Water availability and water demand under Global Change in Benin, West Africa

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GLOWA
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Bundesministerium für Bildung und Forschung
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Outline

- From local scale knowledge to regional simulation
- From analysis of the current situation to scenario development and quantification
- From water availability to water demand: Is there water scarcity in Benin?

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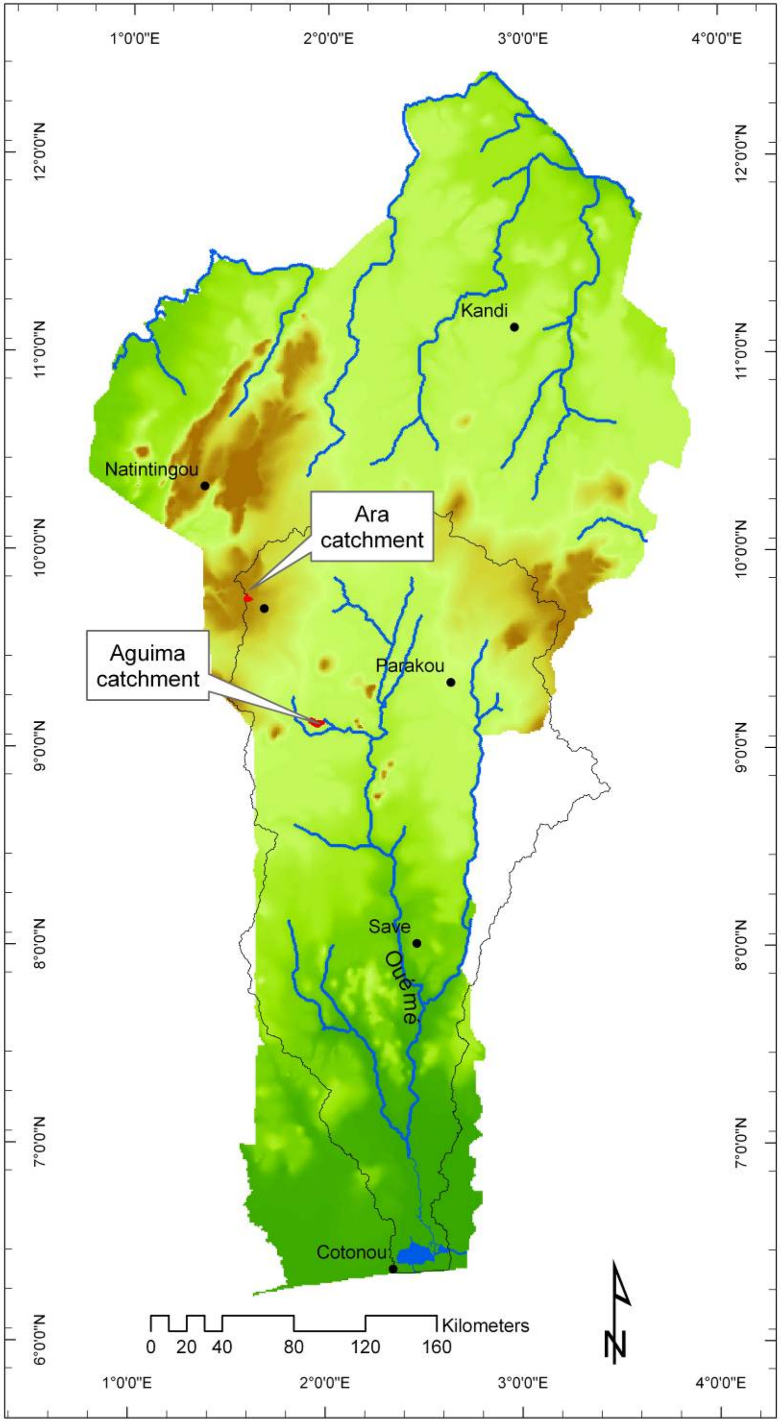


Why local scale analysis?

- to understand the effects of global change on the hydrological processes
- to be able to develop models which describe the Global Change effects correctly

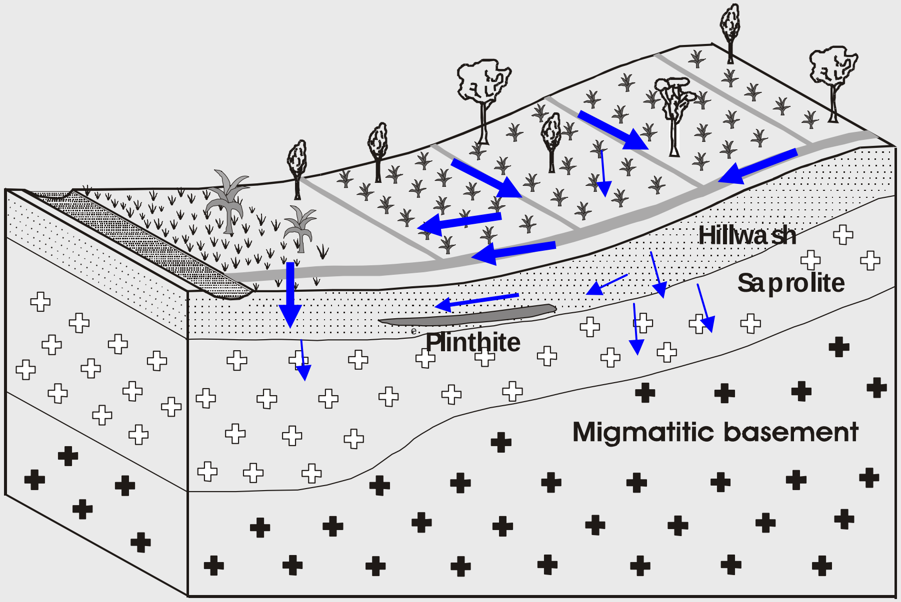
Approach

- local scale gained through measurements and analysis of processes in the Ara and the Aguima catchments
- transfer of the knowledge to the whole Ouémé basin

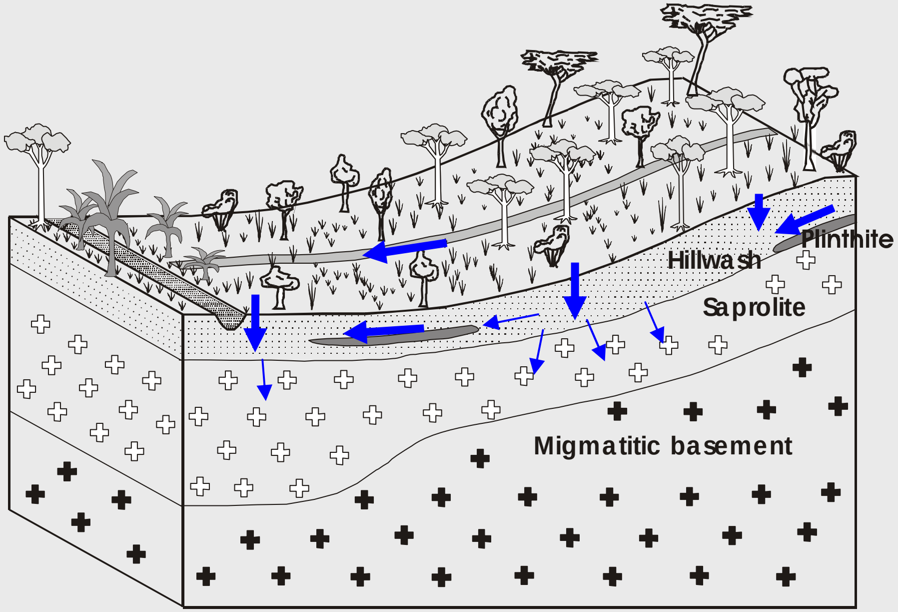
Hydrological processes at the local scale

Process studies

Agricultural land use

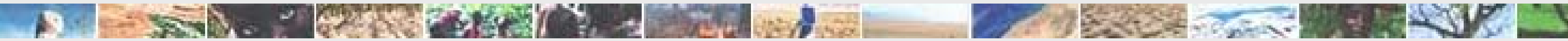


Natural vegetation



Giertz et al. HESS 2006

Lateral processes are important!
Processes differ with land use

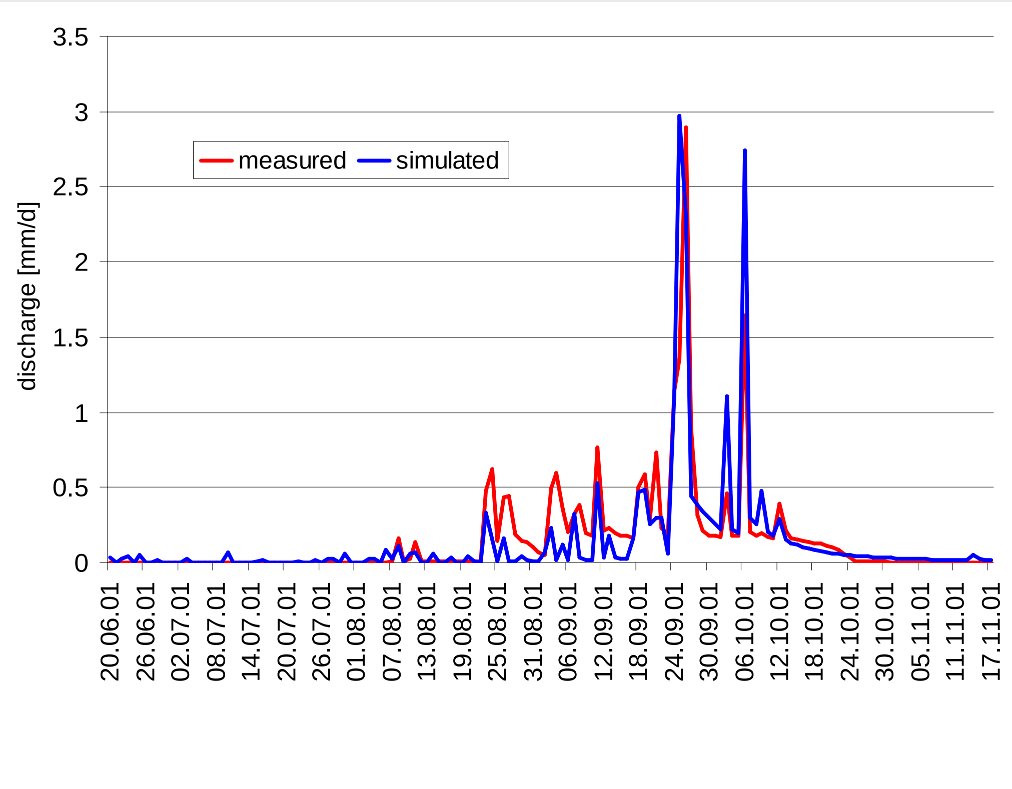


Modeling water fluxes at the local scale

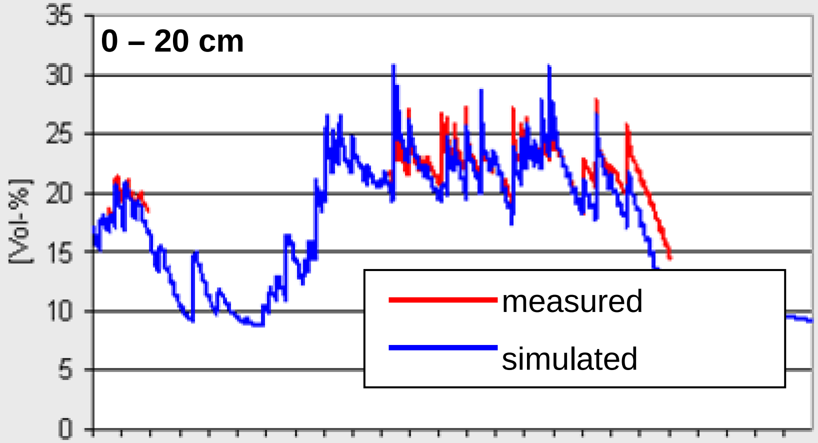
Physical-based model on the local scale

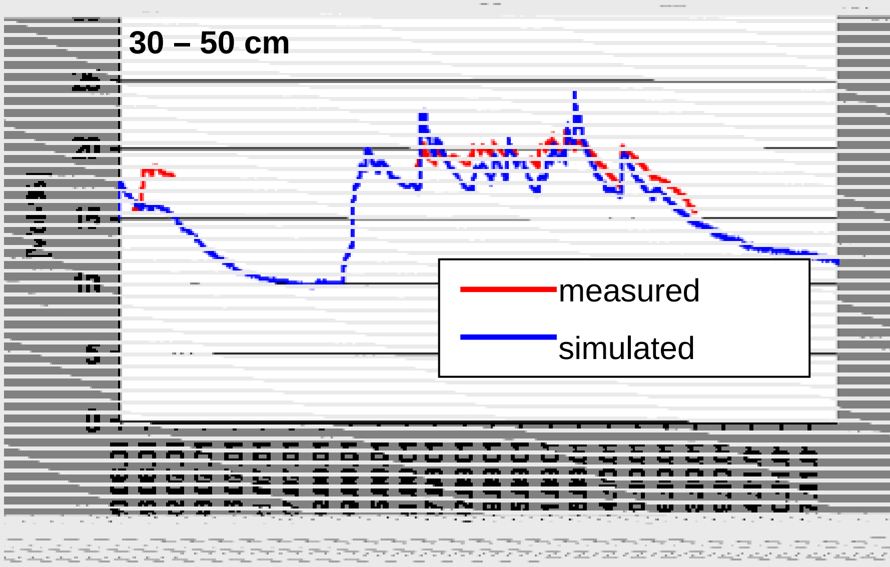
SIMULAT- H

Aguima Catchment 16 km²



water content

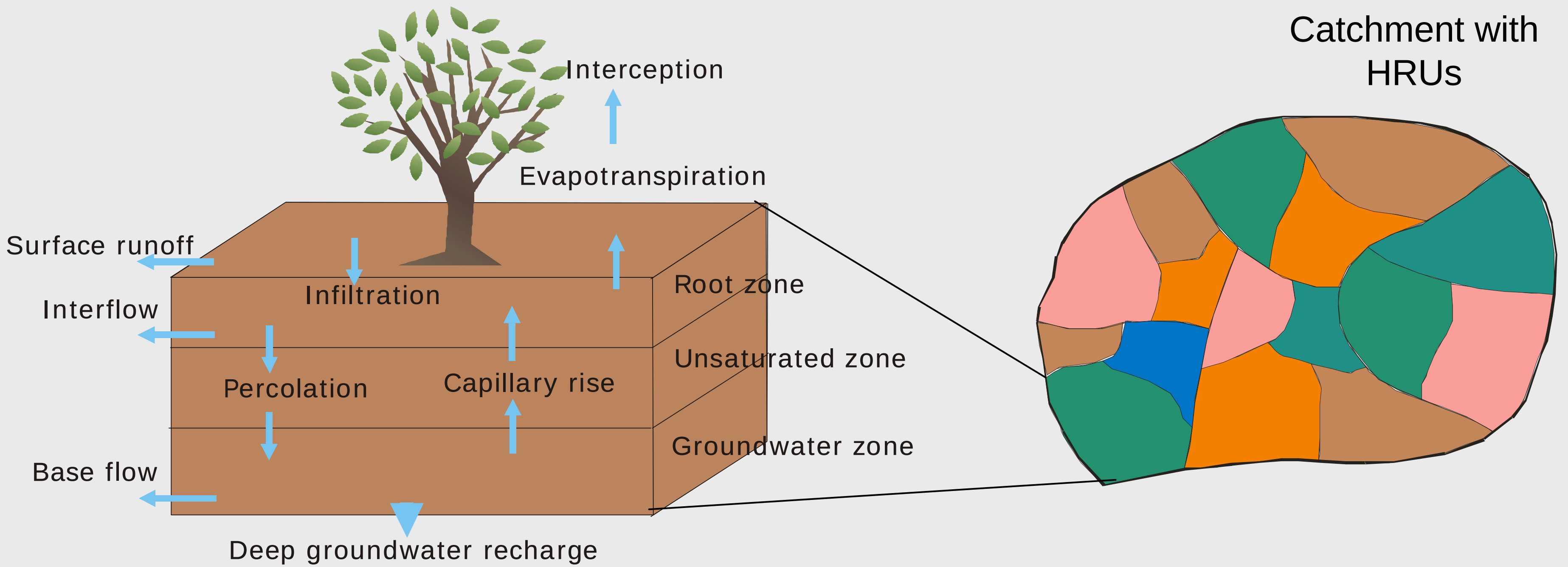




Giertz & Diekkrüger GEO-ÖKO 2006

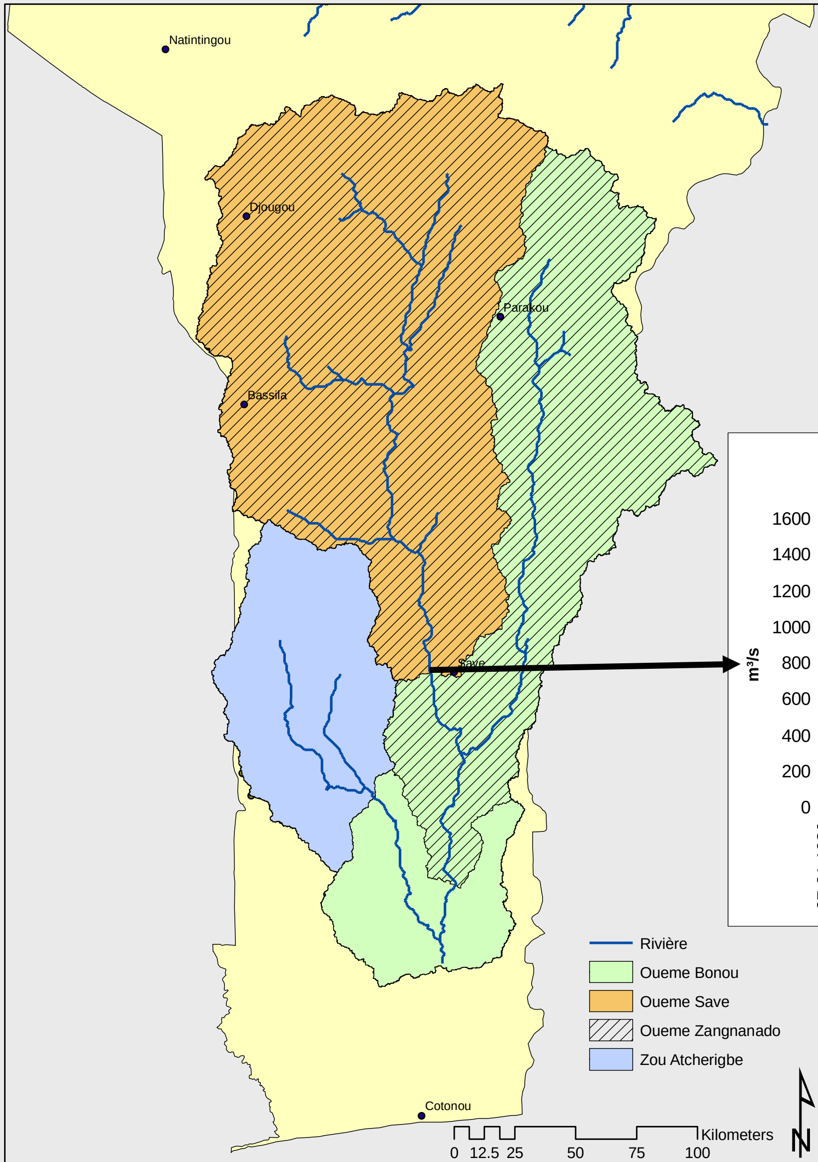
Model concept UHP-HRU

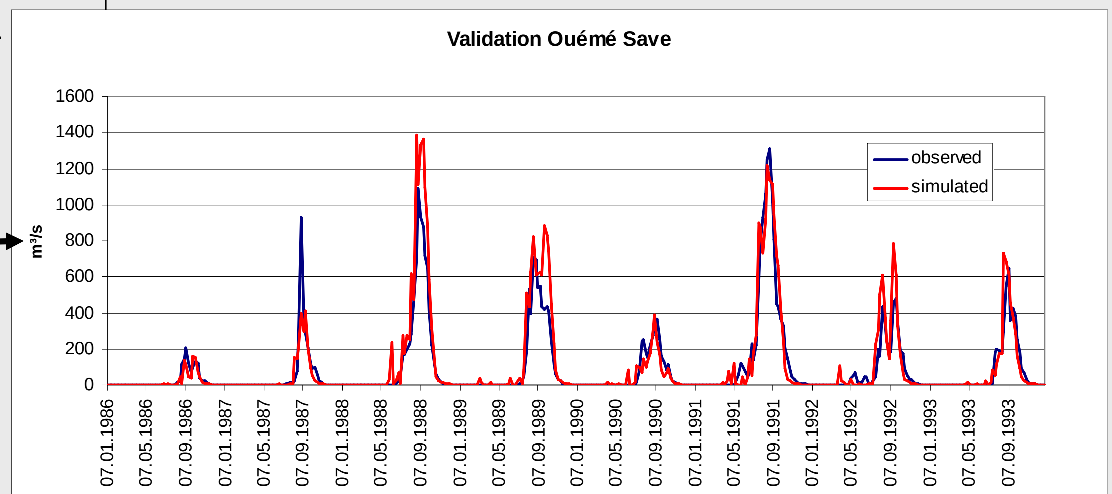
- Conceptual, spatially distributed model with an unlimited number of HRUs, defined by land use and soil types
- Evapotranspiration: optionally: Penman, Priestley-Taylor, Turc
- Surface runoff: SCS curve number
- Linear storage for root zone, unsaturated zone and groundwater zone
- Surface reservoirs
- Inland valleys



Modeling UHP-HRU Ouémé-Bonou: Validation

	Period	Surface (km²)	R^2	ME
Ouémé Save (Cal)	1985-1986	49285	0.9	0.69
Ouémé Save (Val)	1996-2003	49285	0.84	0.8
Ouémé Zangnanado (Val)	1986-1994	23491	0.64	0.55
Zou Atcheribé (Val)	1980-1993	7035	0.84	0.83





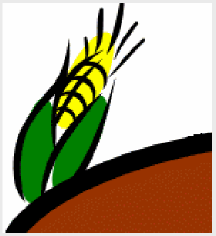
Conclusion: from local to regional scale

- Knowledge on local scale processes is most important for inland valley studies, small reservoirs studies as well as agricultural production.

- Local scale knowledge is considered in the Spatial Decision Support Systems

BenIvis

Pedro



- Hydrological simulation models for the local and the regional scale have been developed and validated

- These models can be applied for scenario quantification and for Decision Support

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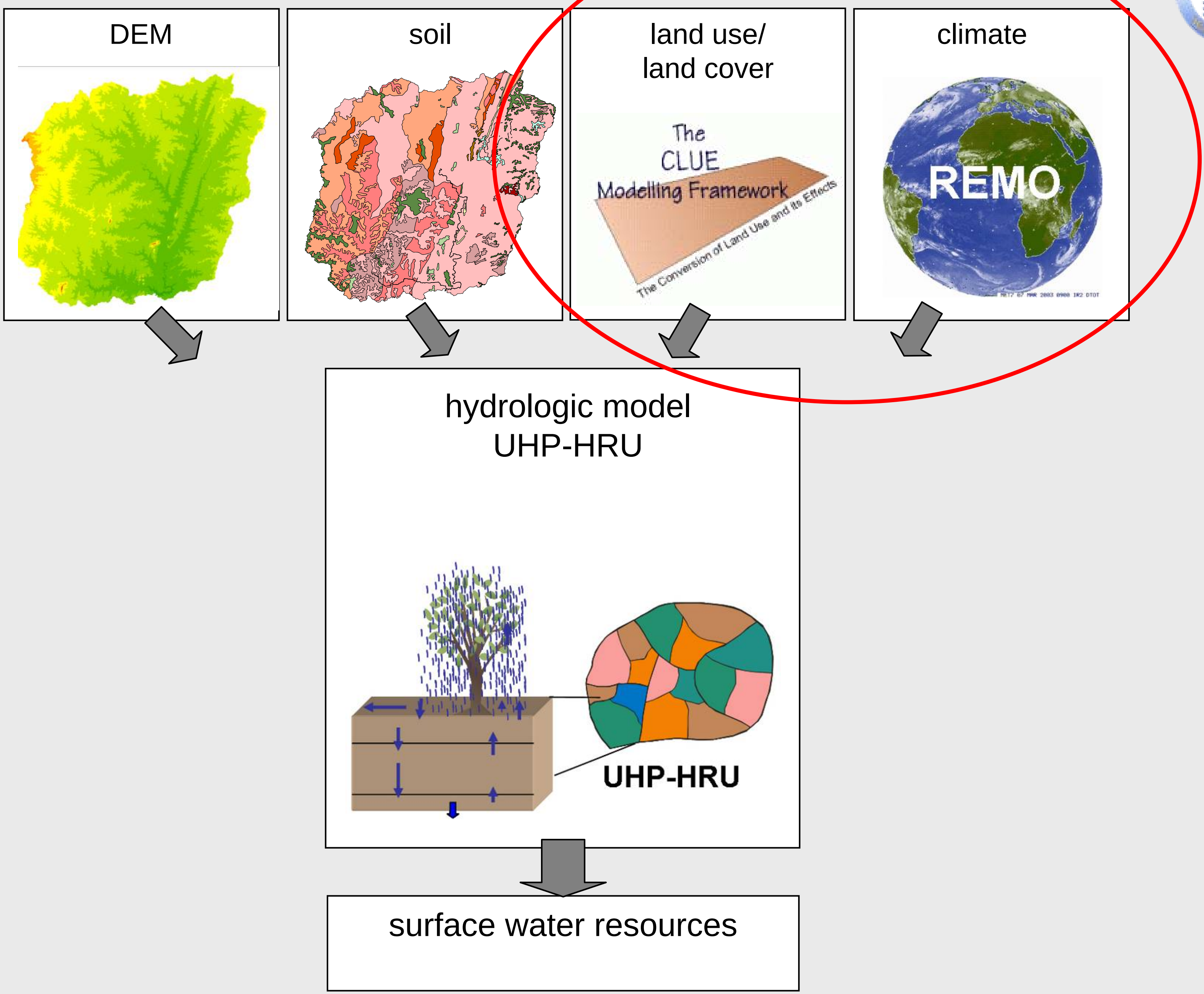
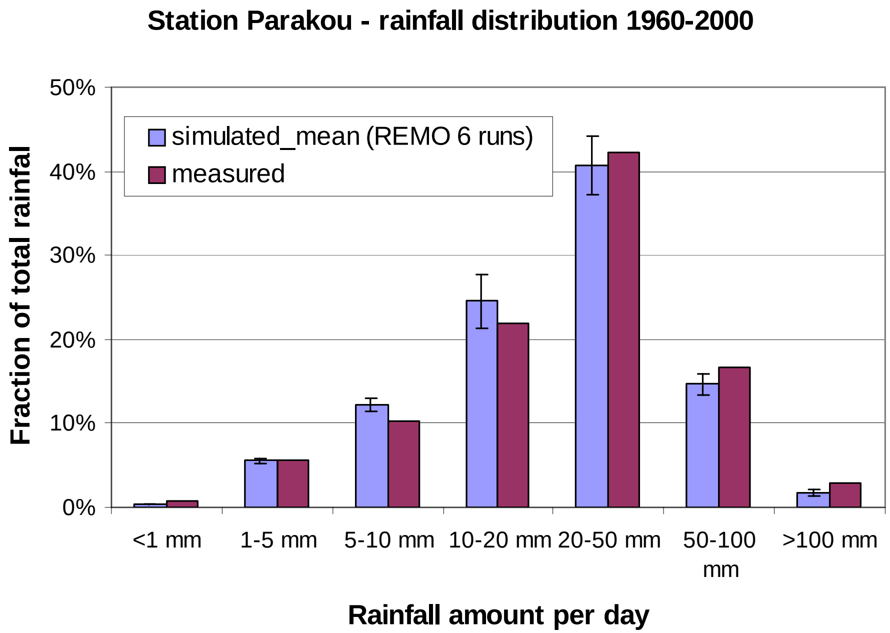
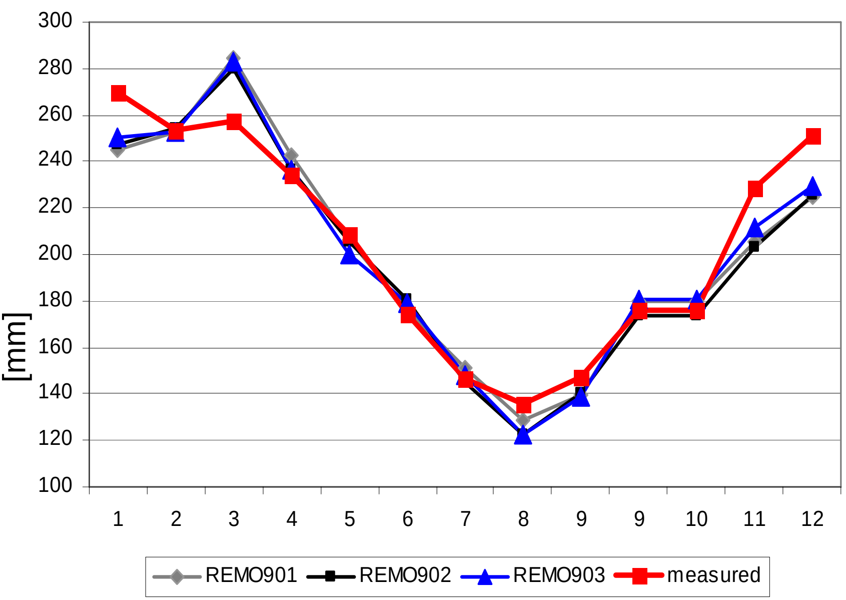

DEM
soil
land use/
land cover
climate
The
CLUE
Modelling Framework
The Conversion of Land Use and its Effects
REMO
hydrologic model
UHP-HRU
UHP-HRU
surface water resources

From climate modeling to hydrological scenarios

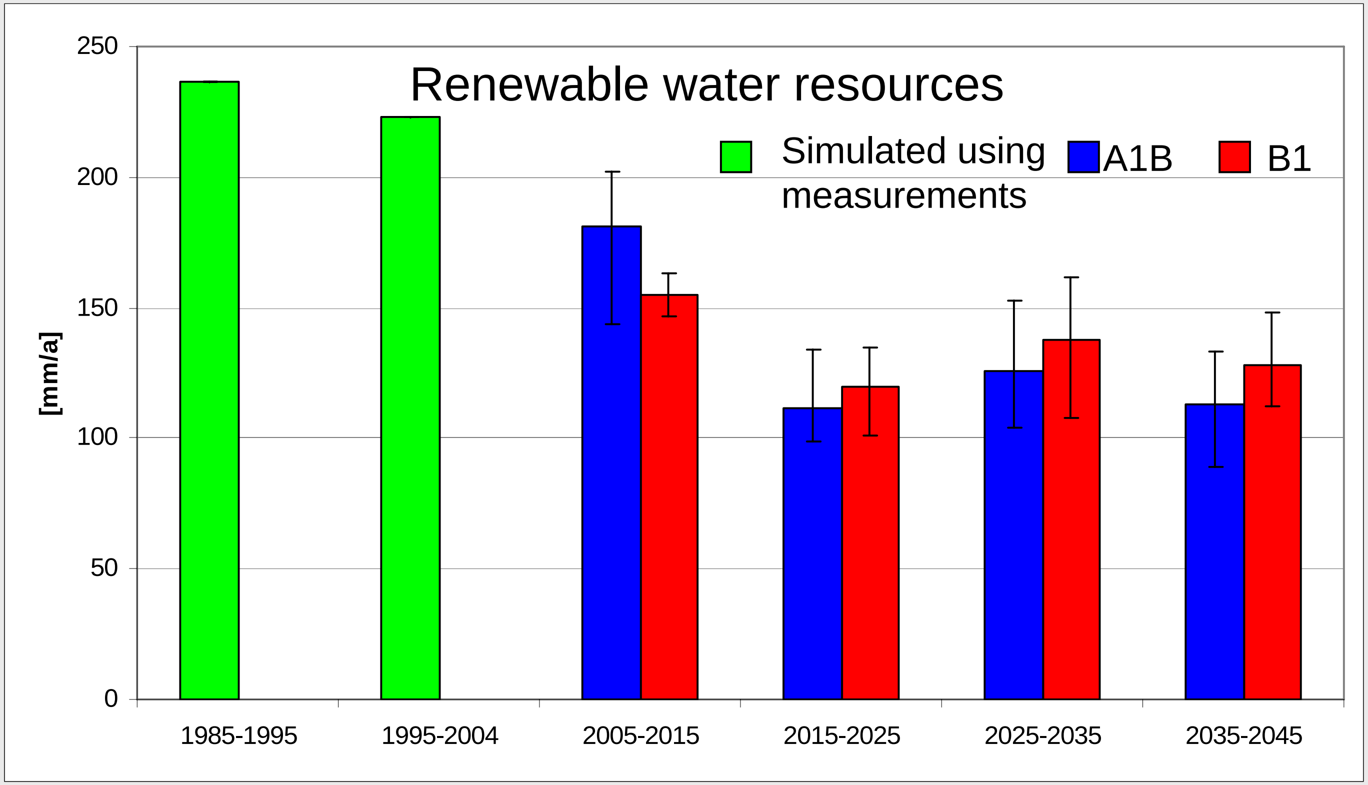


- Scale of climate models often do not match the scale of the hydrological models
- For linking mesoscale climate model output to a hydrological model a probability matching concerning amount and frequency distribution is required
- After post-processing the climate model output an one-way coupling of climate and hydrological model possible

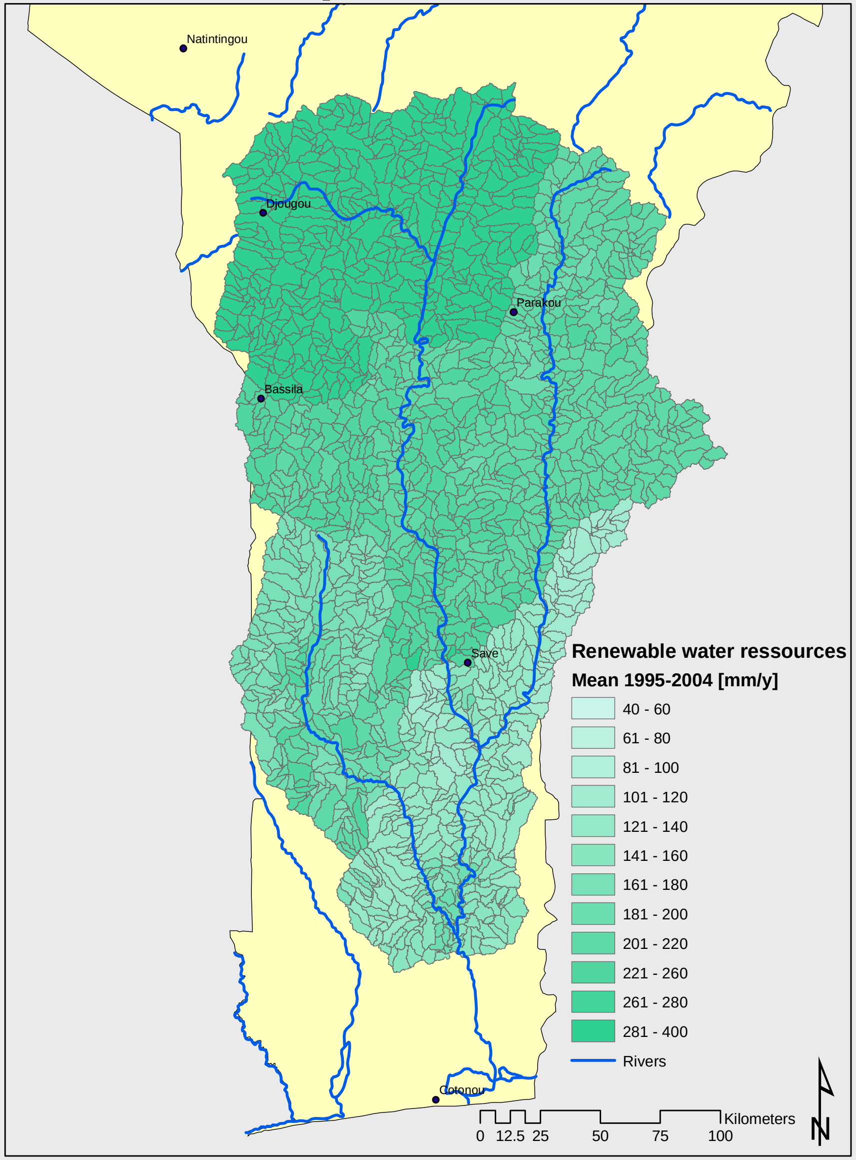


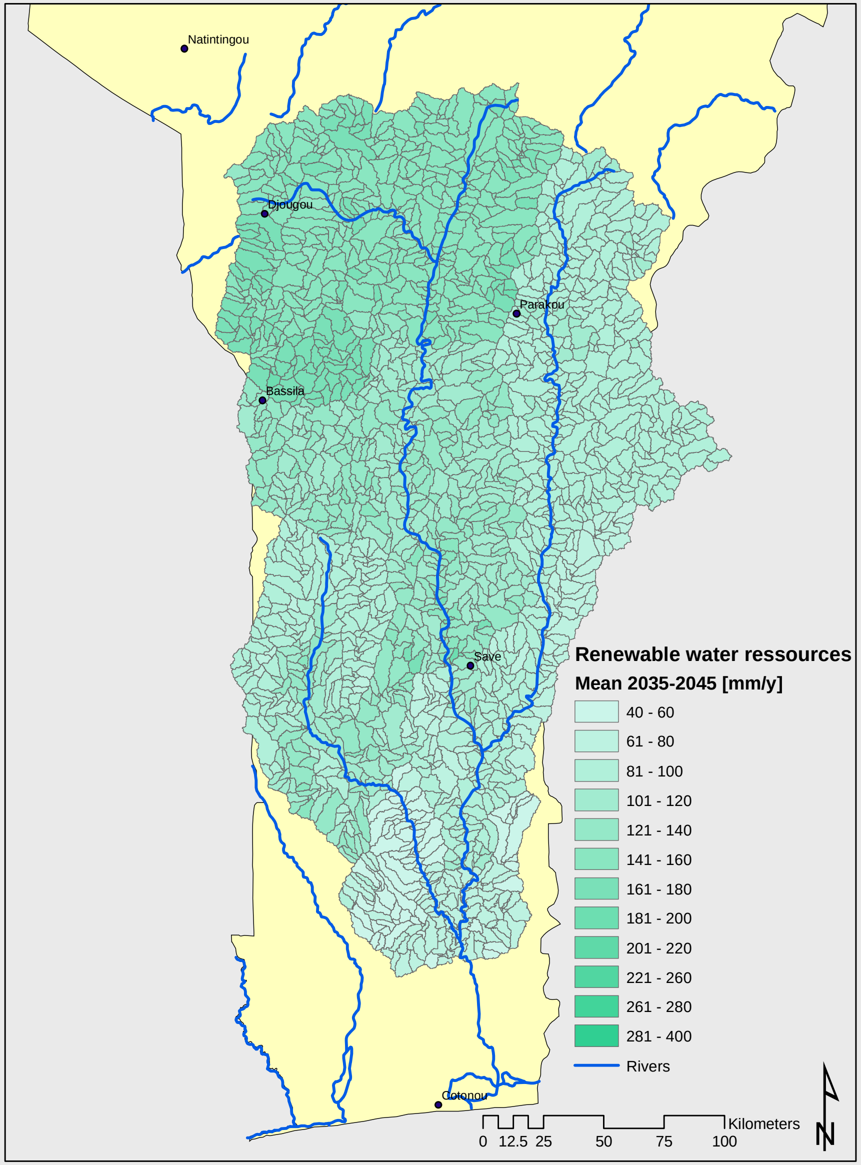
Mean Potential Evapotranspiration for Parakou (1979-1993) calculated using the Penman-Monteith equation with simulated REMO-Data and measured data

Simulated climate scenarios Ouémé Bonou



Comparison of renewable water resources period 1995-2004 and scenario A1B 2035-2045





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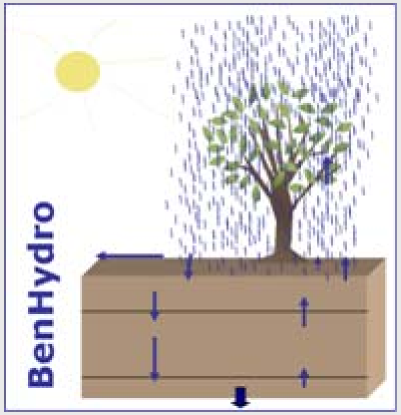
Conclusion: hydrological scenarios

- The scenarios reveal a significant decrease of available water resources in the Ouémé basin
- Detailed and distributed information on water availability is provided based on a thorough understanding of the processes
- The model is implemented in the Spatial Decision Support System BenHydro which allows to analyze the effects of climate change, land use change, reservoirs etc. on water availability
- Test the SDSS BenHydro



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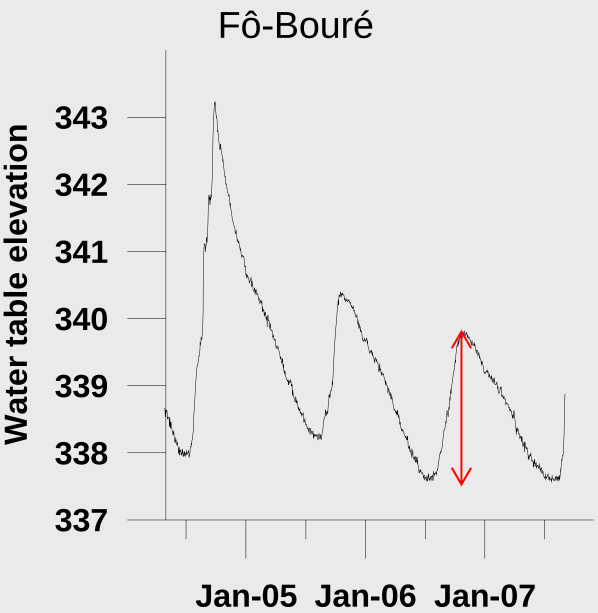
Is water a scarce resource in Benin?

- currently 4000 m^3/cap/a (critical < 1700 m^3/cap/a)

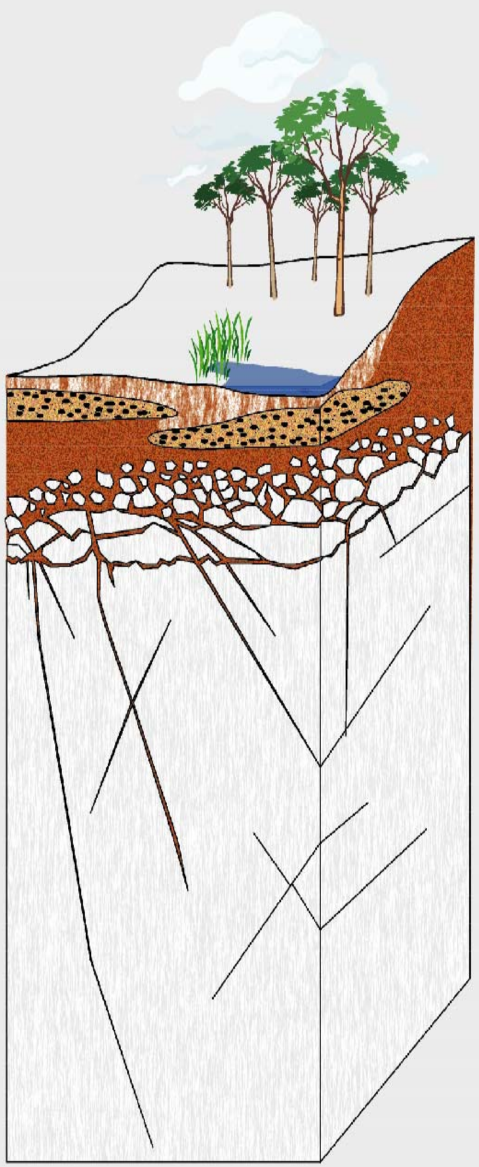
but

- water scarcity at the local scale is currently observed at the end of the dry season (although often due to economic reasons)
- poor drinking water quality
- increase in population cause a decrease in water availability per capita (halving every 22 years)
- increase in irrigation agriculture and livestock causes an increase in water demand

Aquifer properties



Seasonal water level fluctuation of 2.5 meters in the weathered zone influence the water storage by about 25 %



Saturated thickness	Specific Yield [-]	Water volume
~10 m	0.03	300 l/m²
~50 m	0.0001	5 l/m²

Average water storage: 305 l/m²
98% in the weathered zone

Balancing water availability and water demand
WEAP: Water Evaluation and Planning System

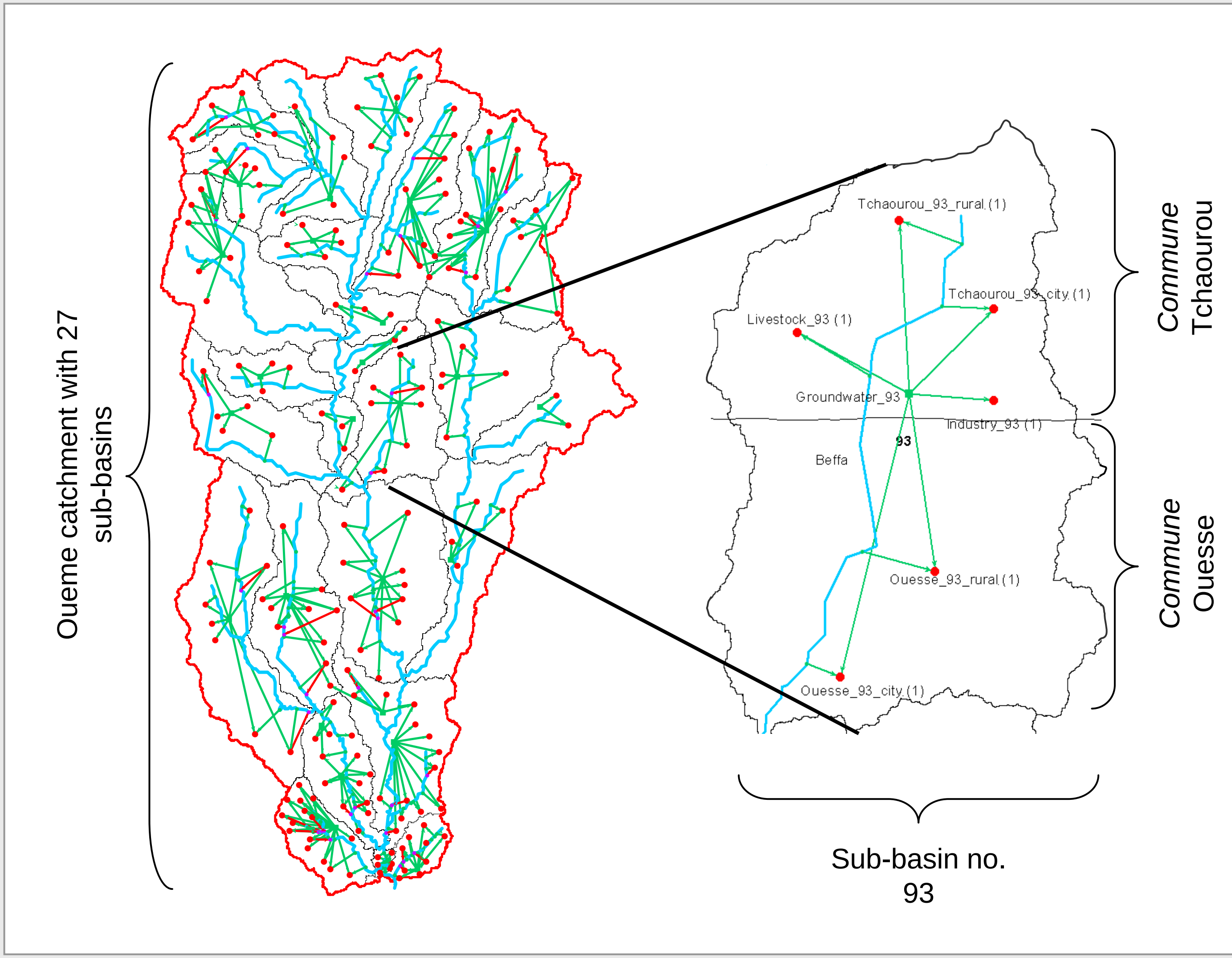
WEAP is able to

- use external simulation results concerning water availability
  or use integrated simple hydrological modeling
- consider surface water reservoirs
- compute water demand considering different sectors
  - domestic water use
  - agricultural water use
  - industrial water use

  and to consider access to water
- consider water price development
- to compute water quality
- …

Application of WEAP to the Ouémé basin

- 27 sub-basins
- 5 departments
- 34 communes
- 32 river segments
- 28 groundwater aquifers
- 188 demand sites
- 4 reservoirs (Djougou, Parakou, Savalou, Savé)
- monthly time steps



Scenario development

Climate scenarios:
IPCC A1B oder B1

B1:
Economic growth
and consolidation of
decentralization

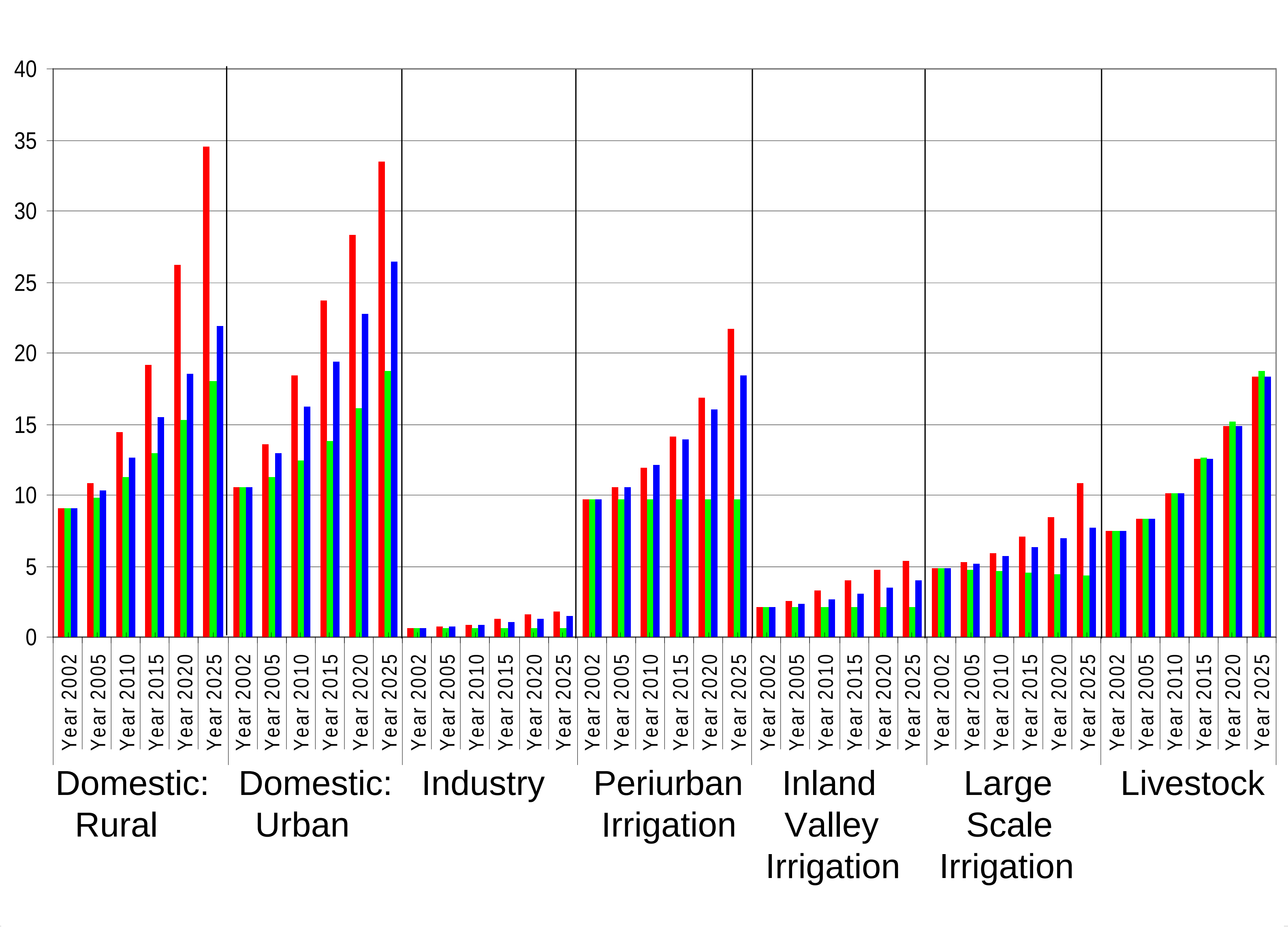
B2:
Economic
stagnation
and institutional
insecurity

B3:
Business as
Usual

Scenarios developed for

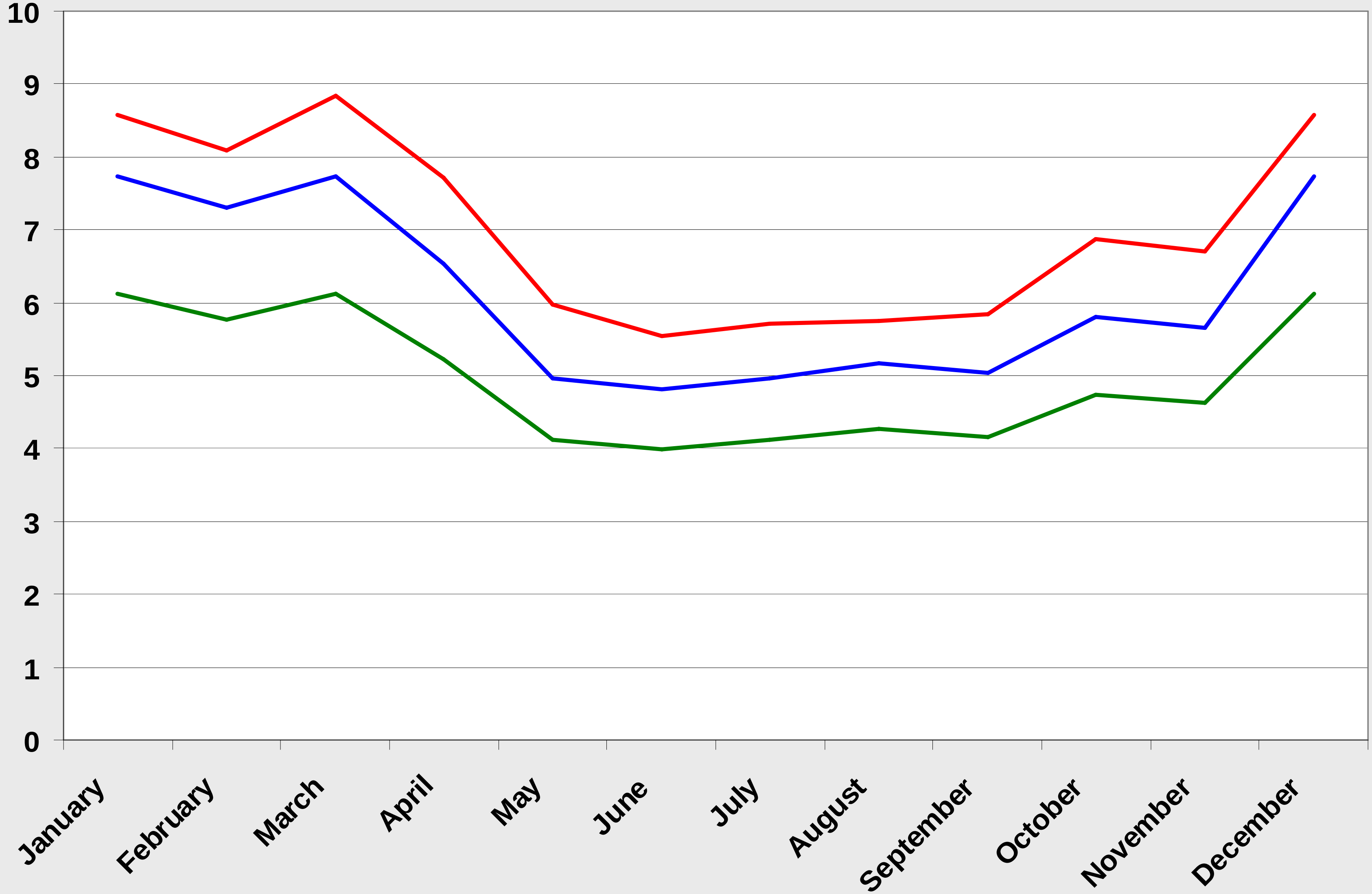
1. **Domestic water use**
2. **Agricultural water demand (irrigation agriculture, livestock)**
3. **Industrial water demand**

Water demand per sector and scenario in Mm³/a



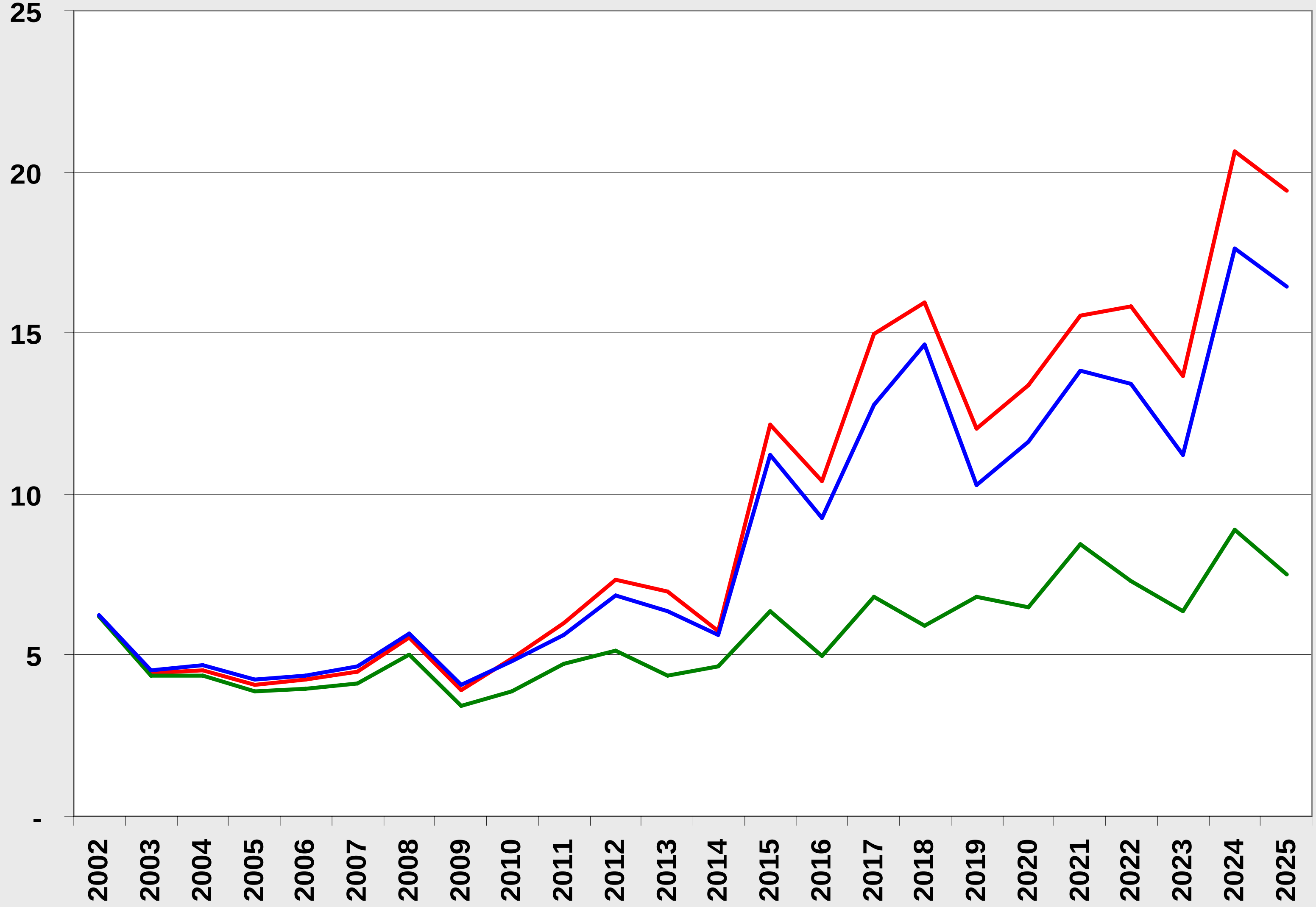
B1: economic growth B2: economic stagnation B3: business as usual

Total monthly water demand in Mm³ mean over 2002 - 2025



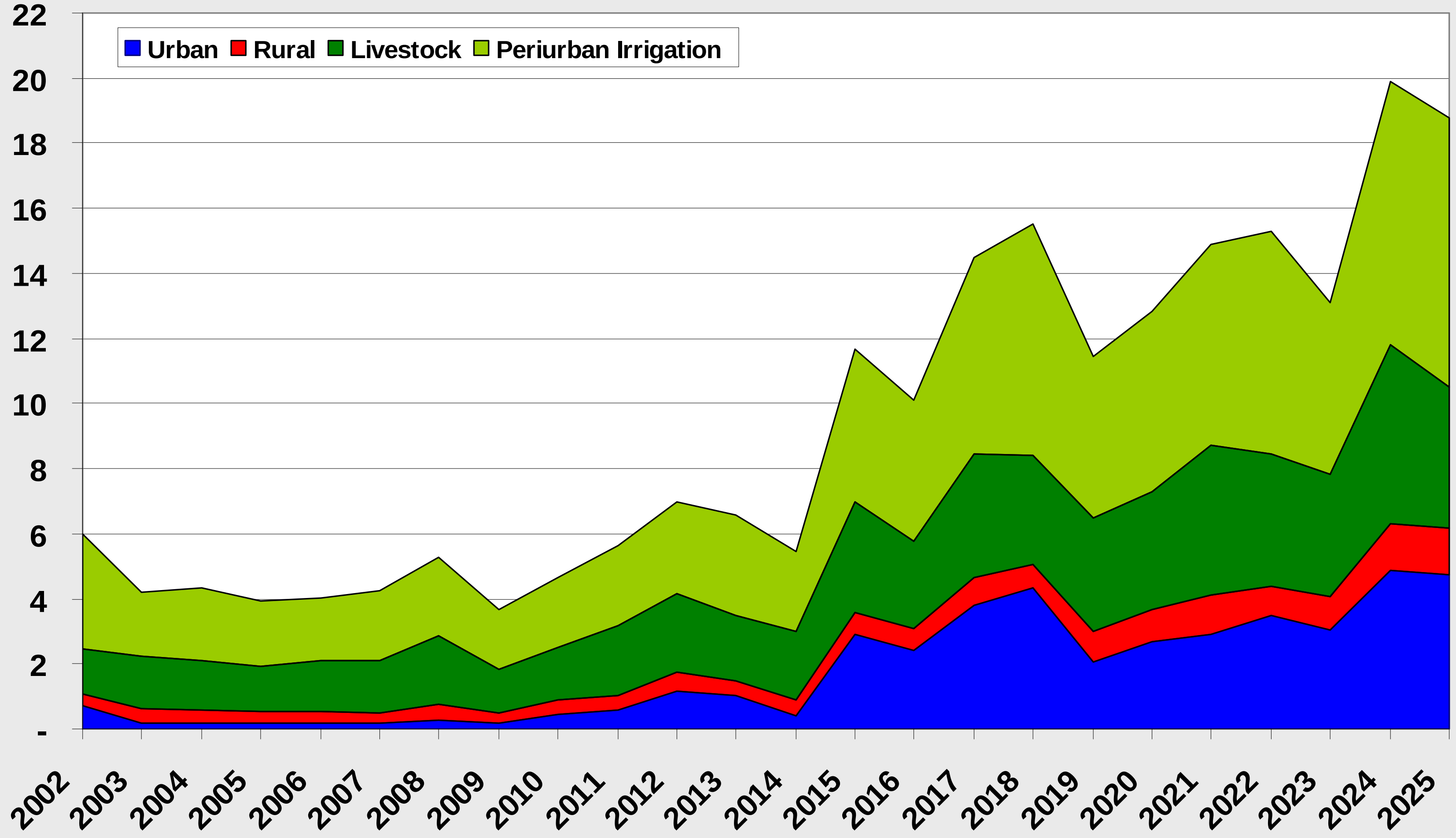
B1: economic growth B2: economic stagnation B3: business as usual

Total unmet demand in Mm³
IPCC climate scenario A1B

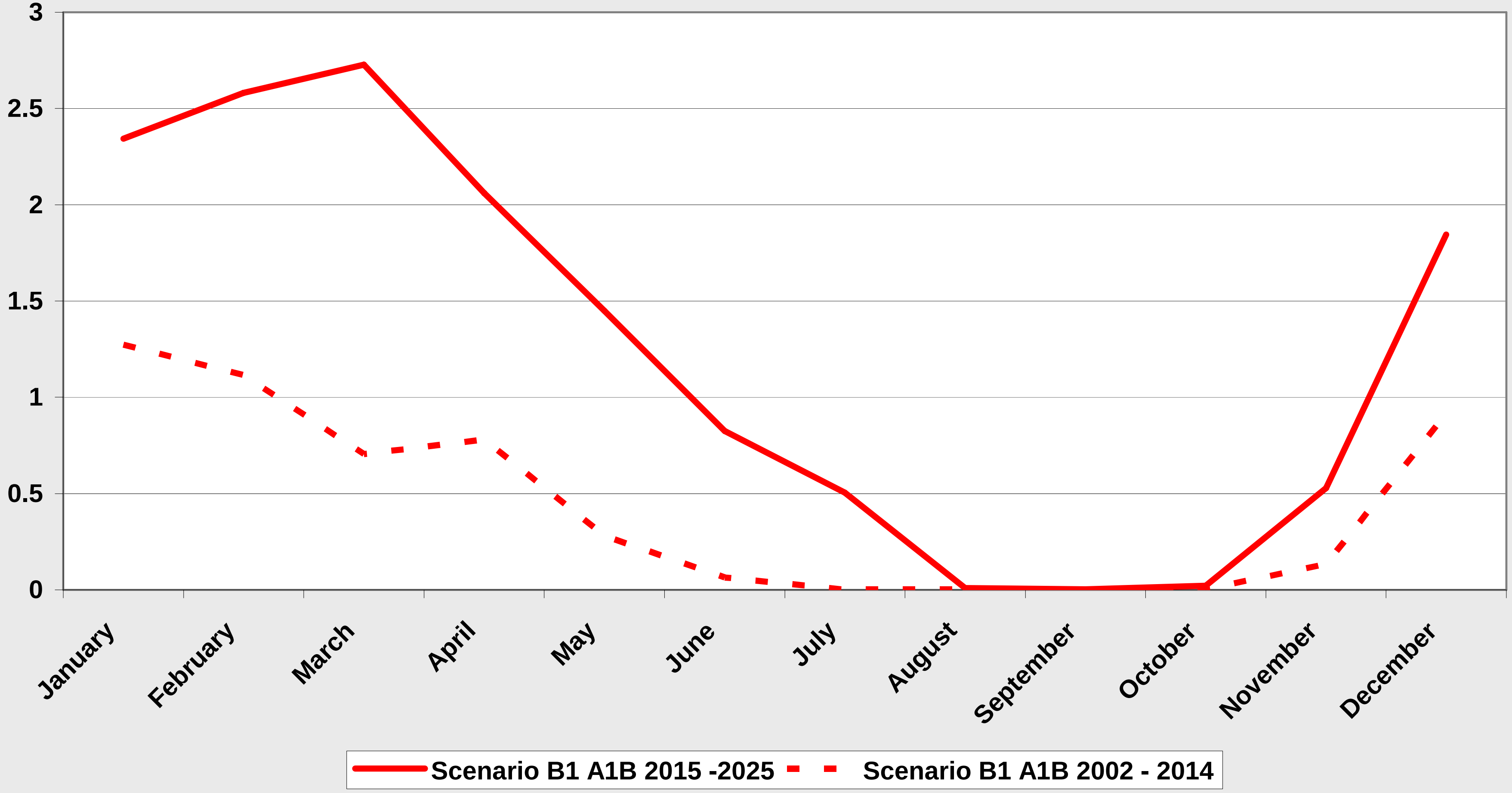


B1: economic growth B2: economic stagnation B3: business as usual

Unmet demand per sector and scenario in Mm³ IMPETUS B1 economic growth with IPCC climate scenario A1B



Total monthly unmet demand in Mm³ IMPETUS B1 economic growth with IPCC climate scenario A1B



Conclusion: water demand

- Scenario calculations reveal an
  - increase in water demand due to an increase in domestic water use and irrigation agriculture
  - increase in total unmet demand (2015 – 2025)
  - increase in length of the water scarcity period up to 8 to 10 months with a peak from December to March
  - increasing pressure on reservoirs and surface water
- User relying upon groundwater are less affected although groundwater level decreases
  (economic scarcity possible)
- Test the Spatial Decision Support System BenEau

Conclusion

- The analysis of water availability and water demand reveals that water is one of the key issues for sustainable development in Benin

- The IMPETUS studies are important for supporting the Integrated Water Resource Management process which is currently developing in Benin

- Based on the interdisciplinary modeling approach a number of Spatial Decision Support Systems have been developed which links knowledge gained at different scale with scenario development

- Please visit the poster session and test our SDSS

Thank you for your attention