Climate or land use change – identification of future main factor influencing water management. Narew River Basin (NRB) case study

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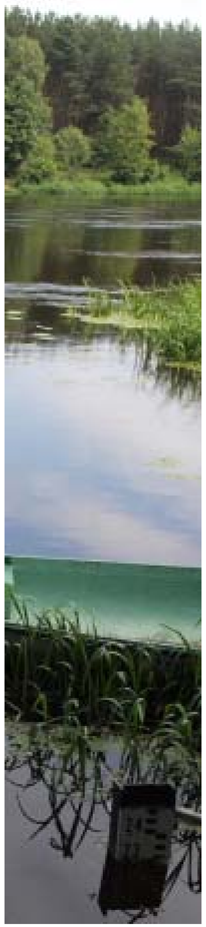
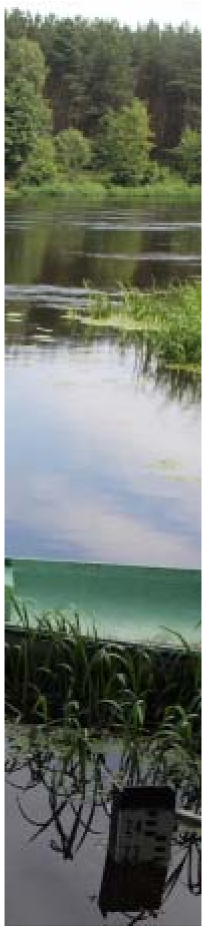
CASEE Conference. **Szent Istvan University, Gödöllő, Hungary, 28-29 April 2011**

Outline



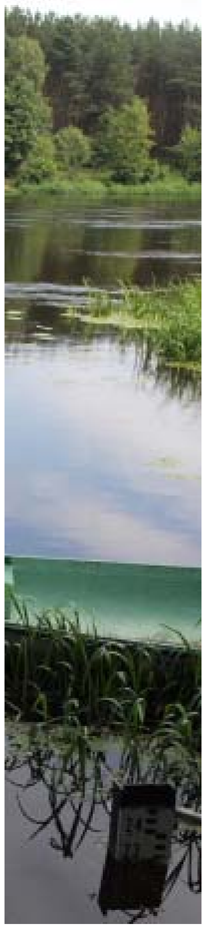
- Background & Objective
- Hydrological model SWAT
- Development of land use change scenarios in the SCENES project
- Climate change scenarios
- Scenario impact on hydrological indicators
- Conclusions & Outlook

Objective



- To investigate the effect of climate and land use change on various hydrological indicators in a large semi-natural river basin
- Tools & Methods:
  - Hydrological model SWAT
  - Land use change scenarios elaborated within a framework actively involving stakeholders
  - GCM-based climate change scenarios

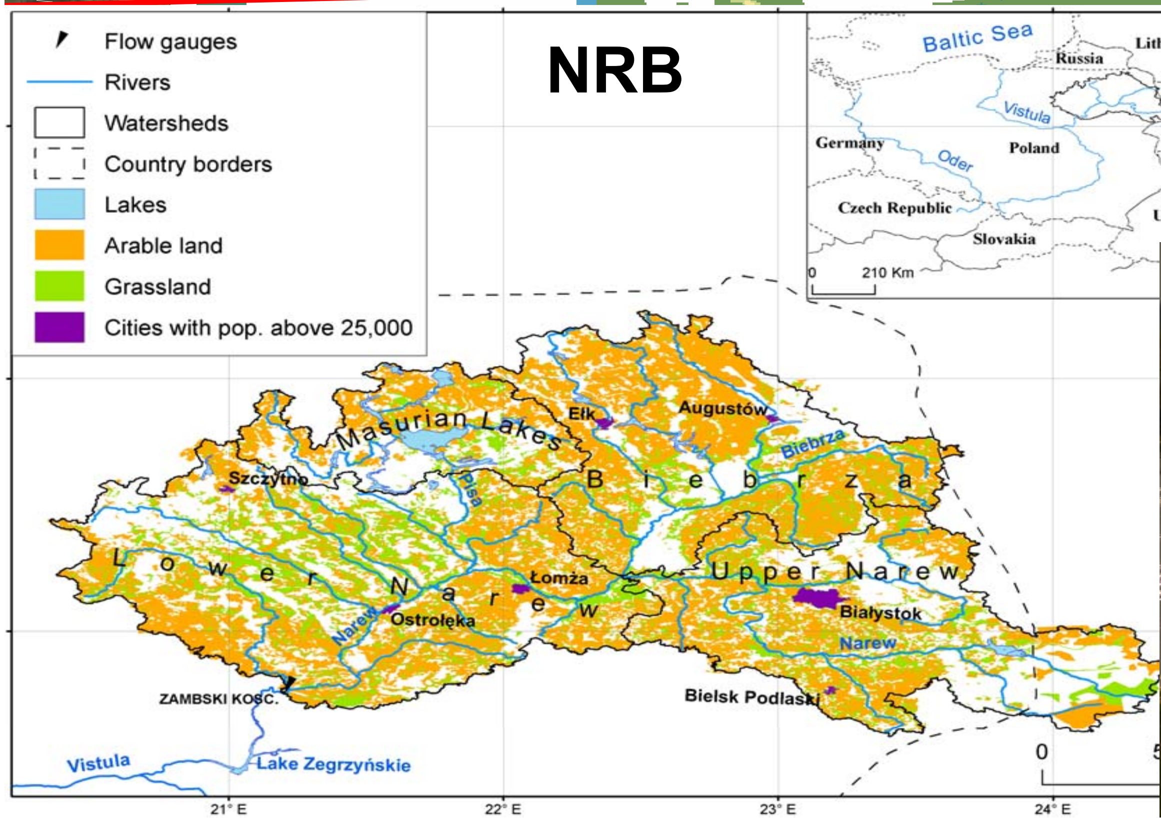
Background – SCENES project



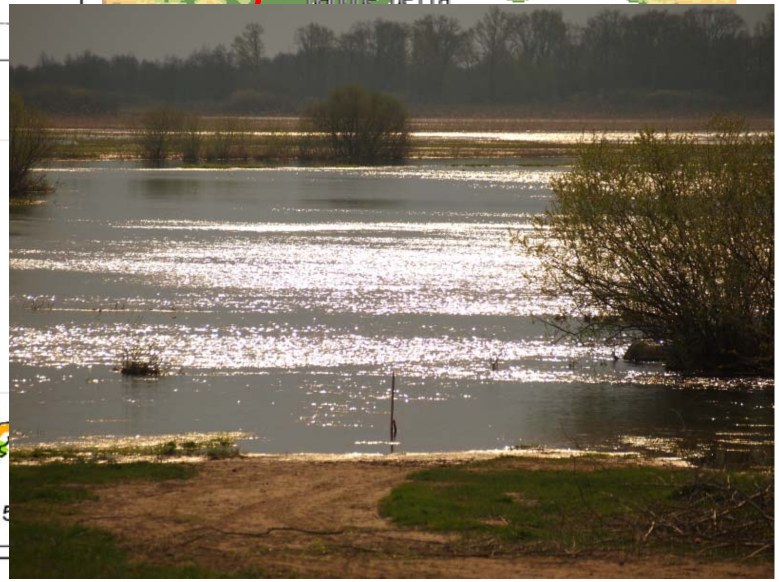
- EU-FP6 IP SCENES „Water Scenarios for Europe and for Neighbouring States”
- Nov 2006 – Apr 2011
- 23 partners from 17 countries
- Similar methodology applied at three levels: pan-European, regional and local (pilot areas)

- study area

Narew
Tisza
Lower Don
Crimea
Danube Delta

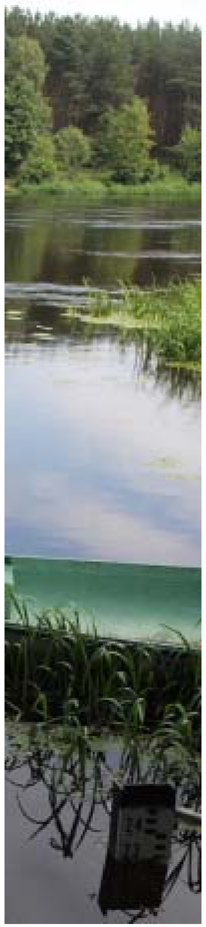


Flow gauges
Rivers
Watersheds
Country borders
Lakes
Arable land
Grassland
Cities with pop. above 25,000
NRB
Baltic Sea
Lithuania
Russia
Byelarus
Vistula
Germany
Oder
Poland
Czech Republic
Ukraine
Slovakia
0
210 Km
55° N
Masurian Lakes
Ełk
Augustów
Biebrza
Szczytno
Pisa
B i e b r z a
L o w e r N a r e w
Upper Narew
Łomża
Ostrołęka
Narew
Białystok
Narew
Bielsk Podlaski
ZAMBSKI KOSC.
Vistula
Lake Zegrzyńskie
0
21° E
22° E
23° E
24° E



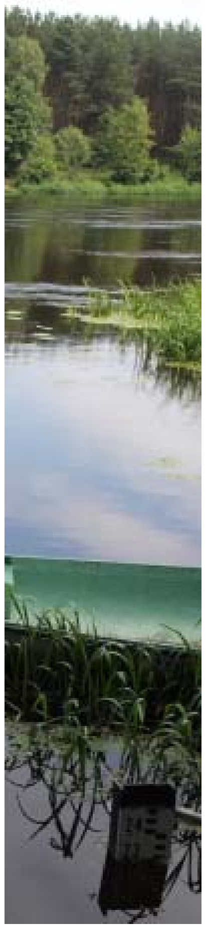
SWAT model – main features

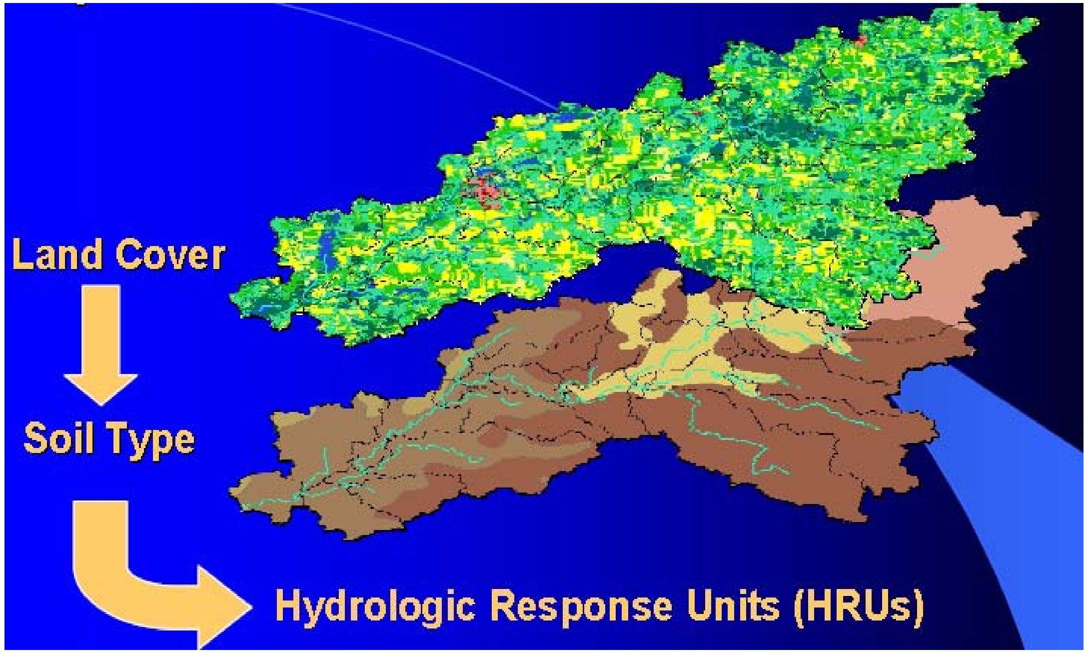
Soil & Water Assessment Tool | SWAT

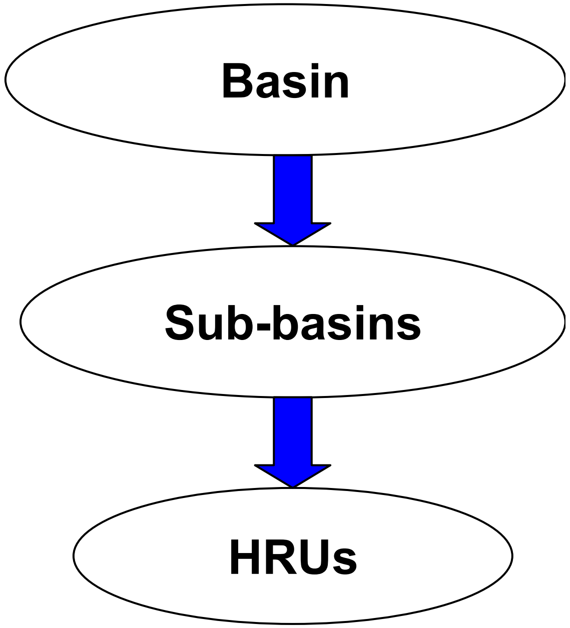


- River basin scale model consisiting of hydrological and water quality components
- Distributed, physically-based, continuous time model coupled with GIS
- Its main purpose is to quantify the impact of land management practices in large, complex river basins

Modelling approach in SWAT

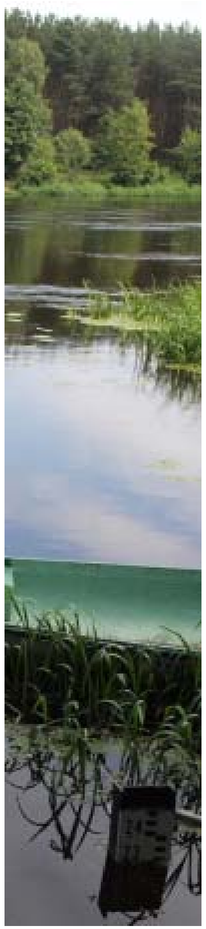






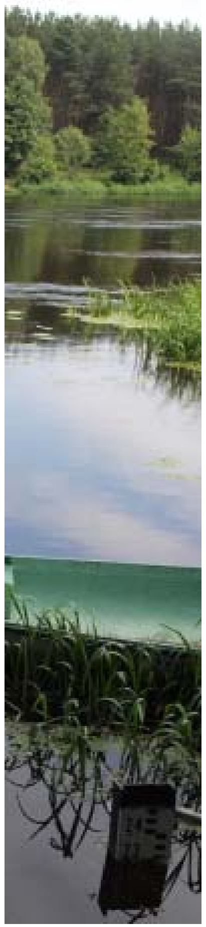
- HRUs – unique in terms of land cover, soils and slopes
- Vertical water balance at HRU level => runoff generation at sub-basin level => routing through the stream network to the main outlet

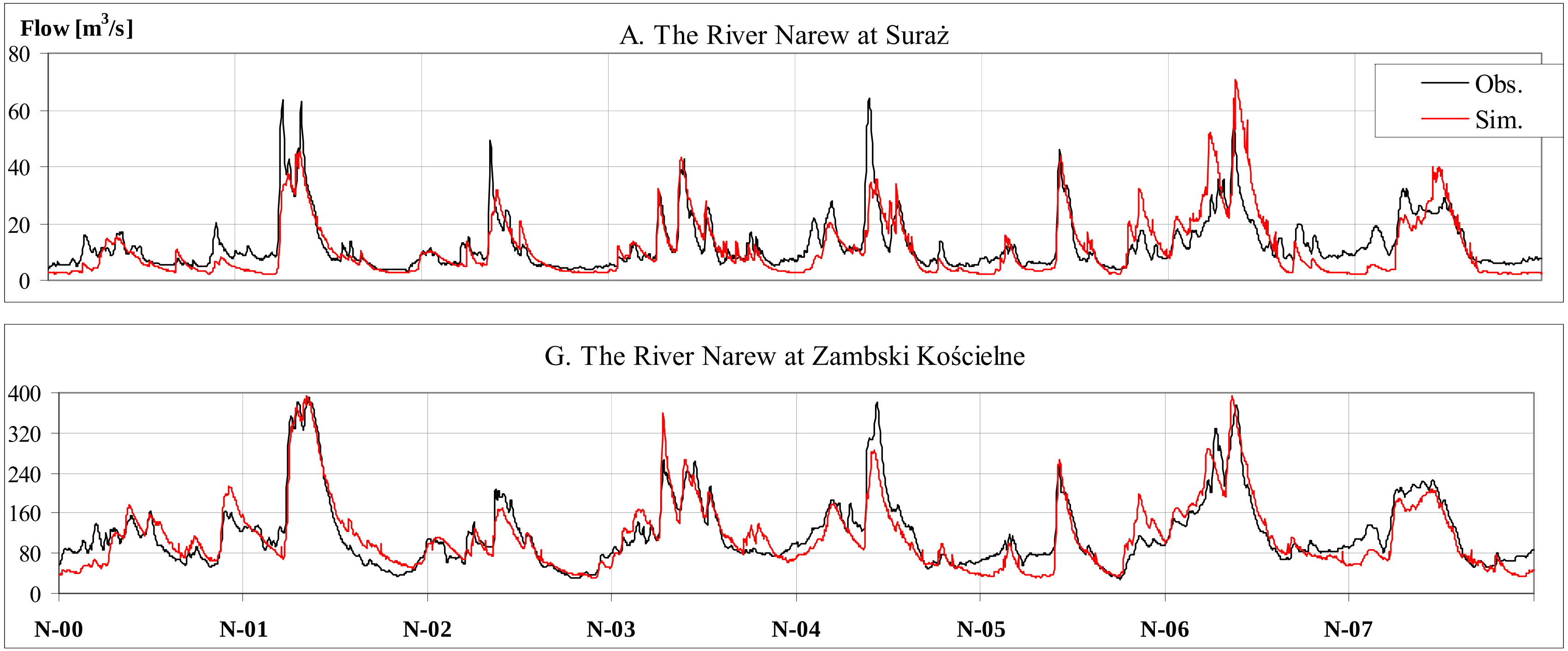
SWAT in SCENES



- In SCENES project SWAT has been applied in the NRB in order to elaborate long term quantitative water scenarios
- Pros: popularity, free of charge, water quantity and quality in one modelling system
- Specification of inputs using readily available data
- Calibration & validation of the hydrological component for the period 2001-08 with daily time step
- Recalibration for the climate normal (baseline period) 1976-2000
- Water quality modelling ongoing

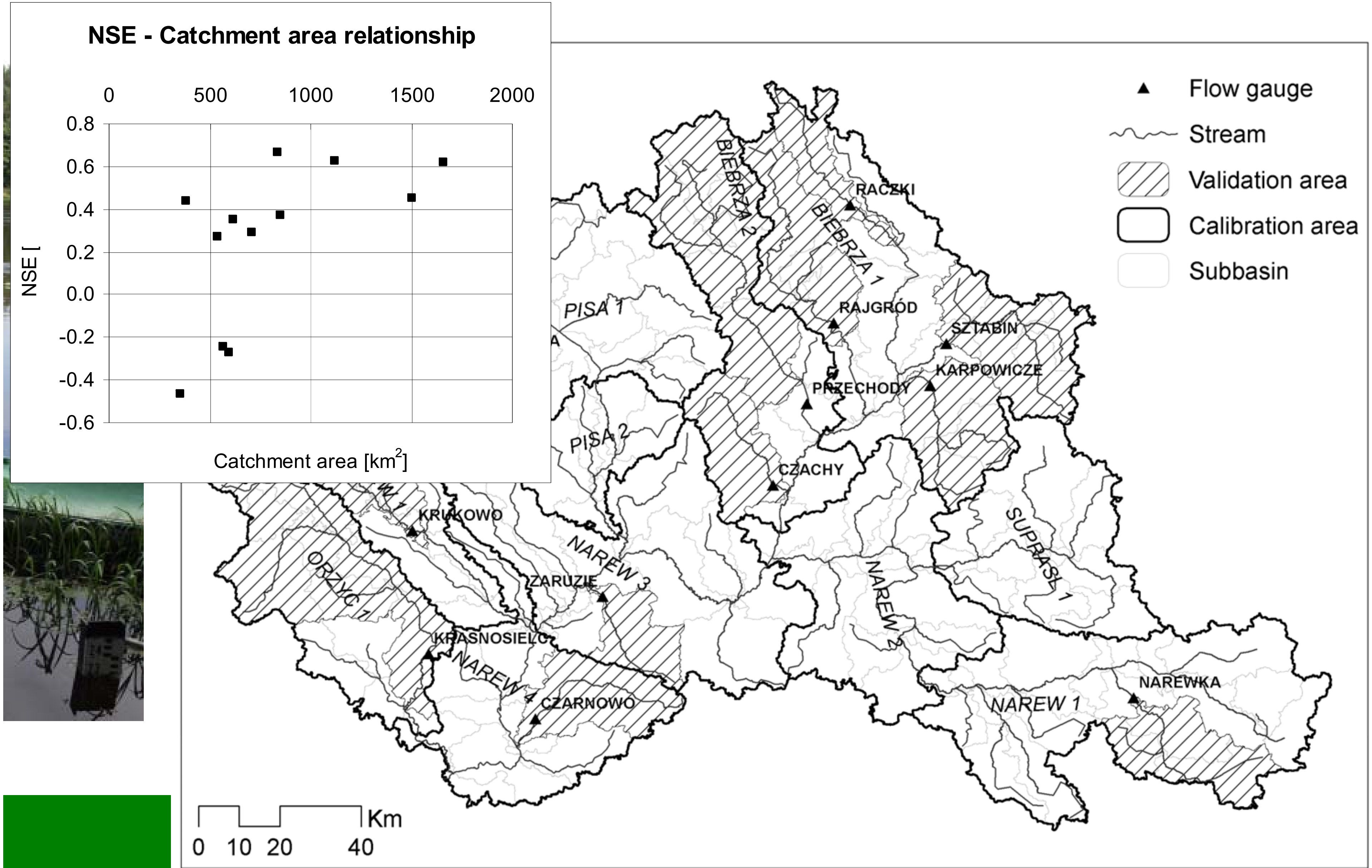
Results: calibration plots



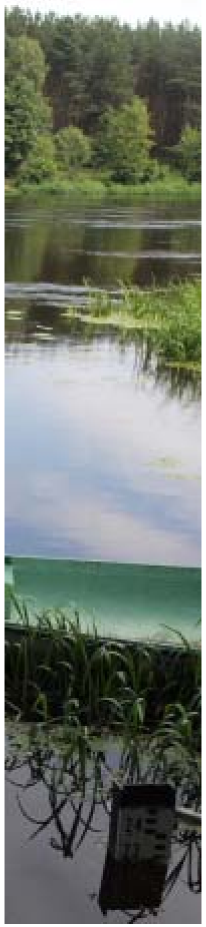


- Mean Nash-Sutcliffe Efficiency (NSE) for 11 calibration gauges
  - Calibration period: 0.68
  - Validation period: 0.57

Results: spatial validation

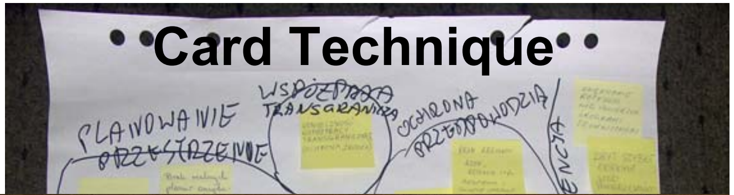


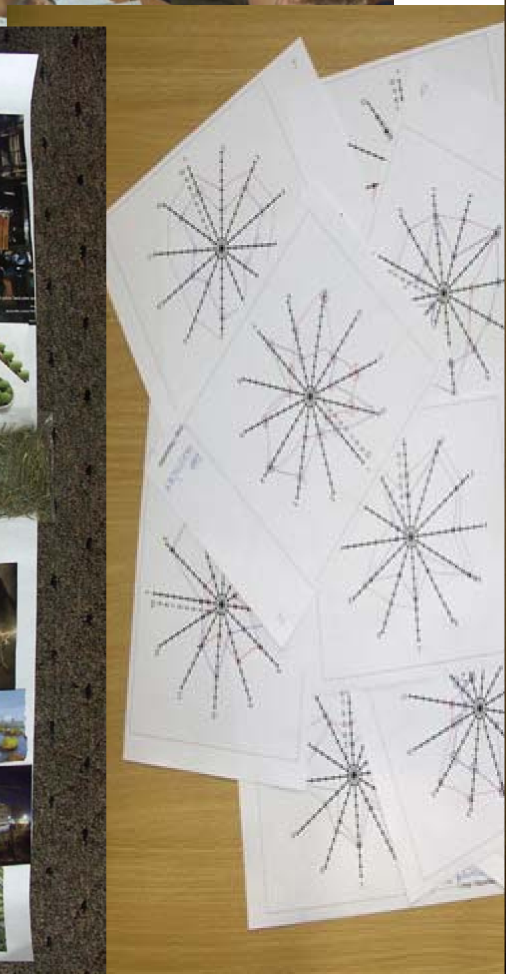
Pilot area workshops summary

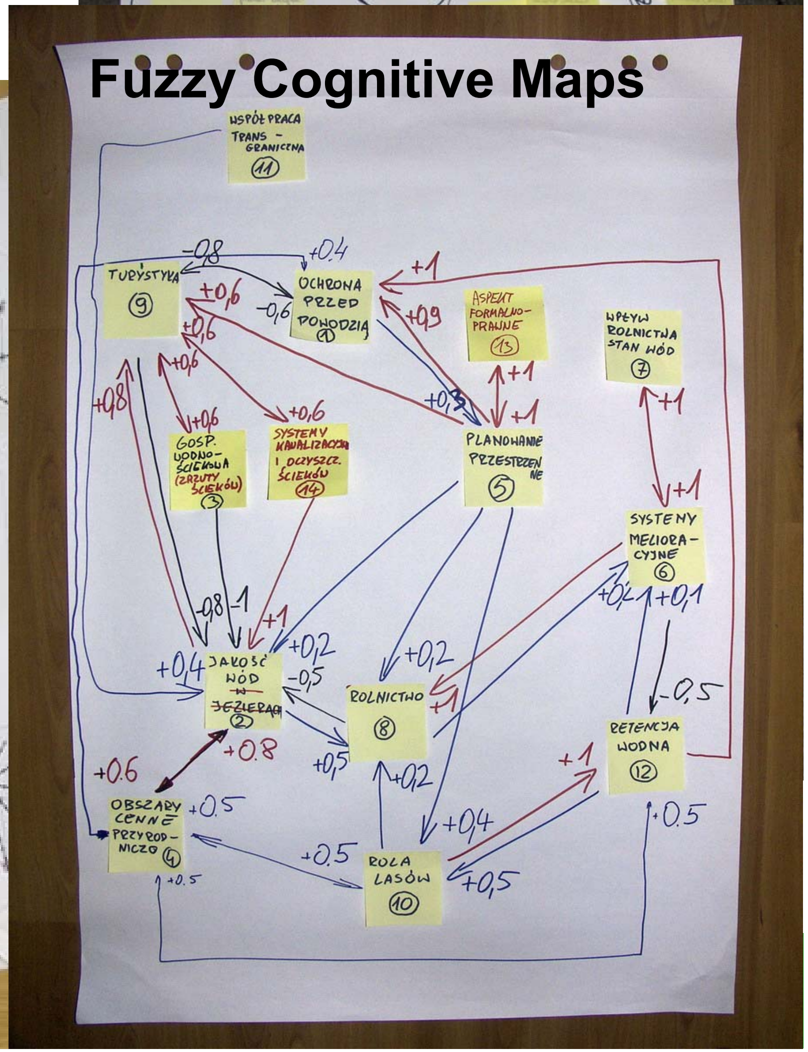


- **Scenario development workshops:** 4 workshops organized in the NRB during 2008-2011
- **Five steps**: 1. Characterising present and near future; 2. Developing future visions; 3. Critical review of developed visions; 4. Backcasting; 5. Quantification for modelling purposes
- **Stakeholder participation:** more than 40 people representing various sectors
- **Combination of different methods:** all involving stakeholders

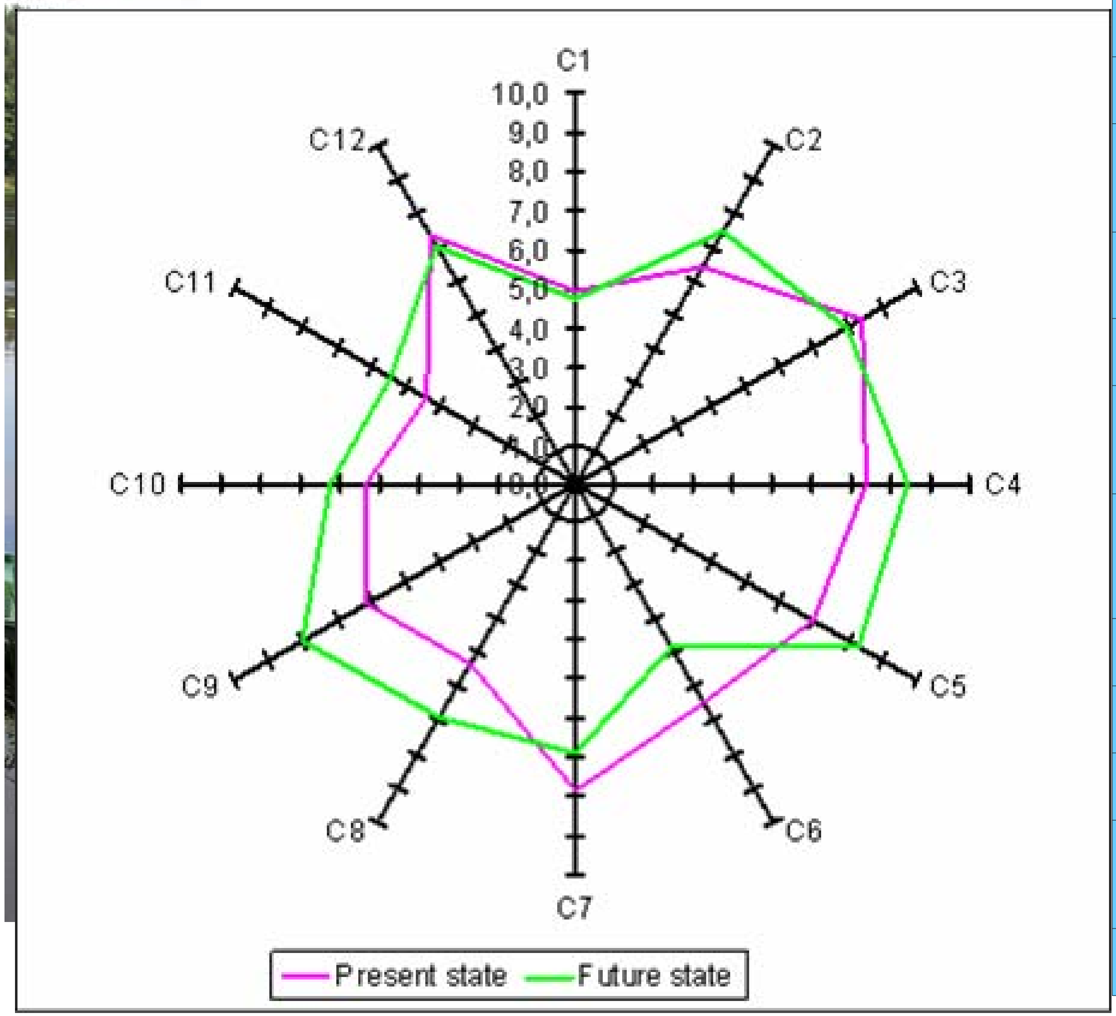
Scenario development methods







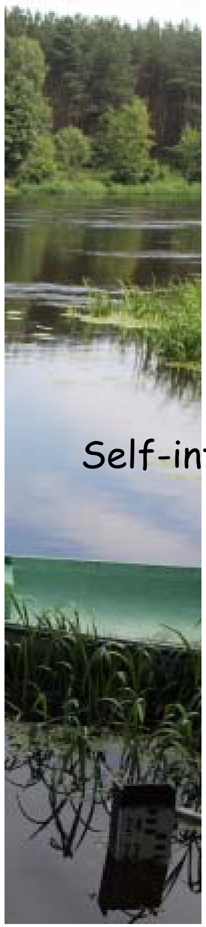
Main drivers and their importance

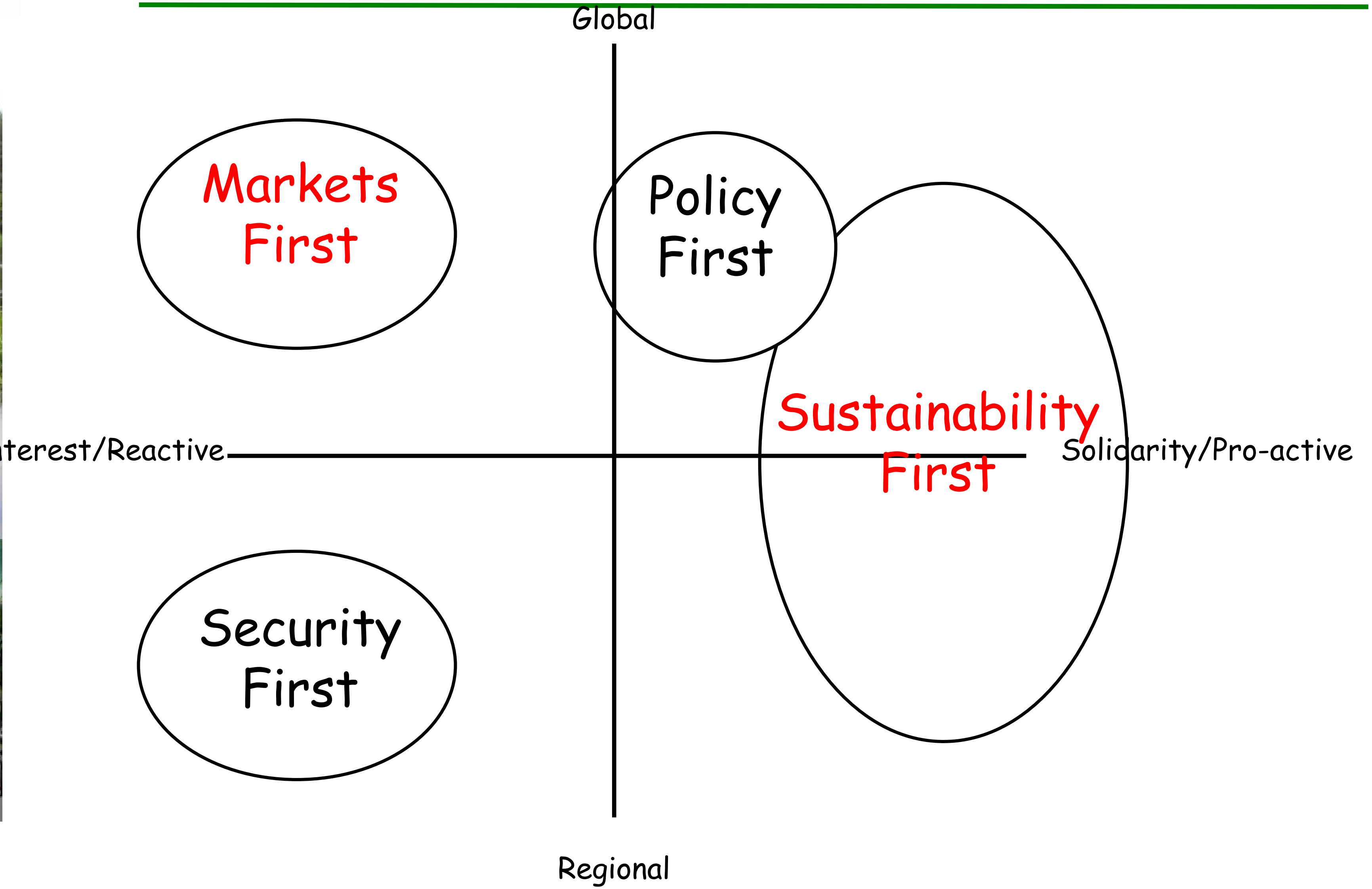


Driver	2008	2025
C1; Flood protection	4,9	**4,7**
C2; Water quality in lakes	6,4	7,4
C3; Water-sewage management	**8,4**	7,9
C4; Nature valuable areas	7,4	**8,4**
C5; Spatial planning	6,9	8,3
C6; Land amelioration systems	6,4	4,8
C7; Impact of agriculture on water status	7,8	6,9
C8; Agriculture	5,3	6,9
C9; Tourism	6,1	8,1
C10; Role of forest	5,3	6,2
C11; Transboundary co-operation	**4,4**	5,4
C12; Water retention	7,3	7,1

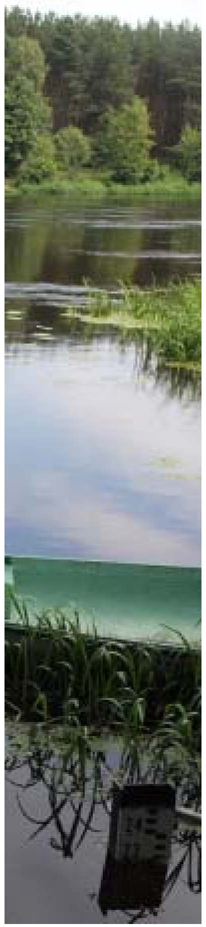
Giełczewski et al. *Journal of Water and Climate Change*, 2011

Fast-track scenarios (global)





Storylines for selected scenarios



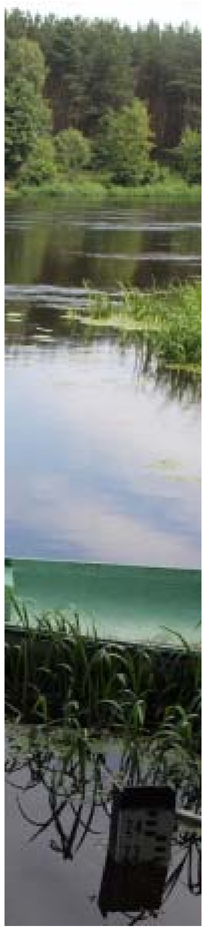
Sustainability First

- Most plausible and desirable scenario
- Agriculture and food industry as main sector – small scale ecological farms
- Importance of environmental policies

Markets First

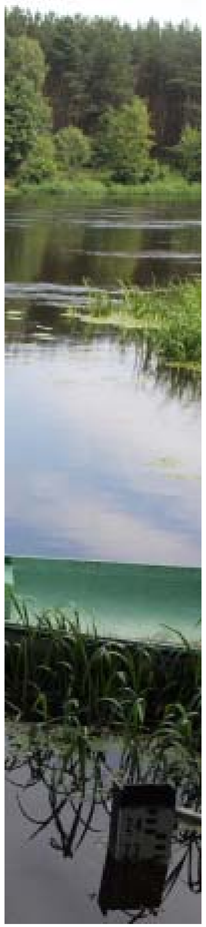
- Not likely to happen, requiring a push by an external factor to go this direction
- Agriculture and food industry as main sector – intensive, profit-oriented
- Liberalisation of environmental policies

Conversion to model inputs



- Objective: translation of qualitative visions (SF & MF) into model scenarios
- Best judgement by experts not reproducible and not transparent
- Adaptation of the method proposed by Alcamo (2008) – a 3-step protocol for converting qualitative into quantitative knowledge
  - Specifying qualitative trends of driving forces
  - Developing a translation key
  - Computing numerical trends of driving forces to use them as model input

Driving forces



- 11 questions asked to stakeholders focused on the future changes in:

(1) **land use** (especially agricultural and built-up areas)

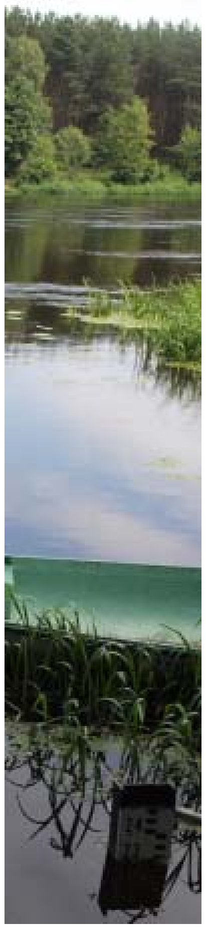
(2) amount of **fertilisers** applied in agriculture

(3) percent of **irrigated grasslands** and **drained arable land**

(4) amount and treatment level of **municipal and industrial wastewater**

- Two scenarios (SF & MF) and two time horizons (2025 & 2050)
- NRB divided into 4 sub-basins to account for spatial variability of drivers

Quantification of drivers – forested areas

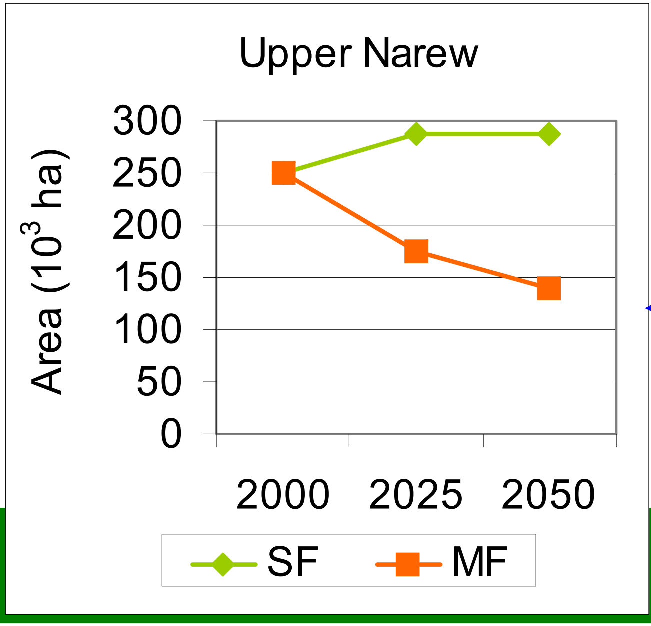


Question: What will be the future change in **forested areas**?

Qualitative changes

Region	Scenario			
	SF		**MF**	
	2025	2050	2025	2050
Upper Narew	**+ +**	**0**	**- - -**	**- -**
Biebrza	**+**	**0**	**-**	**-**
Masurian Lakes	**+**	**0**	**- -**	**- -**
Lower Narew	**+**	**0**	**- - -**	**- -**

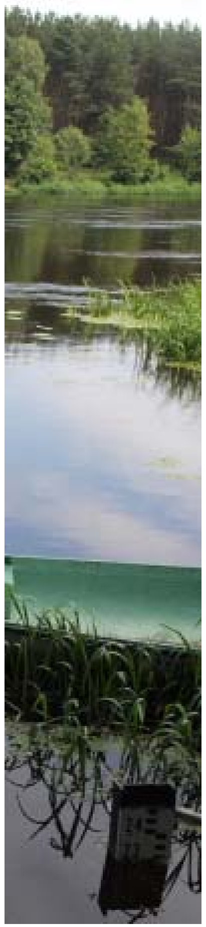
Numerical trends



quantification

e.g. *a small increase in forested area is from 5 to 10% (in 25 years)*

Quantification of drivers – built-up areas



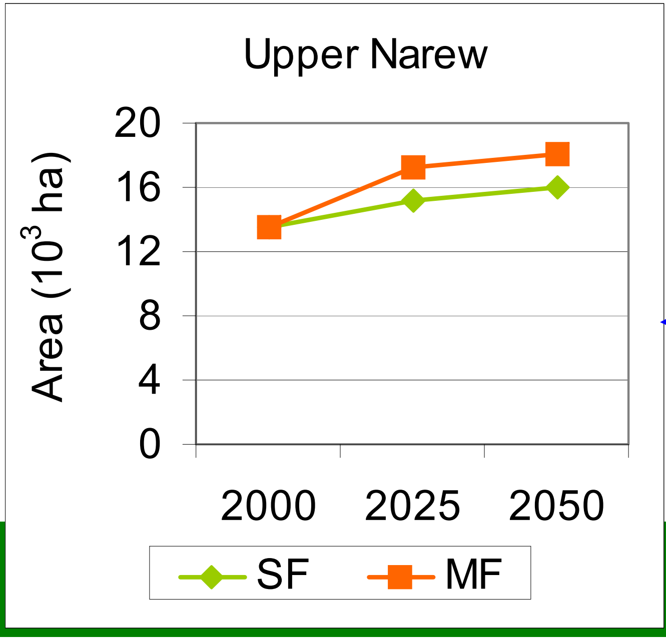
Question: What will be the future change in **built-up areas**?

Qualitative changes

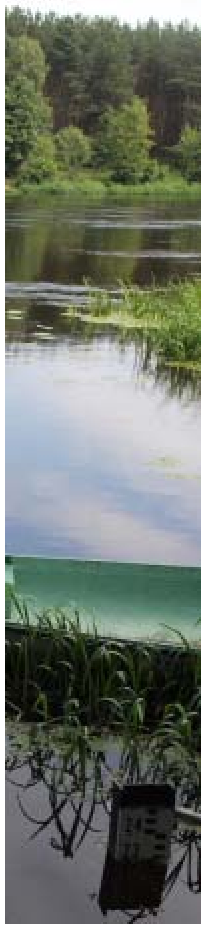
Region	Scenario SF 2025	SF 2050	MF 2025	MF 2050
Upper Narew	+ +	+	+ + +	+
Biebrza	+ +	+	+ +	+
Masurian Lakes	+ +	+	+ +	+
Lower Narew	+ +	+	+ + +	+ +

quantification

Numerical trends



Quantification of drivers – grasslands



Question: What will be the change in percent of agricultural area used as **grasslands**?

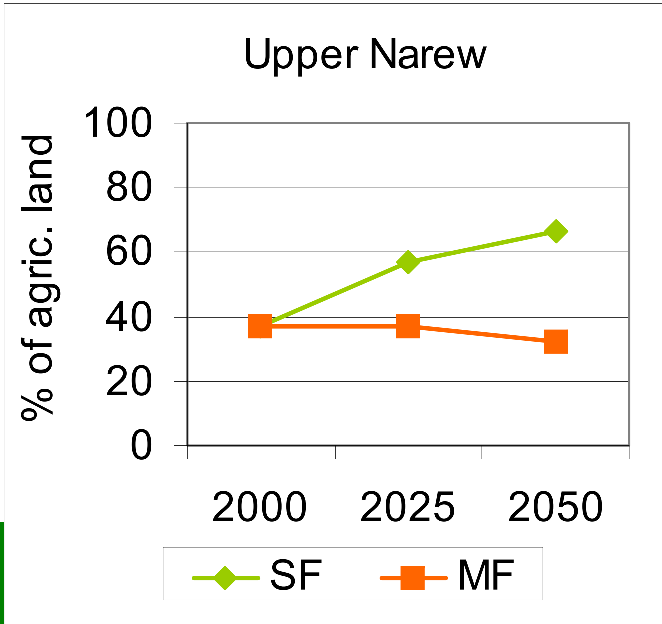
Qualitative changes

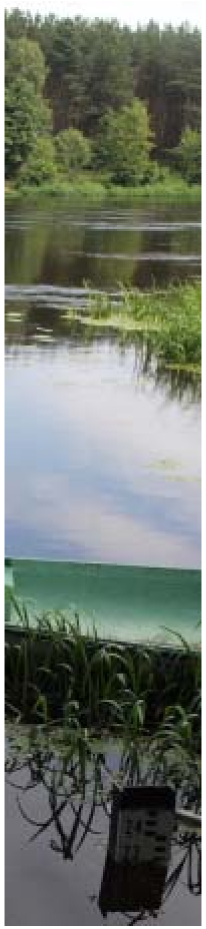
Region	SF 2025	SF 2050	MF 2025	MF 2050
Upper Narew	+ + +	+ +	0	-
Biebrza	+ + +	+ +	0	-
Masurian Lakes	+ + +	+ +	0	-
Lower Narew	+ + +	+	0	- -

(Scenario: SF, MF)

quantification

Numerical trends



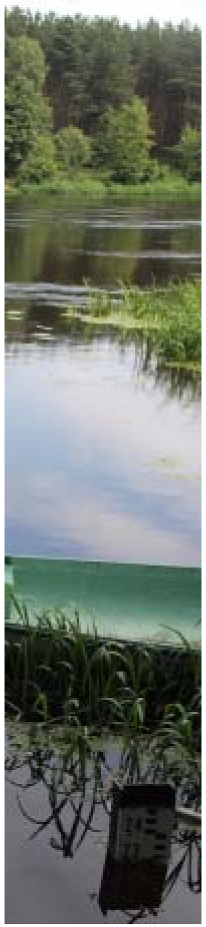


Land use change scenarios - summary

Land use type	SF	MF
Forests	Small increase	Large decrease
Built-up	Medium increase	Large increase
Grasslands	Large increase	Small decrease

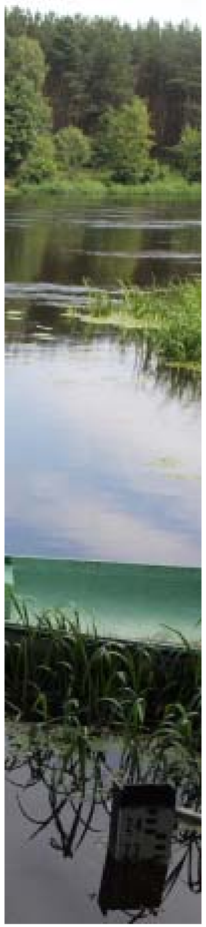
- Small spatial variability within scenarios
- Next step: making simulation runs in SWAT

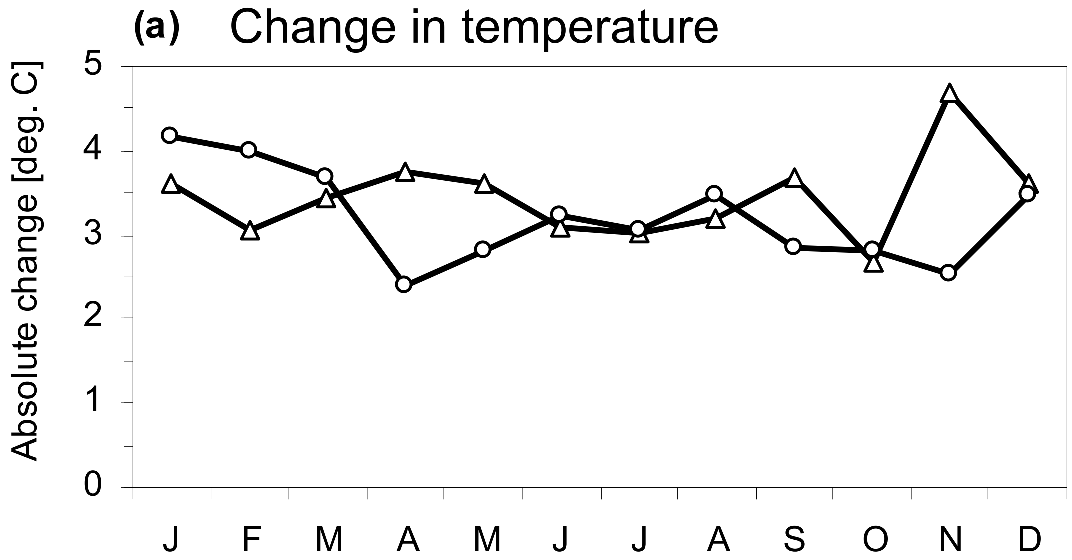
Climate change scenarios



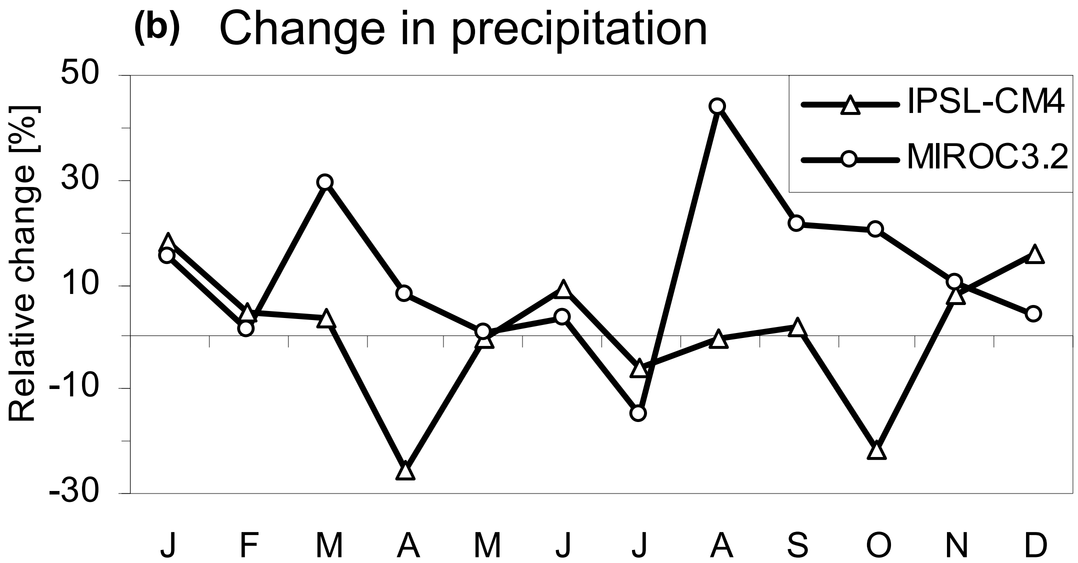
- Two GCMs used
  - IPSL-CM4, France
  - MIROC3.2, Japan
- Each coupled with the A2 SRES emission scenario (choice made by SCENES stakeholders)
- Delta change approach applied for bias correction
  - Difference between future (2040-2069) and reference (1976-2000) climate
- Variables: temperature and precipitation (not $C0_2$ levels)
- Acknowledgements to CESR Kassel

Projections for 2050s (basin-averaged)



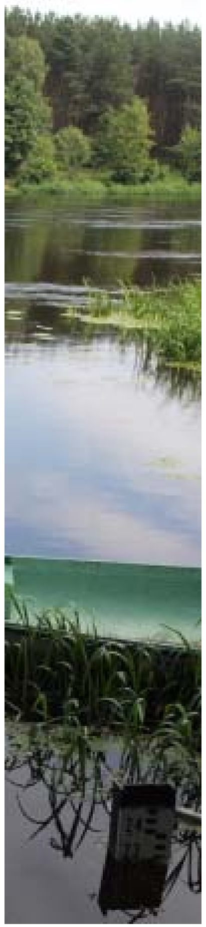


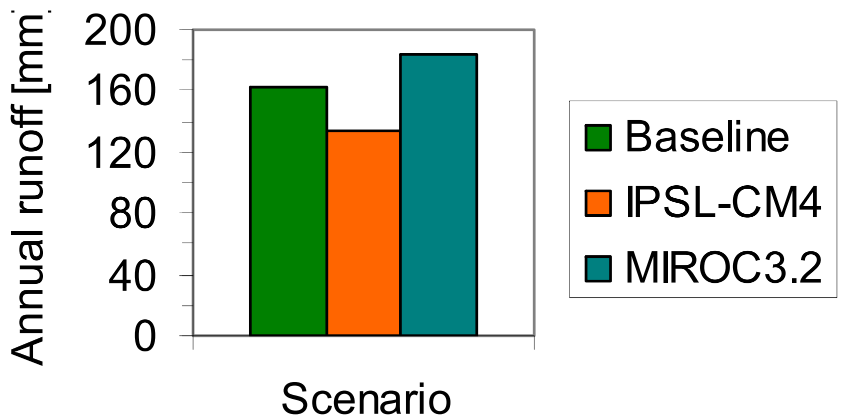
Mean annual change:
IPSL-CM4: 3.5 ˚C
MIROC3.2: 3.2 ˚C

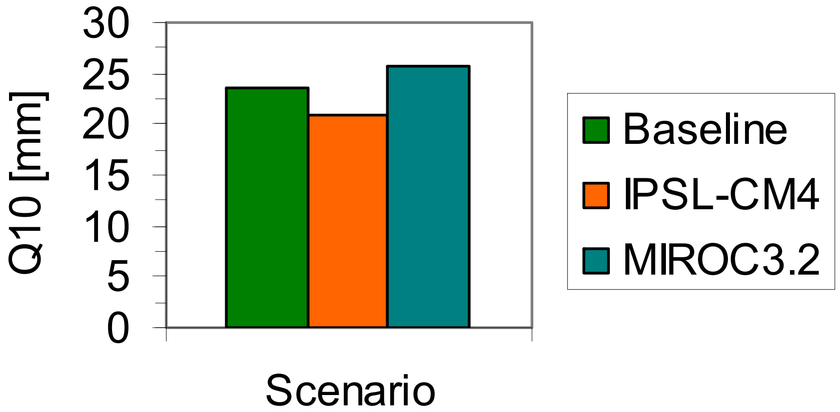


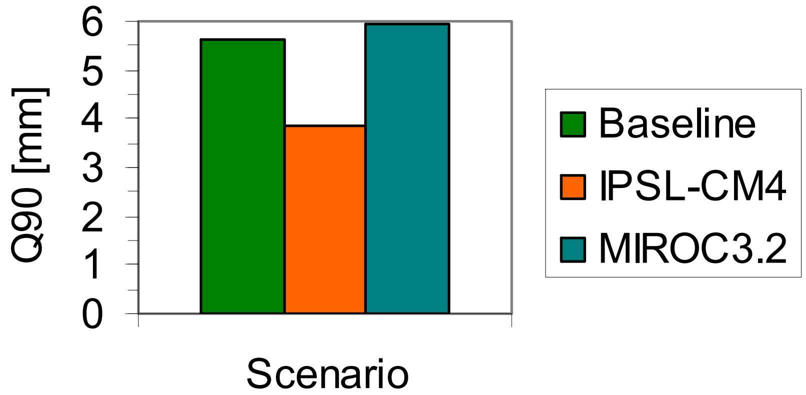
Mean annual change:
IPSL-CM4: 1%
MIROC3.2: 11%

Changes in annual runoff, Q10 & Q90

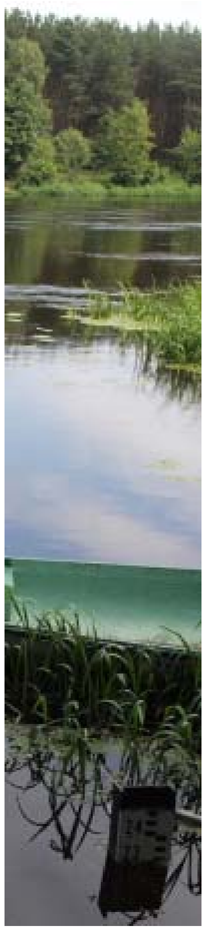


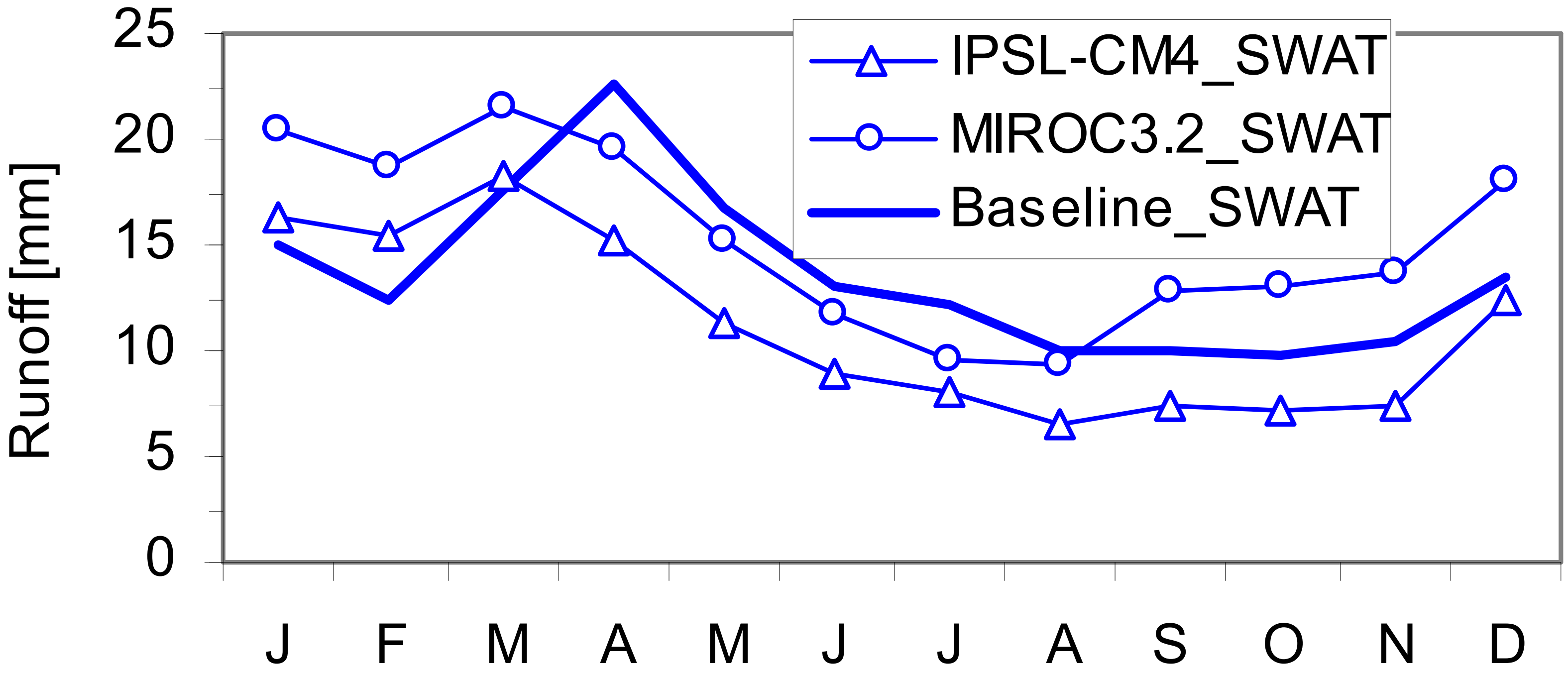




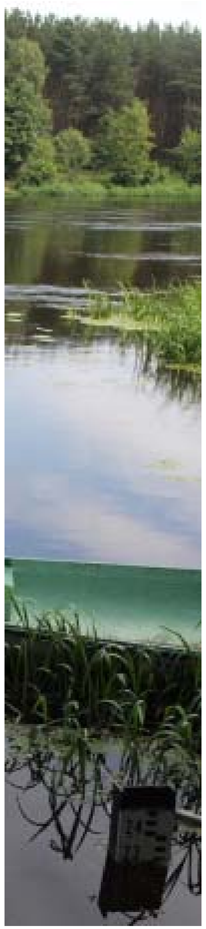


Changes in seasonal cycle



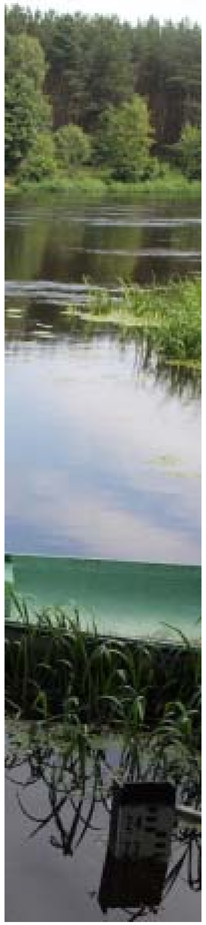


Conclusions & Outlook



- SWAT model works in the NRB (scale issue)
- An approach of converting qualitative into quantitative scenarios (e.g. of land use change) tested
- Considerable impact of climate change
- Large climate modelling uncertainty (in this region)
- Impact on environmental flows?

Central Eastern European SWAT Workshop
Introductory & Advanced



Date: 27 June to 1 July 2011

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WULS-SGGW Water Centre
Warsaw, Poland

Workshop Information

Introductory and Advanced SWAT Workshops will be led by Dr. Raghavan Srinivasan, Texas A&M, USA.

Introductory SWAT:	Standard: 300 €	Student: 150 €
Advanced SWAT:	Standard: 200 €	Student: 100 €

For more information please contact
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Organizing Committee

Dr. Jarosław Chormański (WULS-SGGW, Poland)
M.Sc. Mikołaj Piniewski (WULS-SGGW, Poland)
Dr. Raghavan Srinivasan (Texas A&M, USA)

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Thank you!