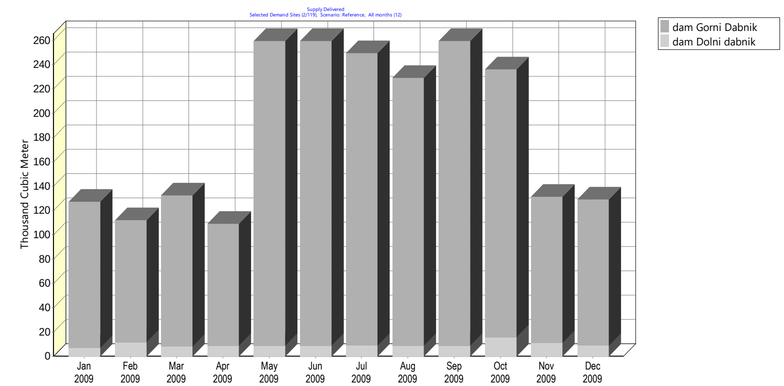
Physical use table (according to the model in SEEA-Water)

units: million m^3

		Industries (by ISIC category)								Rest	
		1-3	5-33, 41-43	35							
From the environment	**1. Total abstraction (=1.a+1.b = 1.i+1.ii)**	**12.66**	**6.02**	**63.87**							
	1.a. Abstraction for own use	12.66	6.02	63.87							
	1.b. Abstraction for distribution		0	0							
	1.i. From inland water resources:	**12.66**	**6.02**	**63.87**							
	1.i.1 Surface water	0		63.87							
	From Vit river to HPP Rakita										
	-from reservoirs to industry										
	-from reservoirs to irrigation										
	-from reservoirs to HPPs			63.87							
	1.i.2 Groundwater	0.00	6.02	0.00	7.08				0		**13.10**
	For public water supply				7.08				0.24		
	For industry		6.02								
	1.i.3 Soil water	12.25	0	0			0	**12.25**	0		**12.25**
	1.ii. From others:	**0**	**0**	**0**		**0**	**0**	**0.00**			**0.00**
	1.ii.1 Collection of precipitation	0	0		0	0	0	**0.00**	0		
	1.ii.2 Abstraction from the sea	0	0		0	0	0	**0.00**	0		
Within the economy	**2. Use of water received from other economic units**	8.65	2.23	32.32	12.30	9.99	2.39	**67.56**	7.00	0	**74.55**
	2.a. Reused water										
	2.b. Wastewater to sewerage										



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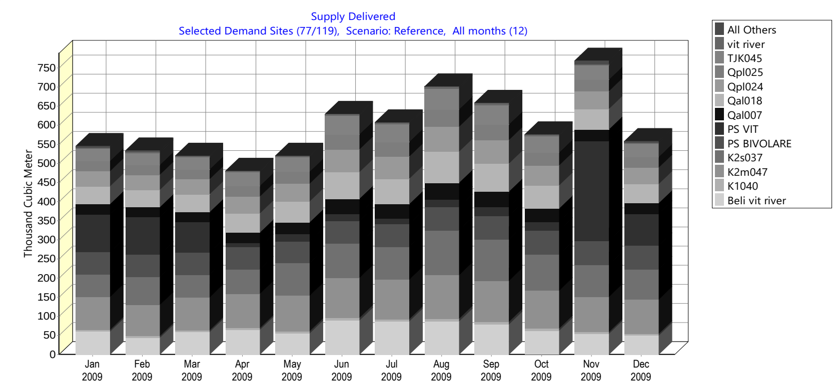
Physical use table (according to the model in SEEA-Water)

units: million m^3

		Industries (by ISIC category)							Households	Rest of the world	Total
		1-3	5-33, 41-43	35	36	37	38,39, 45-99	Total			
From the environment	**1. Total abstraction (=1.a+1.b = 1.i+1.ii)**	**12.66**	**6.02**	**63.87**	**73.40**	**0**	**0**	**155.24**	**0.24**		**155.49**
	1.a. Abstraction for own use	12.66	6.02	63.87				**81.84**	0		**81.84**
	1.b. Abstraction for distribution		0	0	73.40			**73.40**	0		**73.40**
	1.i. From inland water resources:	**12.66**	**6.02**	**63.87**	**73.40**	**0**	**0**	**155.24**	**0.24**		**155.49**
	1.i.1 Surface water	0		63.87	66.32	0		**130.19**	0		**130.19**
	From Vit river to HPP Rakita				50.39						
	-from reservoirs to industry				2.65						
	-from reservoirs to irrigation				13.28						
	-from reservoirs to HPPs			63.87							
	1.i.2 Groundwater	0.00	6.02	0.00	7.08	0	0	**13.10**	0		**13.10**
	For public water supply										
	For industry		6.02								
	1.i.3 Soil water	12.25	0	0							
	1.ii. From others:	**0**	**0**	**0**							
	1.ii.1 Collection of precipitation	0	0	0							
	1.ii.2 Abstraction from the sea	0	0	0							
Within the economy	**2. Use of water received from other economic units**	8.65	2.23	32.32							
	2.a. Reused water										
	2.b. Wastewater to sewerage										



Matrix of flows (User / Supplier)		Industries (by ISIC category) 1-3	5-33, 41-43	35	36	37	38,39, 45-99	**Total**	Households	Rest of the world	Supply of water to other economic units (row 4 of table III.1)
Industries (by ISIC category)	1-3							**0.00**			**0.00**
	5-33,41-43					**2.01**		**2.01**			**2.01**
	35							**0.00**			**0.00**
	36	8.65	2.23	32.32			2.39	**45.59**	7.00		**52.59**
	37							**0.00**			**0.00**
	38,39,45-99					**2.03**		**2.03**			**2.03**
	Общо	**8.65**	**2.23**	**32.32**	**0.00**	**4.04**	**2.39**	**49.64**	**7.00**		**56.64**
Households						3.88		**5.62**	0.00		**3.88**
Rest of the world					12.30			**12.30**	0		**12.30**
Use of water received from other economic units (row 2 of table III.1)		**8.65**	**2.23**	**32.32**	**12.30**	**7.92**	**2.39**	**65.82**	**7.00**		

Physical supply table

Units: million m^3

		Industries (by ISIC category)							Households	Rest of the world	Total
		1-3	5-33, 41-43	35	36	37	38,39, 45-99	**Total**			
Within the economy	**4. Supply of water to other economic units**	**0**	**2.01**	**0.00**	**52.59**	**0**	**2.03**	**56.64**	5.62	12.30	**74.55**
	of which:							**0.00**			
	4.a. Reused water		0	0	0	0		**0.00**			
	4.b. Wastewater to sewerage	0	2.01	0.00	52.59	0	2.03	**56.63**	5.95		
Into the environment	**5. Total returns (=5.a+5.b)**	**8.25**	**5.42**	**96.19**	**27.96**	**7.92**	**0.29**	**114.13**	**2.19**		**148.22**
	5.a. To inland water resources	**8.25**	**5.42**	**96.19**	**27.96**	**7.92**	**0.29**	**114.13**	**2.19**		**148.22**
	5.a.i. Surface water	5.50	0	96.19		7.92	0	**78.61**	0		**109.61**
	5.a.ii. Groundwater	2.75	0	0	27.96		0.29	**30.09**	2.19		**33.19**
	- From water leakages from distribution network				9.99						**0.00**
	- From irrigation chanels				2.86						**0.00**
	- From chanels for HPP				15.12						**0.00**
	- From septic tanks								2.07		**2.07**
	- From private wells		5.42						0.12		**0.12**
	5.a.iii. Soil water	0	0	0	0	0	0	**0**	0		**0.00**
	5.a. To other sources (e.g., sea water)	0	0	0	0	0	0	**0**	0		**0.00**
6. Total supply of water(=4+5)		**8.25**	**7.43**	**96.19**	**80.56**	**7.92**	**2.32**	**202.67**	**6.07**		**208.74**
7. Consumption(=3-6)		**12.66**	**0.83**	**0**	**5.14**	**0.00**	**0.07**	**18.69**	**1.17**		**19.86**
of which	evaporation losses during transport				4.73						
	trade losses										

Забележка: Клетките в сиво са неприложими или се въвежда нула

Receiver / Source	EA.131 Surface water				Units:		million m^3
	EA.1311 Artificial reservoirs	**EA.1312 Lakes**	**EA.1313 Rivers**	**EA.1314 Snow, ice and glaciers**	**EA.132 Groundwater**	**EA.133 Soil water**	**Outflows to other resources in the territory**
EA.1311 Artificial reservoirs	6.02/3.14	0	39.68	0	na	na	***45.70***
EA.1312 Lakes	0	0	0	0	0	0	**0.00**
EA.1313 Rivers	97.99/83.71	0		0	н.и.	н.и.	**97.99**
EA.1314 Snow, ice and glaciers	0				0	528.28	**528.28**
EA.132 Groundwater	0	0		0		0	**0.00**
EA.133 Soil water	0	0	866.85		404.58		**1271.43**
Inflows from other resources in the territory	**86.85**	**0**	**906.53**	**0**	**404.58**	**528.28**	**1943.40*** **1926.24**

* Water abstraction is not taken into account

Asset account	EA.131 Surface water				Units:		million m^3
	EA.1311 Artificial reservoirs	EA.1312 Lakes	EA.1313 Rivers	EA.1314 Snow, ice and glaciers	EA.132 Groundwater	EA.133 Soil water	Total
1. Opening stocks	79.987	n.a.	n.a.	n.a.	400	n.a.	**479.99**
Increases in stocks							
2. Returns	54.91	n.a.	44.90		30.71	8.65	**139.17**
3. Precipitation	*0.00*			*528.28*		3583.94	**4112.22**
4. Inflows:	86.85	0.00	906.53	0.00	404.58	528.28	**1926.24**
4.a. From upstream territories	0	0	0,0	0	н.и.		**0.00**
4.b. From other water resources in the territory	86.85	0.00	906.53	0.00	404.58	528.28	**1926.24**
Decreases in stocks							
5. Abstraction	79.81	n.a.	50.39	0	13.34	12.66	**156.19**
6. Evaporation/actual evapotranspiration	7.84		n.a.	n.a.		2836.79	**2844.63**
7. Outflows:	45.70	0.00	867.57	528.28	0.00	1271.43	**2712.98**
7.a. To other water resources in the territory			783.86	0	n.a.		**783.86**
7.b. To the sea			n.a	0			**0.00**
7.c. To downstream territories	***45.70****	0.00	***97.99****	528.28	0.00	1271.43	***1943.40****
8. Other changes in volume	0,00	0,00	0,00	0,00	0,00	0,00	
9. Closing stocks	**88.40***	0.00	**33.48***	0.00	**821.95**	0.00	

Note: Cells in gray are not applicable or zero is entered

n.a.- Not available

Disadvantages of SEAWater

There is no information about necessary water - water shortage;

The transfer of water between water bodies through derivation channels (from human activity) is not reported;

Water consumption for settlements is defined as the difference between the water used and the water supplied. The delivered water includes one part to nature and another part to an economic unit. The part to nature is divided into surface and underground water sources. It is not possible to measure exactly what part of the leaks enters the groundwater and what part enters the sewerage network and from there into the river (surface water source);

At the moment the dams are not reported in the tables for used and delivered water;

It is not clear where the surface runoff from the catchment should be recorded - whether to the groundwater or directly into the river;

Additional data are needed to determine the natural water (precipitation, infiltration) entering the sewerage system.

Advantages of simulating data for filling in the SEEA-Water tables

1) Allows simulation and computation of missing data and/or to check credibility of excising data.
2) Allows automations of the process of filling in the tables. In this way the room for errors is reduced significantly.

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