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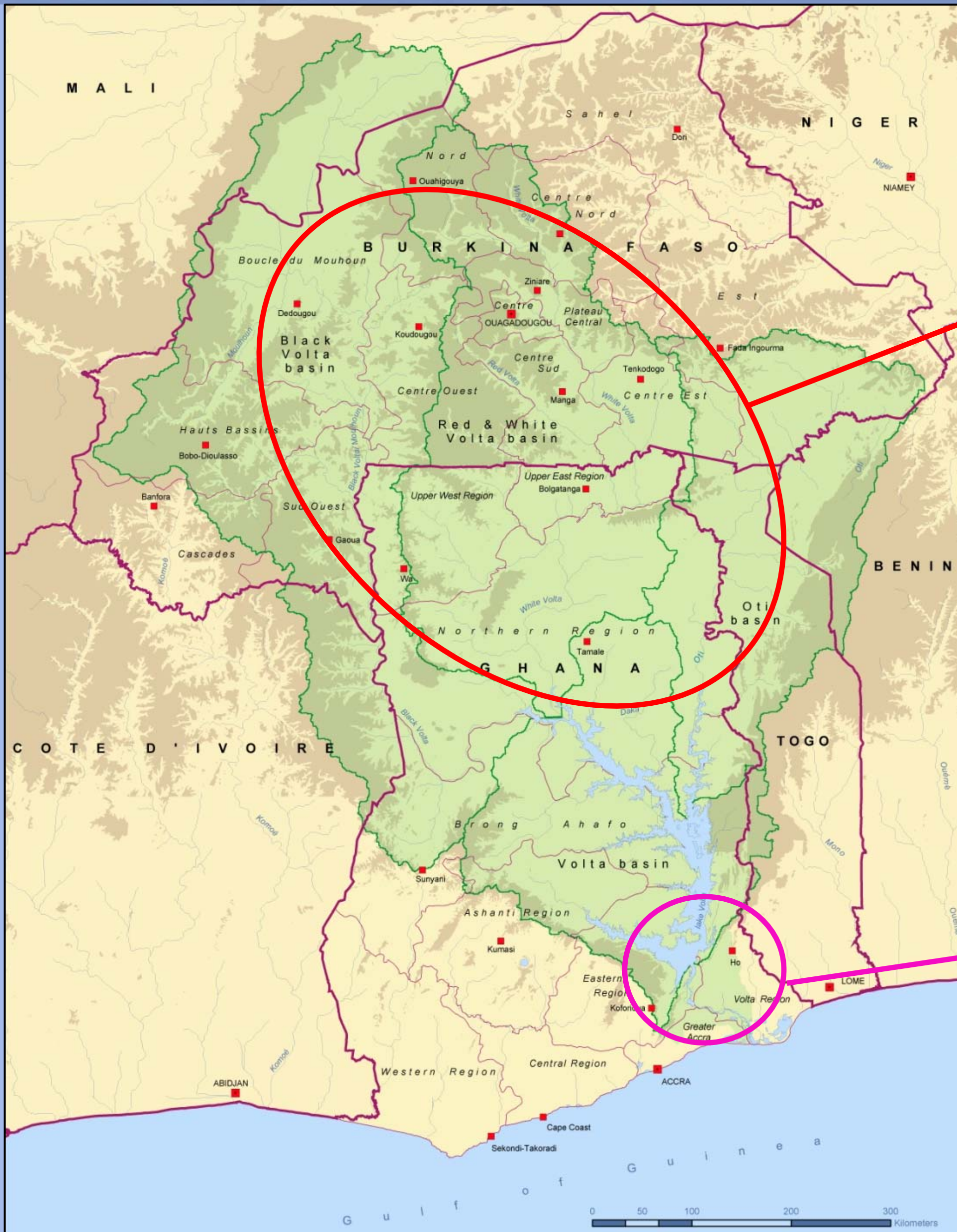
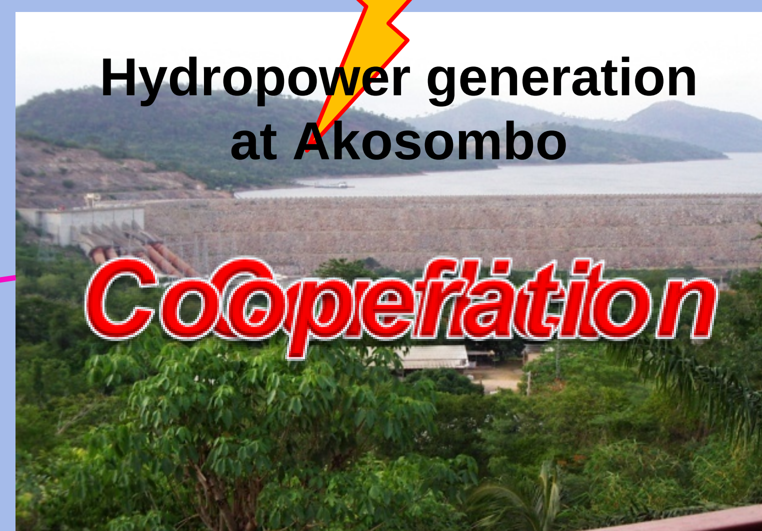
The M³ WATER Model for the Volta Basin:

Hydro-economic water resources assessment in Sub-Saharian Africa

Paul L.G. Vlek,
Nicos Perez, Anik Bhaduri,
Constanze Leemhuis,
Ivan Denisovich, Alexandr Savinov, and Jens Liebe

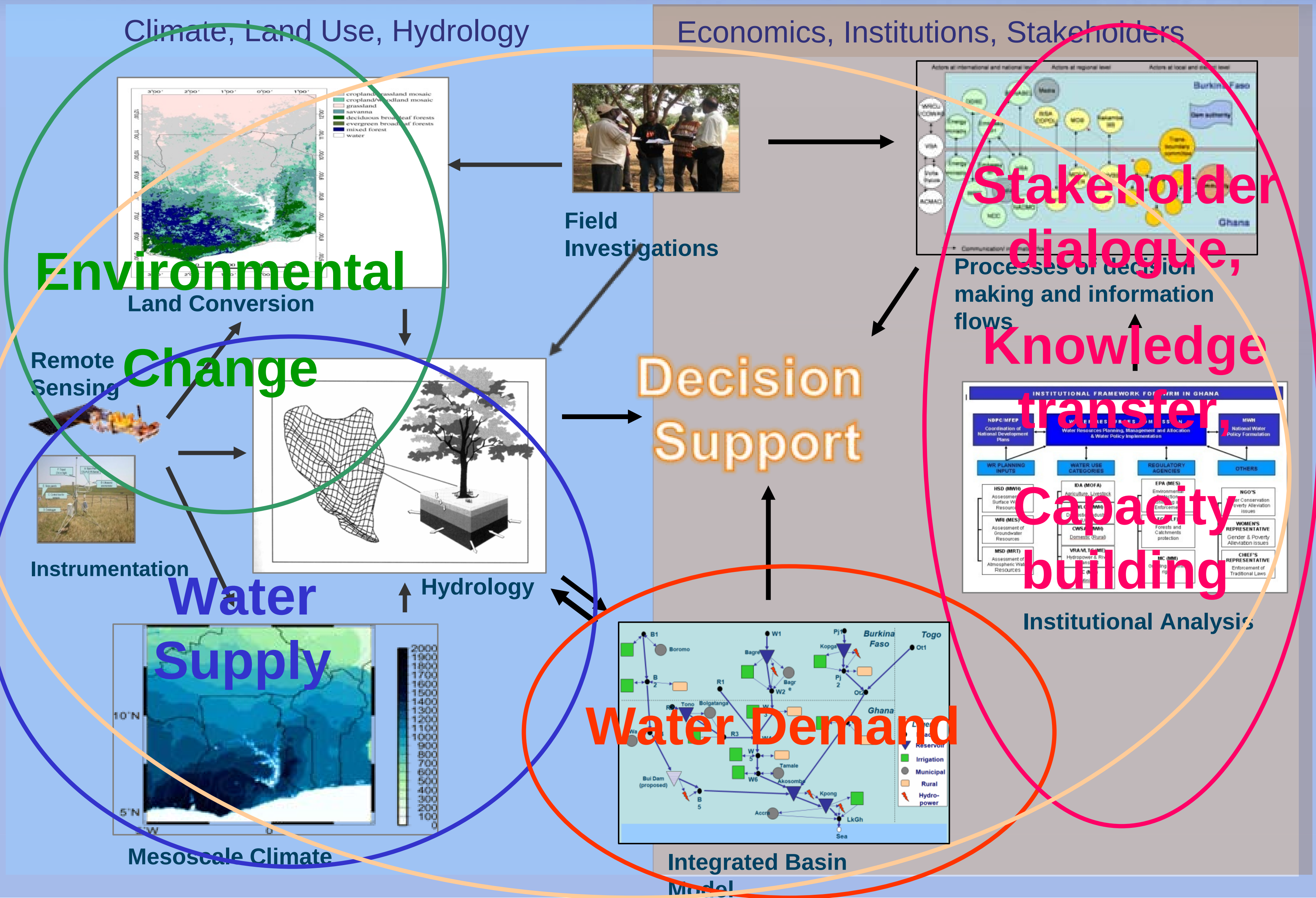

M A L I
N I G E R
B U R K I N A   F A S O
G H A N A
B E N I N
T O G O
C O T E   D ' I V O I R E
Sahel
Nord
Centre Nord
Est
Boucle du Mouhoun
Centre
Plateau Central
Centre Sud
Centre Ouest
Centre Est
Hauts Bassins
Sud Ouest
Cascades
Black Volta basin
Red & White Volta basin
Oti basin
Volta basin
Upper East Region
Upper West Region
Northern Region
Brong Ahafo
Ashanti Region
Eastern Region
Volta Region
Greater Accra
Central Region
Western Region
Gulf of Guinea
NIAMEY
Dori
Ouahigouya
Ziniare
OUAGADOUGOU
Dedougou
Koudougou
Tenkodogo
Manga
Fada Ngourma
Bobo-Dioulasso
Banfora
Gaoua
Bolgatanga
Wa
Tamale
Sunyani
Kumasi
Koforidua
Ho
LOME
ACCRA
Cape Coast
Sekondi-Takoradi
ABIDJAN
0 50 100 200 300 Kilometers


Expansion of irrigated agriculture
Potential


Hydropower generation at Akosombo
Cooperation

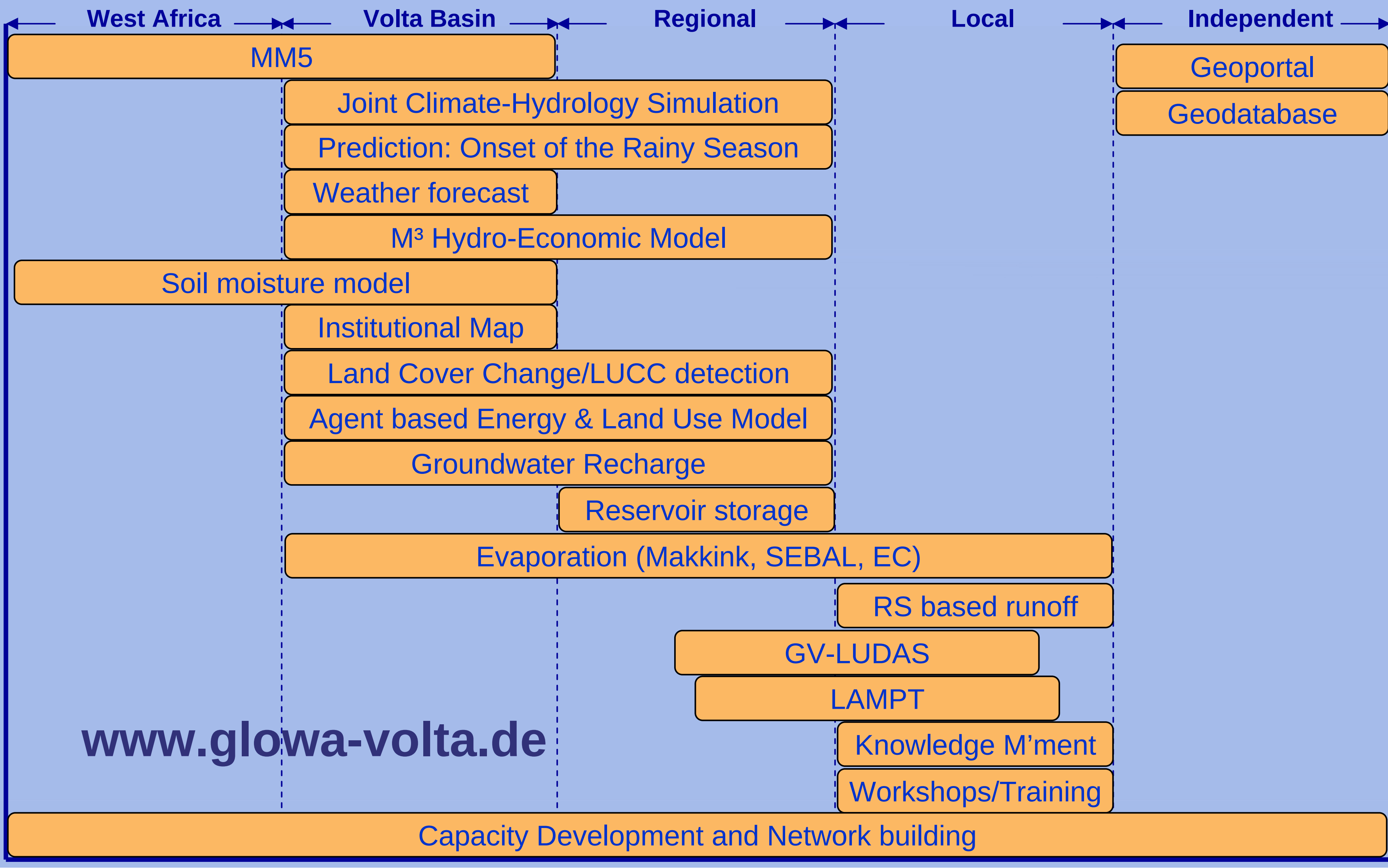
“A model that represents the entire Volta Basin and is accepted by the international community can improve communication between each country, and support efforts towards environmental sustainability. At present, no comprehensive model exists which makes objective communication about water issues nearly impossible.“

(Andreini, 2000)



Climate, Land Use, Hydrology
Economics, Institutions, Stakeholders
Field Investigations
Land Conversion
Remote Sensing
Instrumentation
Hydrology
Mesoscale Climate
Decision Support
Processes of decision making and information flows
Institutional Analysis
Integrated Basin Model
Environmental Change
Water Supply
Water Demand
Stakeholder dialogue,
Knowledge transfer,
Capacity building

Scales addressed in GVP Decision Support



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M³ WATER hydro-economic model

Multi-country **M**ulti-sector **M**ulti-use

W ater
A llocation
T echnology for the
E fficient management of
R esources in the Volta Basin

COUNTRIES: Ghana / Burkina Faso

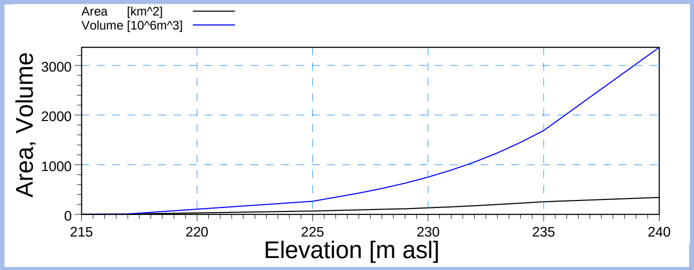
SECTORS: Agriculture / Domestic / Industry / Hydropower

USES: (Non) - Consumptive / Environmental / In (ex) - situ

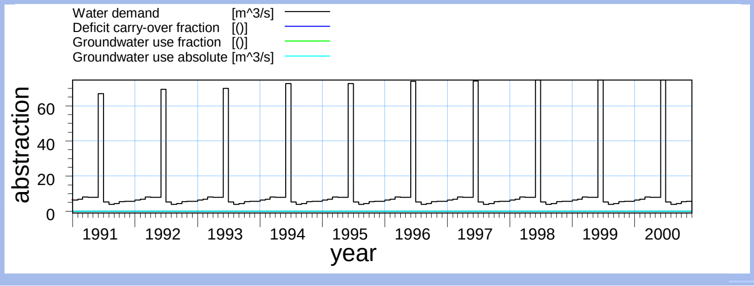
MIKE Basin Setup

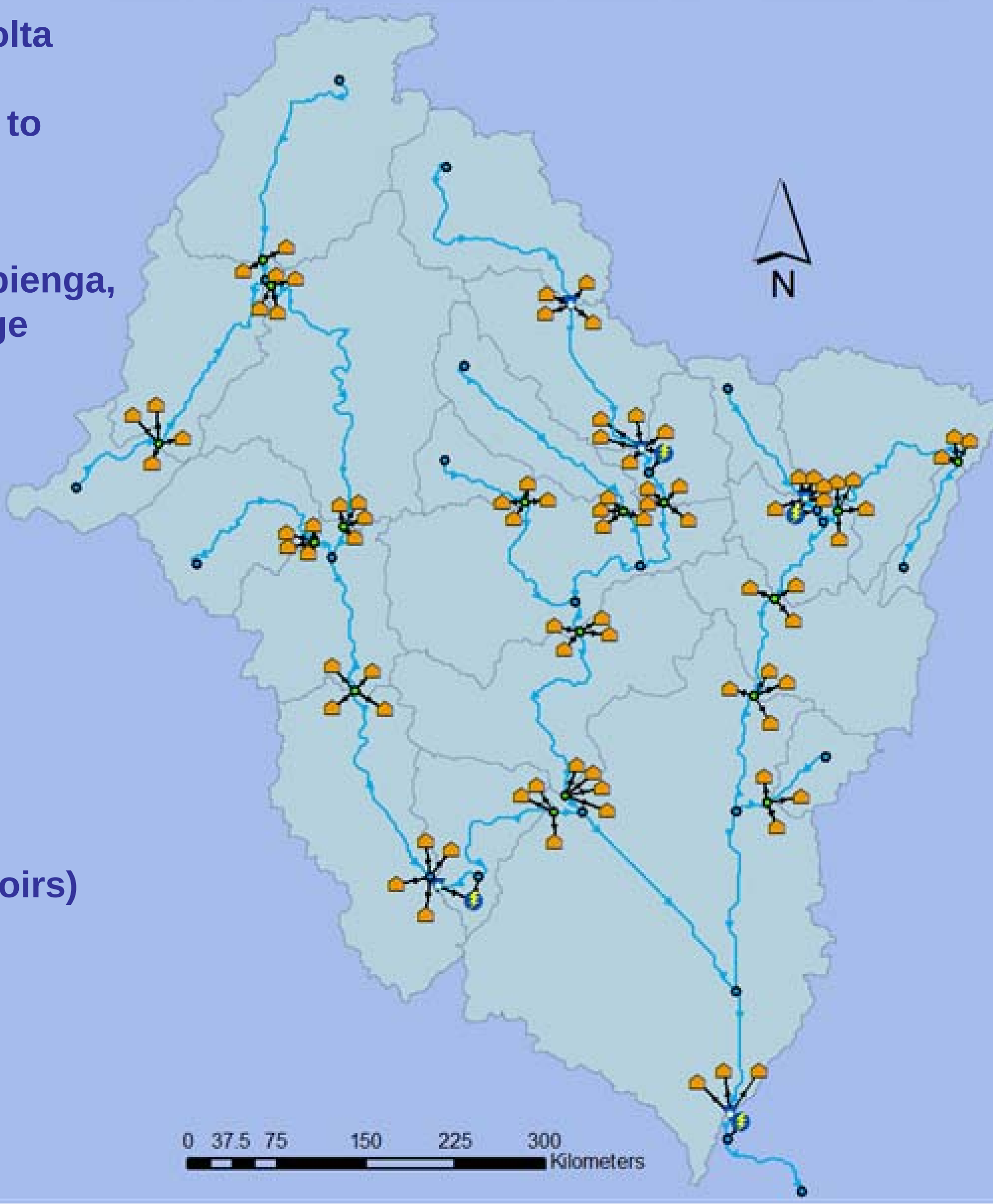
1. 23 hydro-economic catchments for the Volta Basin (specific discharge time series are generated for each catchment) according to national boundaries and large reservoirs.

2. large reservoirs: Akosombo, Bagre, Kompienga, Ziga, (Bui), including hydropower and large reservoir abstractions for irrigation and portable water.



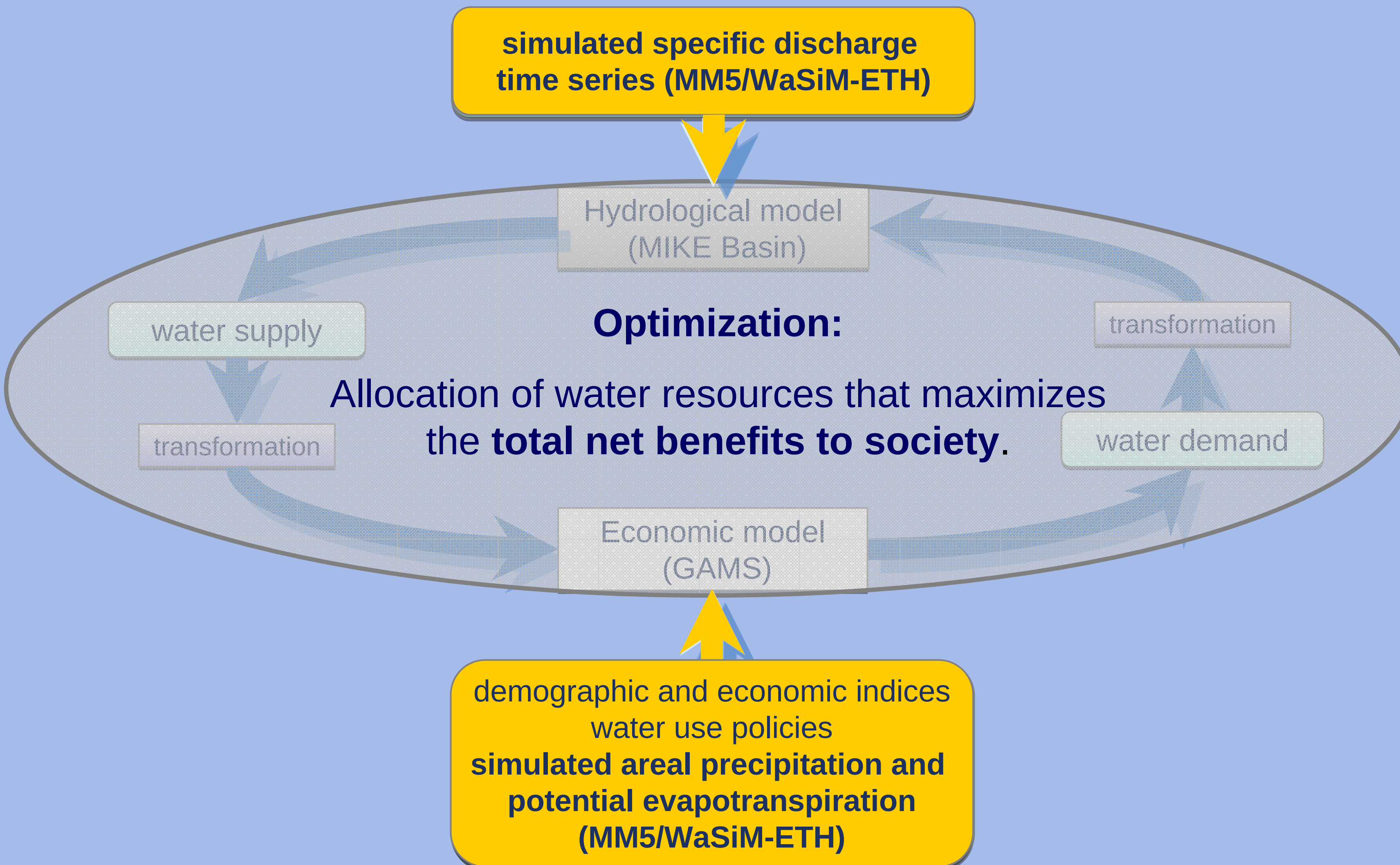
3. water user (sector) per catchment:
   - domestic use
   - industrial use
   - small scale irrigation (small reservoirs)



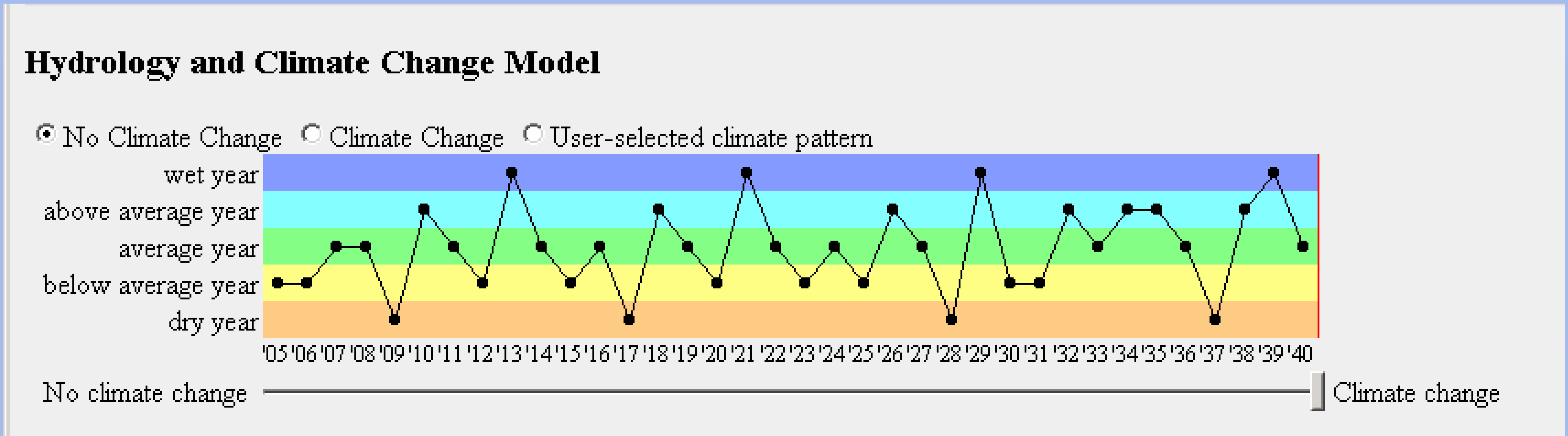


Criteria of Water Allocation
(Optimization with GAMS)

M³ WATER MODEL STRUCTURE



The Climate Generator



High-resolution Regional Climate and Hydrological Modelling for the Volta Basin of West Africa *(Harald Kunstmann and Gerlinde Jung, IMK-IFU, Garmisch-Partenkirchen, Germany)*

- **Two time slices (1991-2000 and 2030-2039) of the ECHAM4 scenario IS92a were dynamically downscaled with MM5 to a spatial resolution of 9 km x 9 km.**

- **The distributed process-based hydrological model WASIM-ETH was run with the MM5 generated climate data for the time slices 1991-2000 and 2030-2039 with a 1 km x 1km resolution.**

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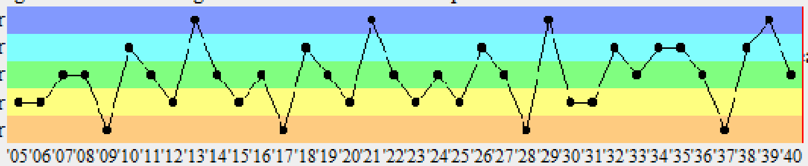
Time frame of the simulation

First year 2005 Last year 2040

Hydrology and Climate Change Model

( ) No Climate Change ( ) Climate Change ( ) User-selected climate pattern



No climate change ——— Climate change

Country development scenarios

Population Growth Rate (%)

Ghana	Burkina Faso
( ) High rate scenario ( ) Medium rate scenario ( ) Low rate scenario ( ) Custom rate scenario 2.0 %	( ) High rate scenario ( ) Medium rate scenario ( ) Low rate scenario ( ) Custom rate scenario 3.0 %

GDP Growth Rate per capita (%)

Ghana	Burkina Faso
( ) High growth scenario (2.5 %) ( ) Medium growth scenario (1.5 %) ( ) Low growth scenario (1.0 %) ( ) Custom rate scenario 1.5 %	( ) High growth scenario (1.5 %) ( ) Medium growth scenario (1.0 %) ( ) Low growth scenario (0.5 %) ( ) Custom rate scenario 1.0 %

Optimize the policy model by maximizing the social benefit of the countries with respect to the water, labor and land constraints

( ) Optimize for Burkina Faso first, then for Ghana

( ) Joint maximization of social benefits of both countries (Integrated Basin-wise)

+ **Policy alternatives**

- expansion of irrigated agriculture
- increase in fertilizer use
- self sufficiency in rice

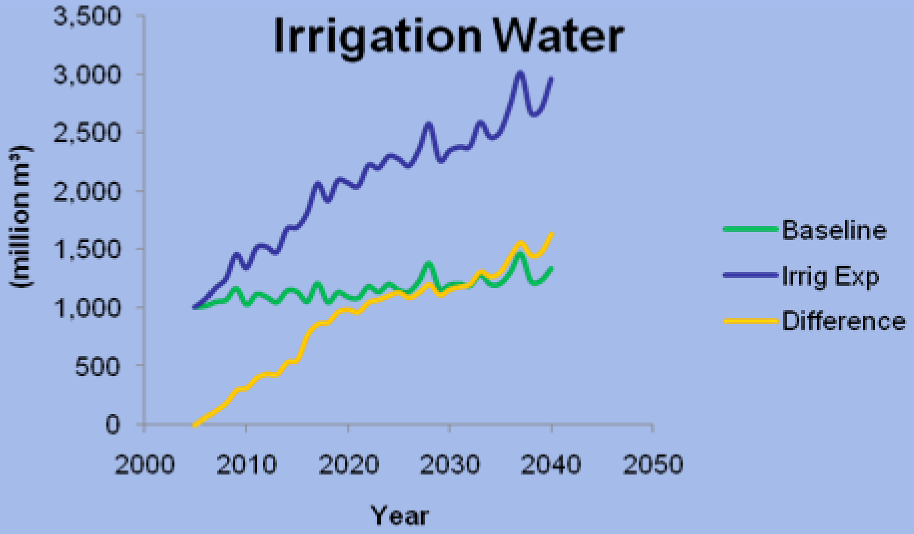
Scenario description

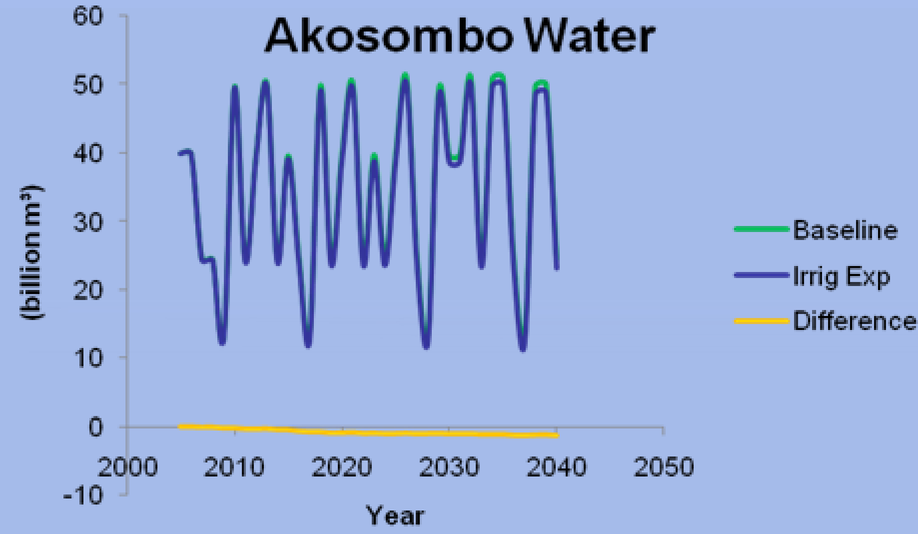
Run models

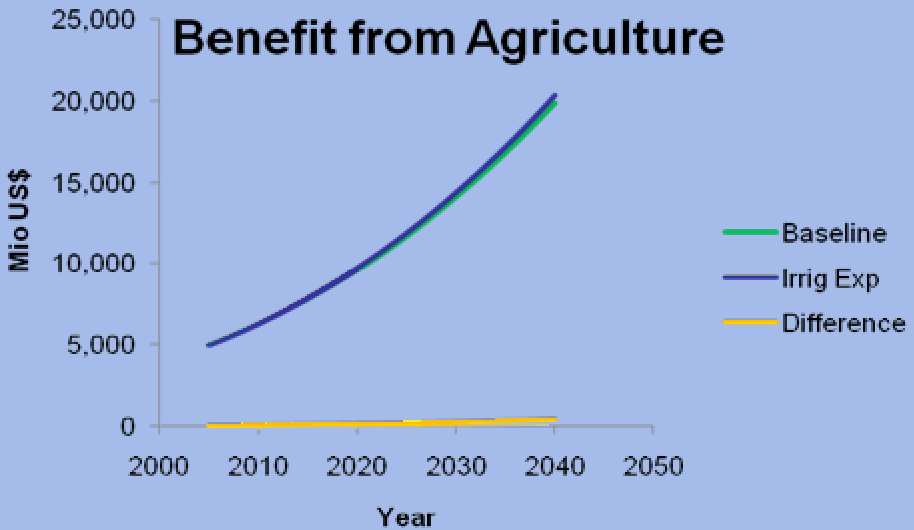
Revert to baseline

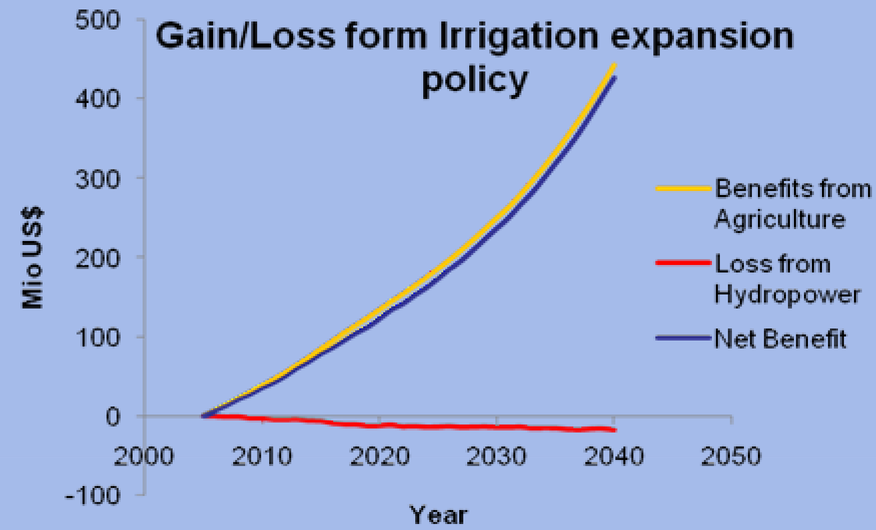
Preset 1

Example: Expansion of irrigated agriculture









Conclusions

- hydrological and economic models combined in a hydro-economic optimization tool

- M^3WATER combines two complex models under a user-friendly interface

- Policies can be tested for their benefit to society, their performance evaluated under different climate scenarios

We wish to thank the German Federal Ministry of Education and Research for their generous support for GLOWA Volta