



The GLOWA-IMPETUS Approach

GLOWA Conference
Ouagadougou, 25th – 28th August 2008



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and about 70 colleagues



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Ministry of Innovation, Science, Research
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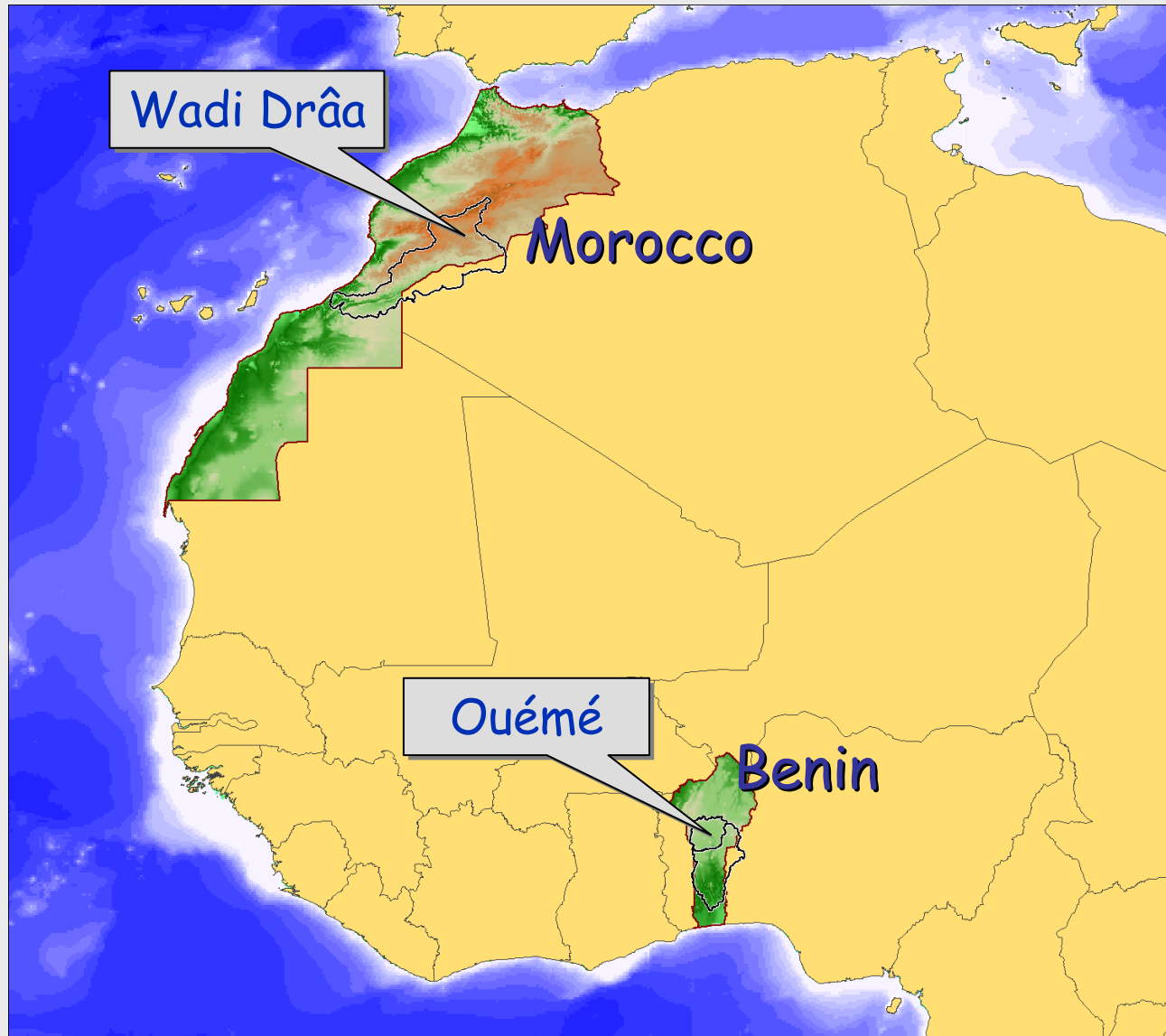


IMPETUS

“An Integrated Approach to the Efficient
Management of Scarce Water Resources
in West Africa”

“Approche Intégrée pour la Gestion Efficace
des Ressources Hydriques Limitées
en Afrique de l’Ouest ”

Choice of Catchments





Motivation

West and Northwest Africa: “hot spots” of Global Change:

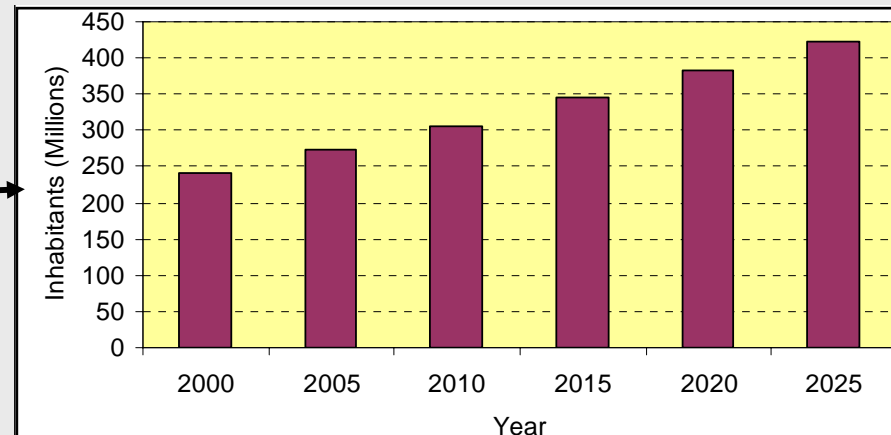
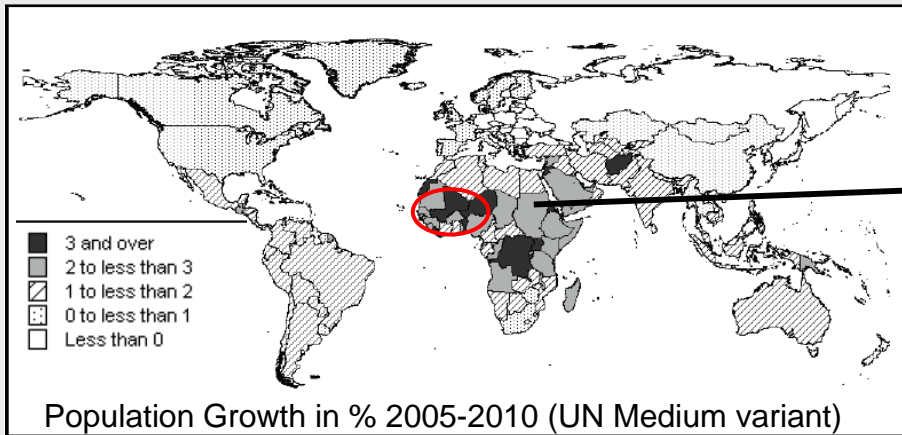
Present situation:

- High population growth & migration
- Sub-Saharan Africa: Rapid land-use change
- Maghreb: Overgrazing, erosion, and salinization of soils
- Sub-Saharan Africa: High mortality due to malaria, diarrhea, and HIV
- Strong natural rainfall variability

Future climate:

- Substantial drying for the Maghreb “likely”
- Rainfall trend for the Sahel and Guinea Coast is uncertain

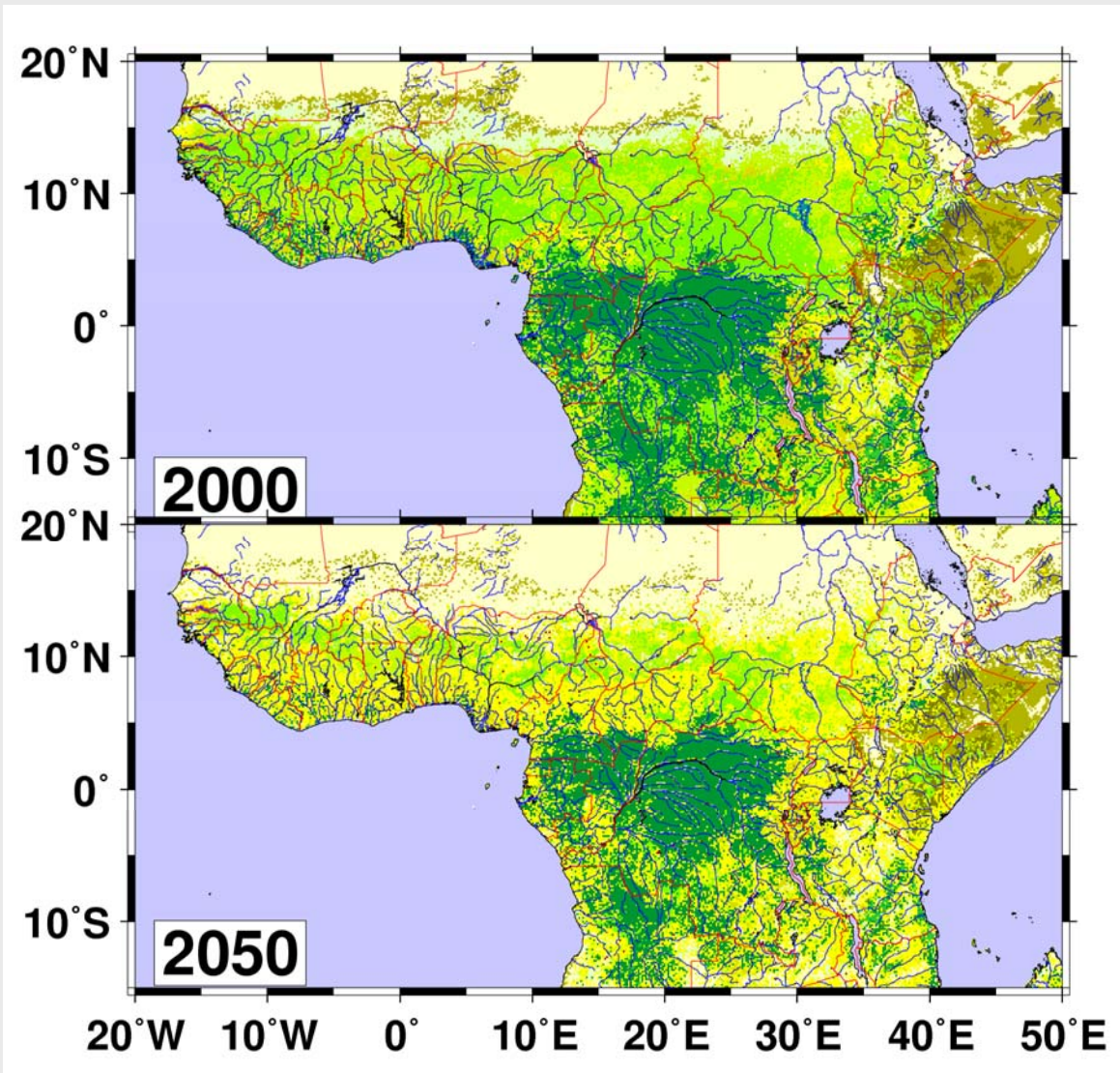
Demographic Changes



Source: United Nations, 2006, 2007

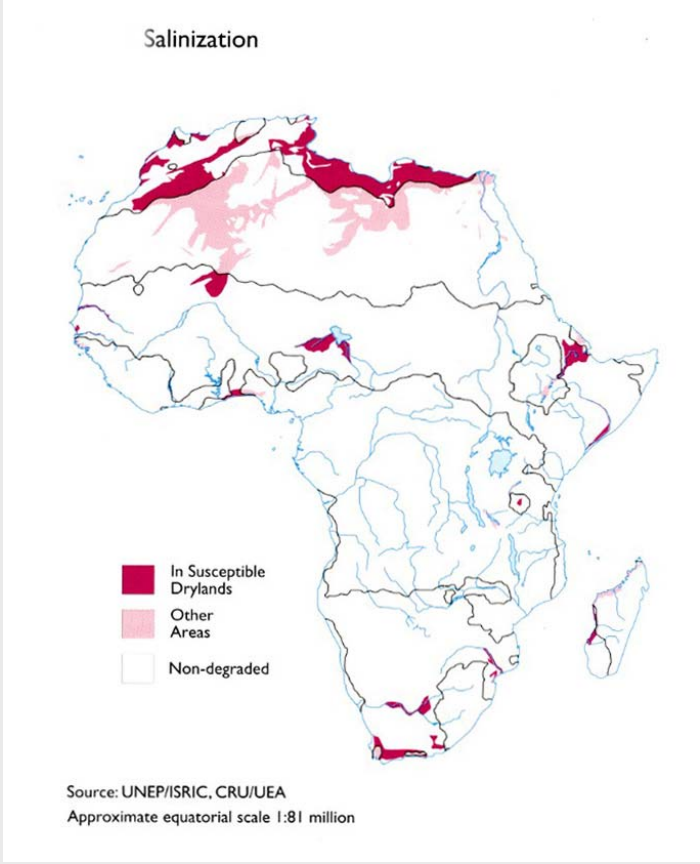
- Sub-Saharan Africa:
Region with the strongest population increase worldwide
- West and Northwest Africa:
Strong migration and urbanization

Land-use Changes in Sub-Saharan Africa



- Substantial loss of biomass and biodiversity
- Shrinking forests along with expanding croplands, especially in the savannah regions of West Africa

Maghreb: Salinization of Soils and Ground Water

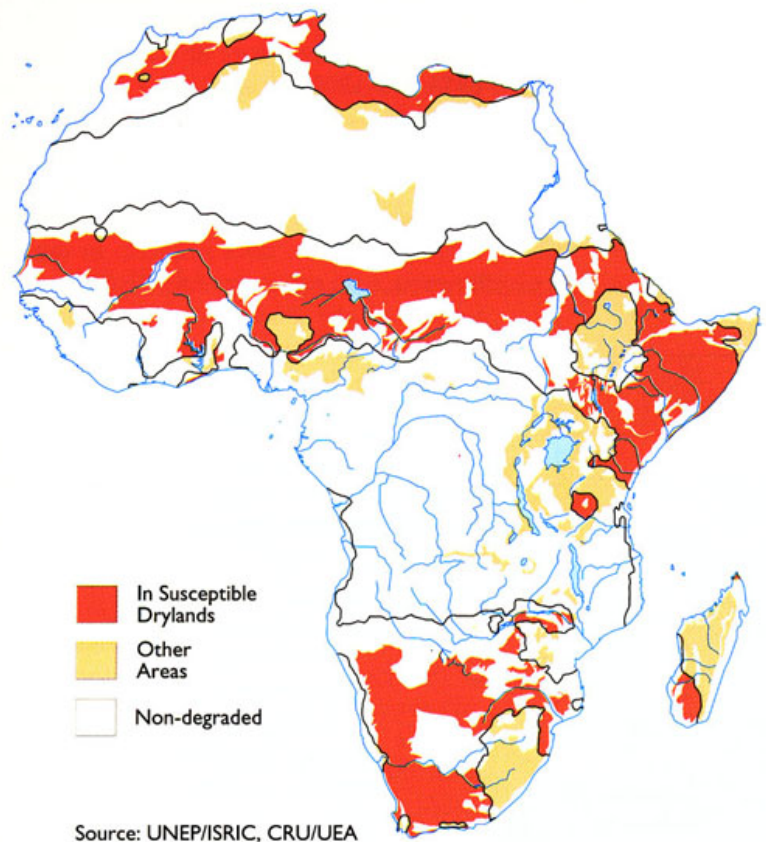


Drâa valley, southern oases

- Irrigation and high evaporation fosters salinization of soils and ground water

Maghreb: Overgrazing and Soil Erosion

Map 2.10 Areas affected by overgrazing



Source: UNEP/ISRIC, CRU/UEA
Approximate equatorial scale 1:81 million



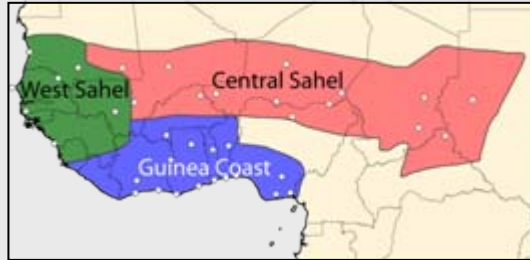
Flood in the High Atlas Mountains



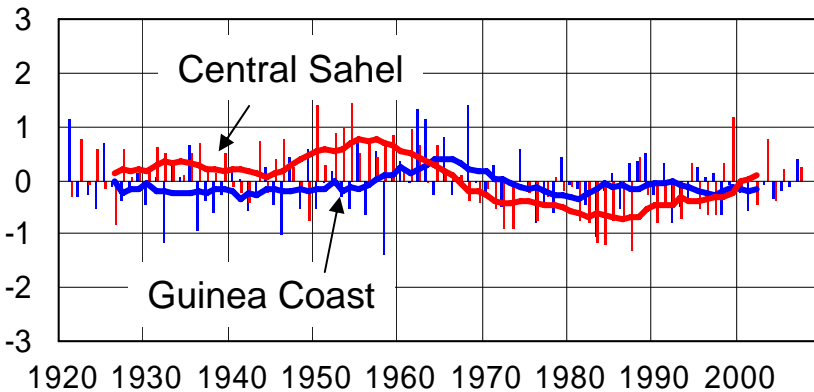
Destroyed bridge in the Anti-Atlas Mountains

Overgrazing -> higher erosion after extreme rainfall -> siltation of reservoirs

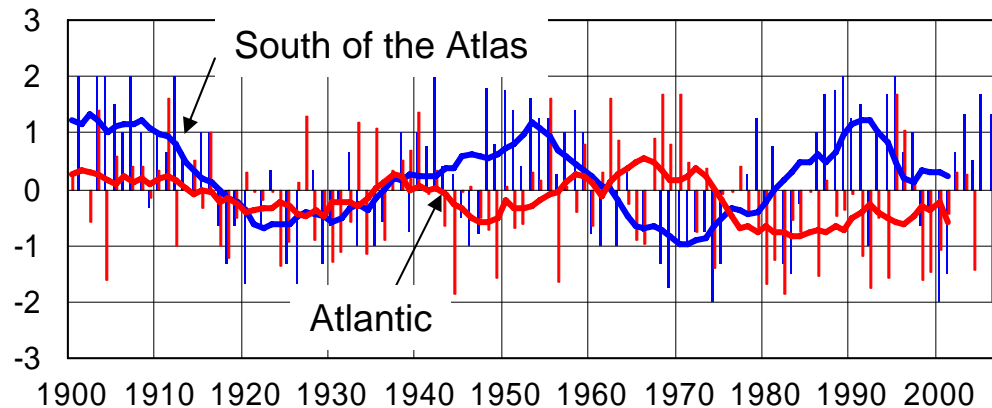
Rainfall Variability in Northwest and West Africa



Rainfall Anomalies West Africa



Rainfall Anomalies Northwest Africa

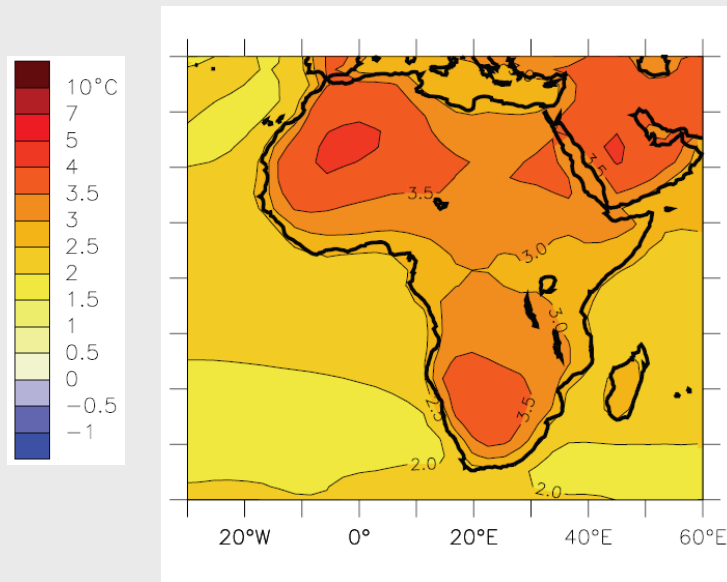


Source: after Fink et al. 2008, IMPETUS Atlas

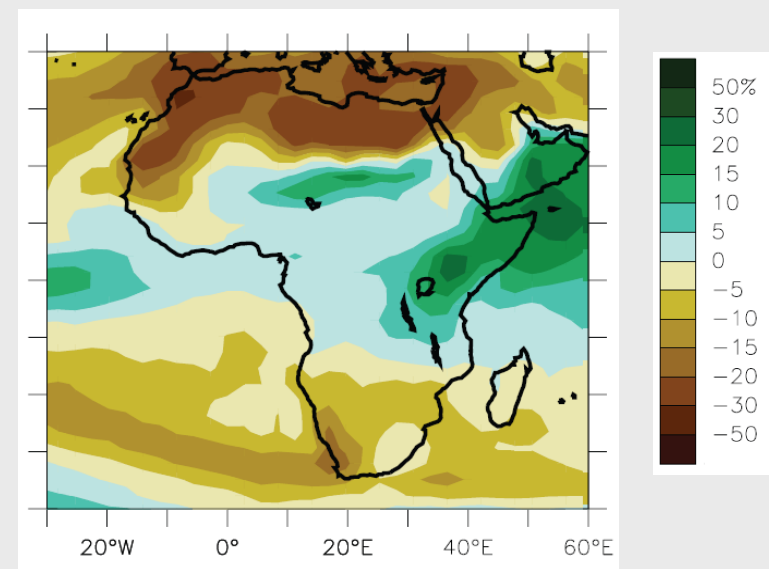
- The regions north and south of the Sahara exhibit a very pronounced, largely natural rainfall variability

IPCC 4th AR Climate Projections

Change in annual temperature (°C)



Change in annual precipitation (%)



Source: IPCC 4th AR 2007

- A warming is “very likely” to be larger than the global annual mean warming throughout the continent and in all seasons
- A “likely” drying trend for North Africa and an uncertain trend in West Africa



Consequences

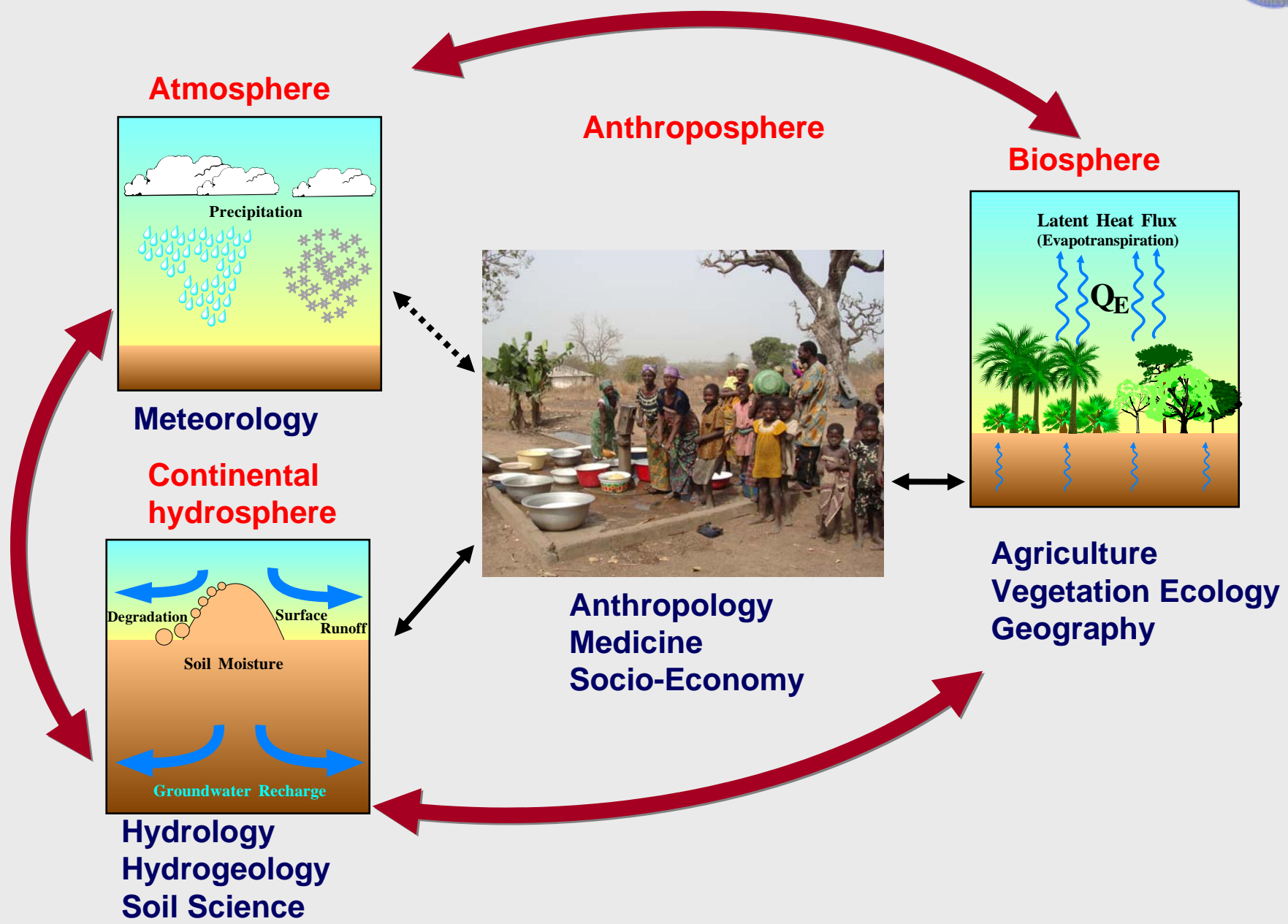
- Reduction of freshwater availability per capita
- Vulnerable food and livelihood security
- Potential changes in the spread of diseases like malaria, meningitis, and diarrhea
- Growing potential of conflicts



GLOWA-IMPETUS GOALS

- Investigation of **complex water-related problems** in a true and broad interdisciplinary approach
- **Development of DSS** based on reliable data, well-adapted models, and on an continuous stakeholder dialogue
- **Capacity development** with respect to the use of
 - the IMPETUS DSS in integrated water management
 - the rich IMPETUS data base
 - the broad IMPETUS research results

Involved "Spheres" and Disciplines



Project Phases: from Science to Application



2006-2009

SDSS, IS, MT
capacity development

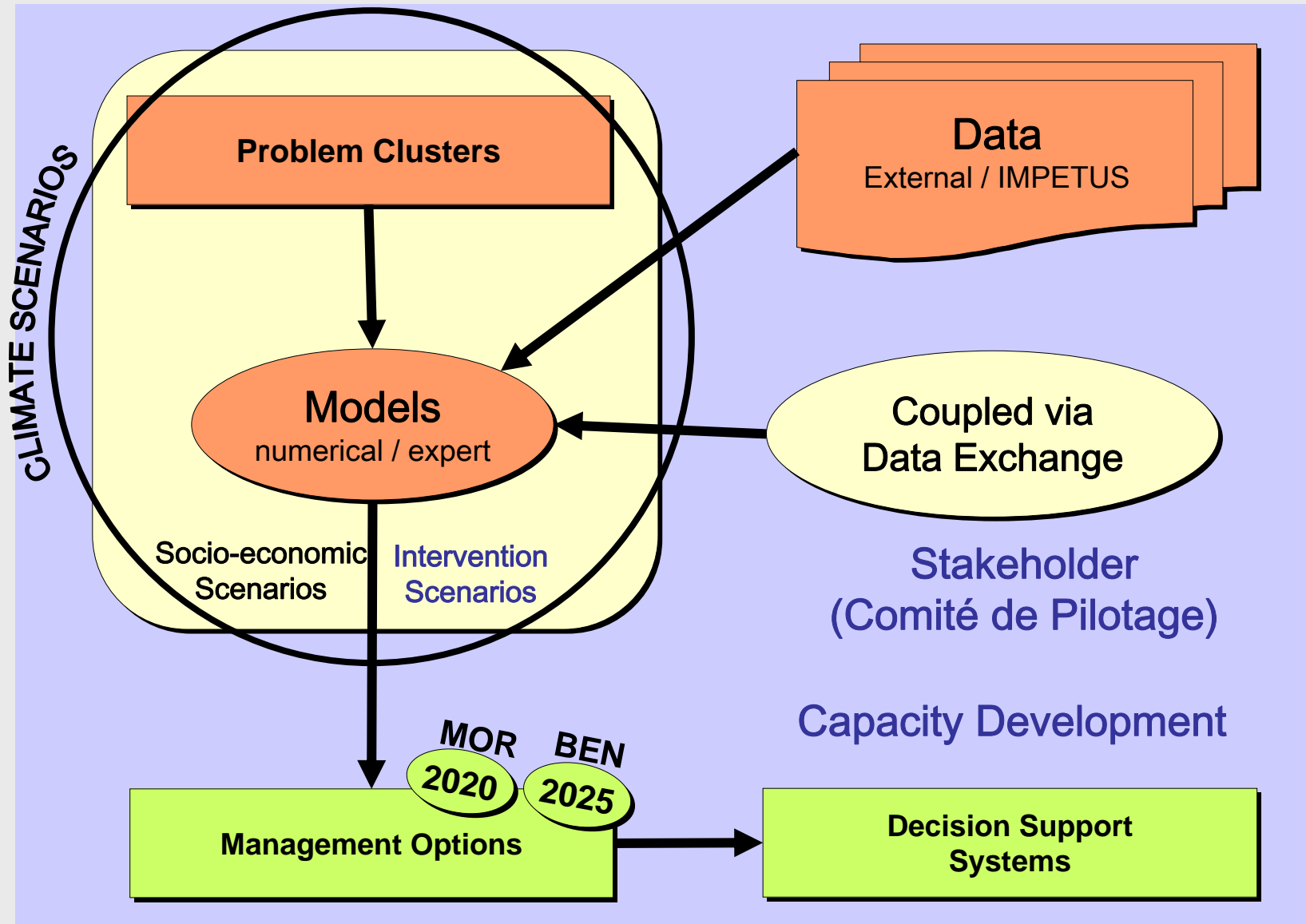
2003-2006

modelling, scenarios

2000-2003

observations, diagnostics

The GLOWA-IMPETUS Approach





Problem Clusters

- **Meta-problems** that require a **multi-disciplinary analysis** in order to allow for drawing conclusions with respect to possible future developments
- Each problem cluster is composed of many single “**thematic complexes**” (= processes or process chains) that reflect the different **disciplinary approaches** involved in this project

➔ **19 (11) Problem Clusters for Benin (Morocco)**

Problem Clusters

The Problem Clusters were stratified into four subject areas:

- (1) Livelihood/Food Security
- (2) Hydrology
- (3) Land Use
- (4) Society and Health

IMPETUS - WEST AFRICA **MOROCCO**

Scheme No. PC Image	Title of problem cluster Short title of problem cluster SDSS/ IS/ MT: Title of SDSS / IS / MT (ACRONYM)
Livelihood Security	
Ma-E.1	Economic aspects of water management in the Drâa valley Economics and water management SDSS: Efficient water distribution in the Drâa oases (MIVAD)
Ma-E.2	Agronomic strategies against water scarcity in the Draa oases Agronomic strategies IS: Agronomic strategies (AGROSIM)
Hydrology	
Ma-H.1	Natural and anthropogenic influences on the dynamics of water resources in the Drâa catchment Water resource dynamics SDSS: Hydrologic model for the water availability in the Upper Drâa catchment (HYDRAA)
Ma-H.2	Interaction between water use and groundwater and soil conditions in the Middle Drâa valley Water exploitation, groundwater and soil SDSS: Interaction between water use and groundwater and soil conditions in the Middle Drâa valley (IWEGS)
Ma-H.3	Seasonal snowmelt runoff forecast for the management of the Mansour Eddahbi reservoir Prognosis of snowmelt runoff MT: Prognosis of snowmelt runoff for the Mansour Eddahbi reservoir (PRO-RES)
Ma-H.5	Impact of climate change and modified water use on precipitation and evaporation Scenarios of precipitation and evaporation SDSS: Possible future developments of evaporation and precipitation for the Drâa catchment (IDEP-Drâa)

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IMPETUS - WEST AFRICA **BENIN**

Scheme No. PC Image	Title of problem cluster Short title of problem cluster SDSS/ IS/ MT: Title of SDSS / IS / MT (ACRONYM)
Food Security	
Be-E.1	Land use and food security resulting from resource scarcity and rainfall variability in Benin Land use and food security SDSS: BenImpact-Crop scenarios for landuse and food supply (BenIMPACT-Crop)
Be-E.2	Effects of land use change, climate change and crop management on soil degradation and crop yield in the Upper Ouémé catchment - Soil degradation and crop productivity SDSS: Soil protection and sustainable use of agricultural resources in the Upper Ouémé Valley (PEDRO)
Be-E.3	Seasonal and long-term precipitation forecast for Benin and applications in agricultural planning Seasonal precipitation forecast SDSS: Seasonal forecast of Sub-Saharan precipitation (PRESAPLUS)
Be-E.4	Sustainable management of small scale barrages for agricultural use Small scale barrages SDSS: System for the sustainable management of small scale barrages (SYMBA)
Be-E.5	Land and water requirements of livestock in Benin Livestock husbandry SDSS: BenImpact-Animal scenarios for land use and food supply (BenIMPACT-ANIMAL)
Be-E.6	Protection of land resources for agricultural use under global change - Sustainable agricultural land use SDSS: Natural and socioeconomic conditions for a sustainable agricultural land use (AGROLAND)
Be-E.7	Agro-ecological potential of Inland Valleys in the Upper Ouémé Catchment Agro-ecological potential of Inland Valleys SDSS: Inland Valley Information System for Benin (BenIVIS)
Hydrology	
Be-H.1	Water availability and water consumption in the Upper Ouémé catchment Water availability in the HVO SDSS: Water availability and water consumption in the Ouémé catchment (BenHydro)
Be-H.2	Water demand in Benin Water demand by sector SDSS: Water demand by sector (BenEAU)
Be-H.3	Satellite-based precipitation monitoring system for applications in agriculture and hydrology - Precipitation Monitoring MT: Precipitation Monitoring (PrecipMon) IS: Information System for Precipitation Variability (PrecipInfo)

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The IMPETUS Socio-economic Scenarios



Benin:

B1: Economic growth and consolidation of decentralization

B2: Economic stagnation and institutional instability

B3: Business-as-usual

Morocco:

M1: Marginalization – non-support of the Drâa region

M2: Rural development in the Drâa region through regional funds

M3: Business-as-usual

The Impetus Climate Scenarios



Scenario X: Process understanding

Scenario Y: Transient climate model predictions
including statistical-dynamical downscaling

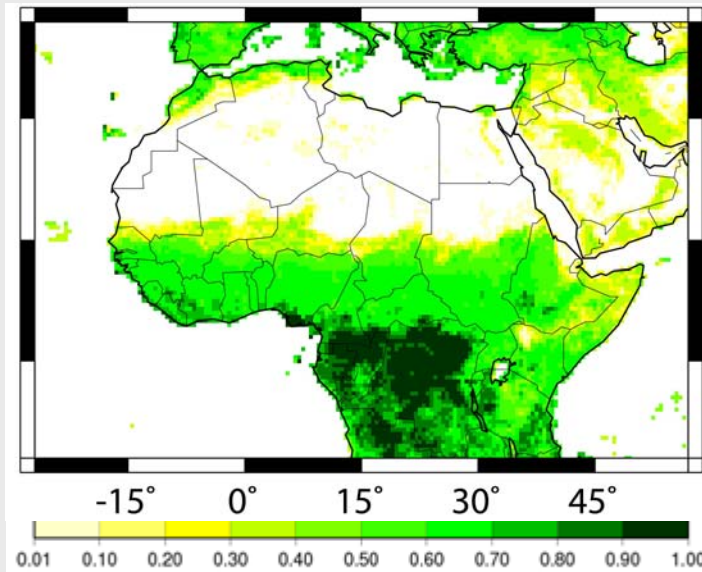
Scenario Z: Persistence of recently observed trends

→ **State-of-the art regionalization of climate change and “post-processing” of climate model data for use in impact modeling**

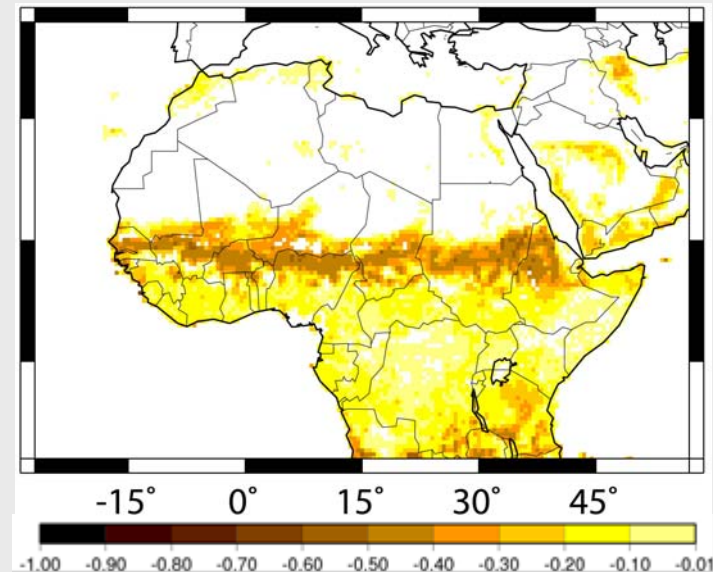
REMO* Land-Use Scenarios



Fractional vegetation cover 2000



Vegetation reduction until 2050



Source: Paeth et al. 2008

Basis of land-use modeling is the reduction in vegetation projected by FAO until 2050

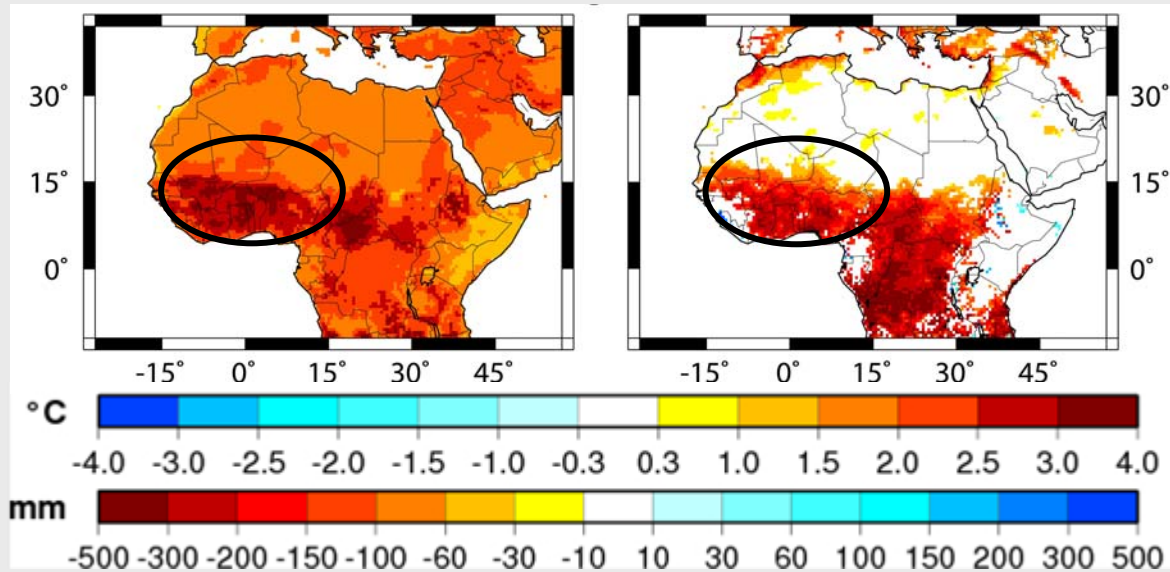
*REMO: Regional Model

REMO Climate Projections until 2050



Temperature change (°C)

Precipitation change (mm)



Source: Paeth et al. 2008

The IPCC A1B climate projections were substantially modified:

West Africa exhibits a **stronger significant warming** and a **significant drying trend**



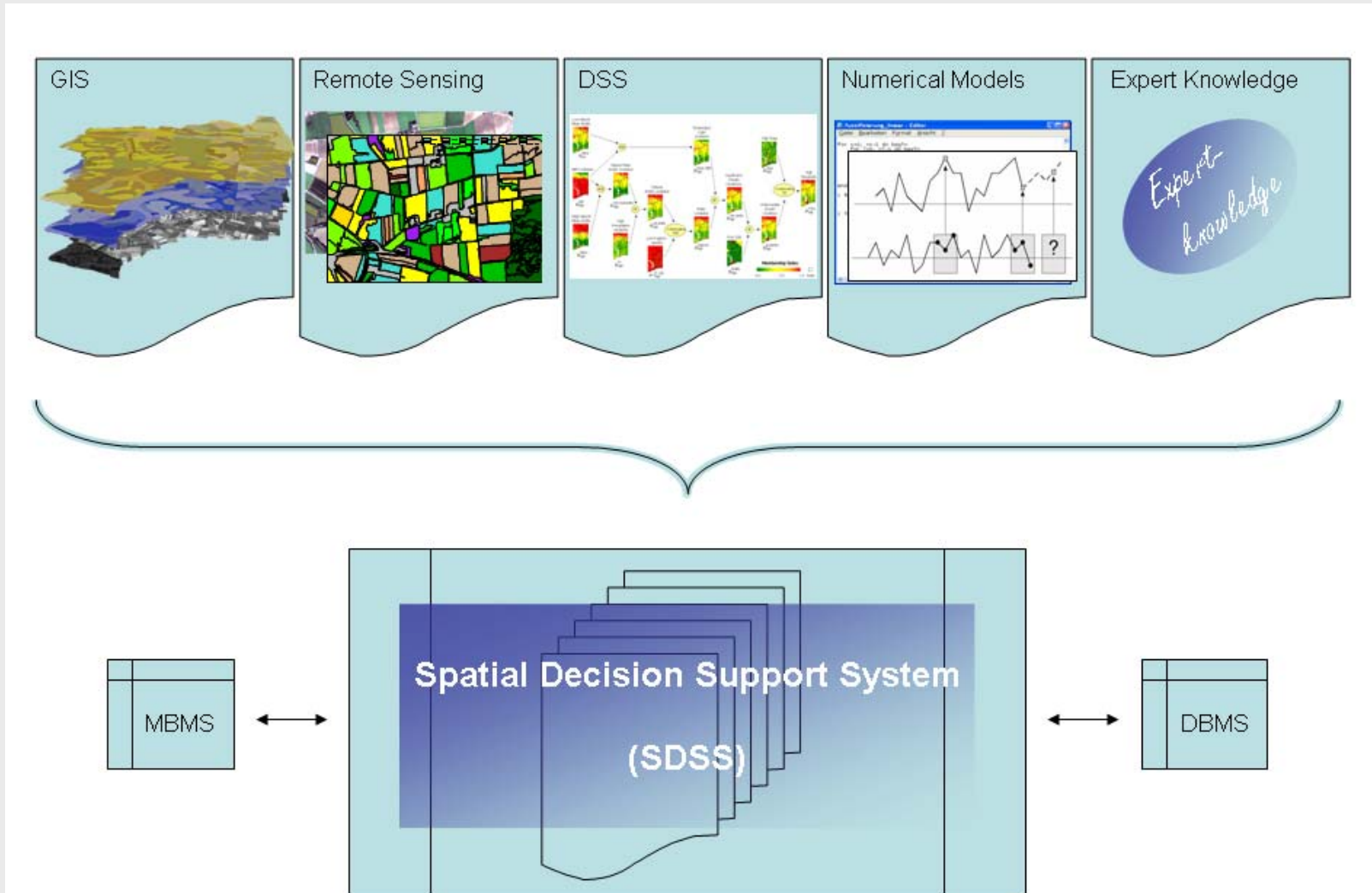
A Major Project Outcome



- Spatial Decision Support System (SDSS)
- Information System (IS)
- Monitoring Tool (MT)

- 19 SDSS / IS / MT have been developed for Benin
- 11 SDSS / IS / MT have been developed for Morocco

Modules of a SDSS



Natural Environment



Upper Ouémé: Forest savannah with inselbergs



Upper Drâa: River oasis and High Atlas divide

Ouémé (Benin)

- sub-humid to humid, bi- / unimodal rainy seasons
- weakly undulated pediplain with isolated inselbergs
- vegetation: forest-savannah mosaic, mostly degraded

Drâa (Morocco)

- arid to semi-arid climate
- heterogonous geologic setting (High Atlas, sedimentary basins, Anti-Atlas)
- sparse vegetation cover (acacia, shrubs, juniperus trees) only dense in the oasis

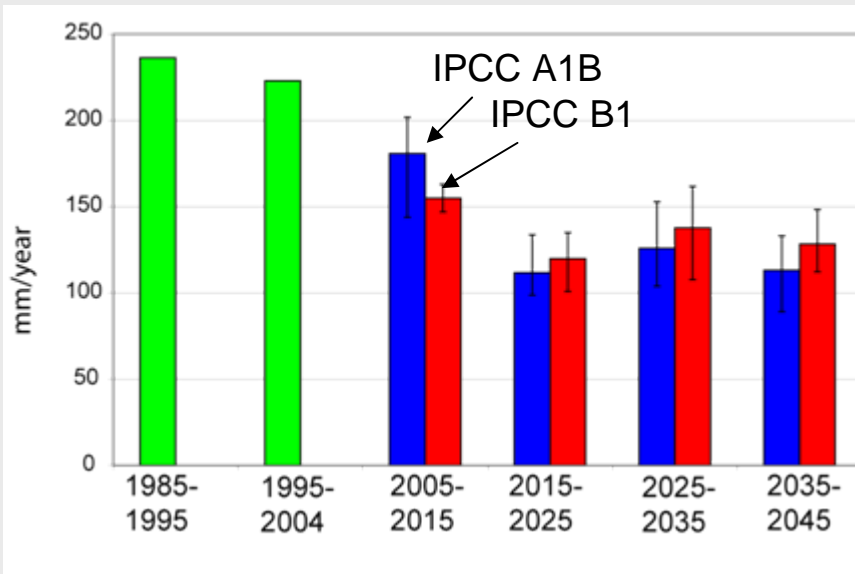


**What has the IMPETUS
approach achieved in the
subject area “Hydrology”?**

Renewable Water Resources in the Ouémé

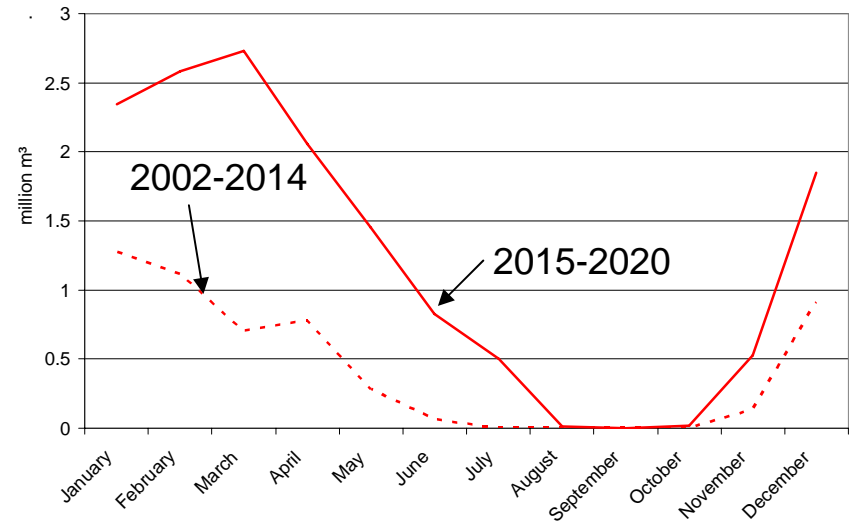


Renewable water resources



Source: Giertz & Dieckrüger, IMPETUS

Unmet freshwater demand (IPCC A1B / IMPETUS B1 scenarios)



Source: Höllermann & Dieckrüger, IMPETUS

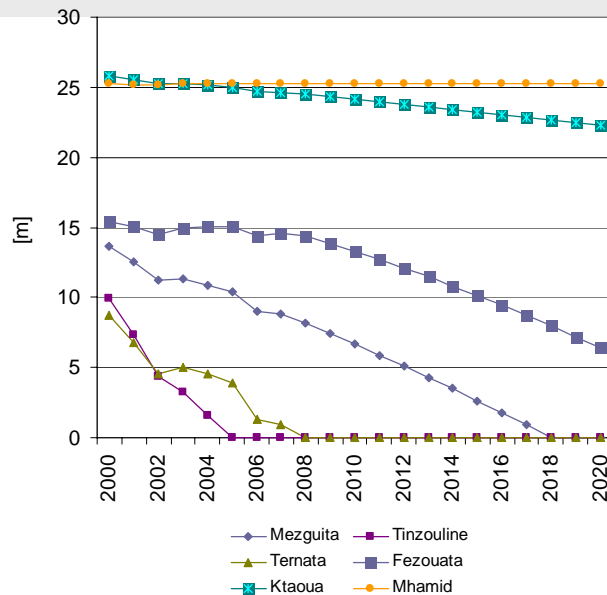
- The renewable freshwater resources in the Ouémé catchment will decline by more than one third until the mid 21st century
- The amount and period of an unmet freshwater demand will increase

Groundwater Levels in the Drâa Oases

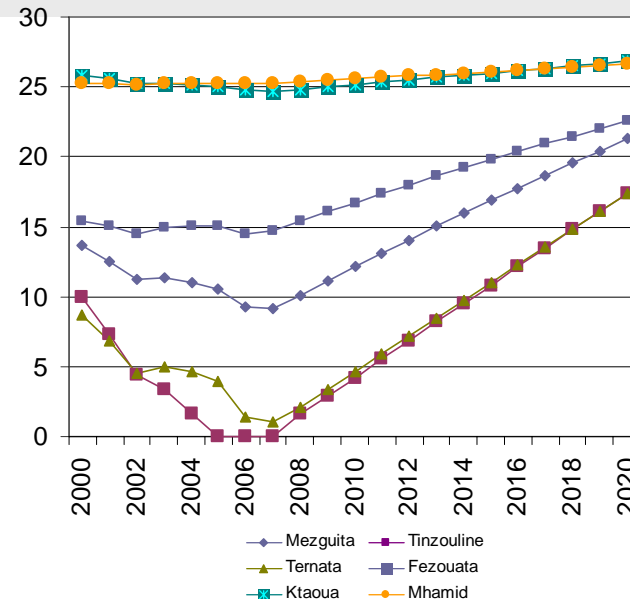


Saturated aquifer thickness for a 10% rainfall reduction until 2020

No intervention



Changed management of reservoir



Source: Reichert & Klose, IMPETUS

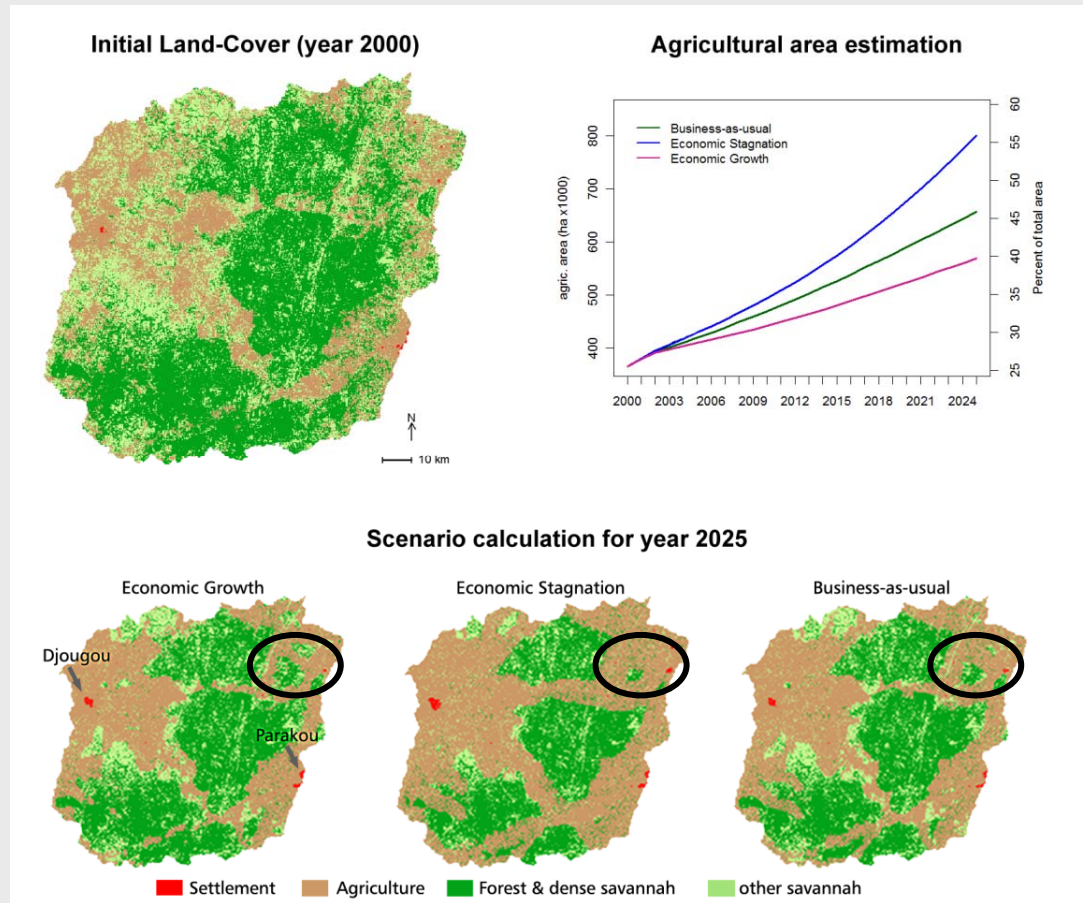
- Complete depletion in the two southern oases of the Middle Drâa valley
- **Intervention scenario:** Adverse impacts can be mitigated by transferring flood runoff directly into the oases without reservoir storage



**What has the IMPETUS
approach achieved in the
subject area “Land-use”?**

Land-Use Change in the Upper Ouémé

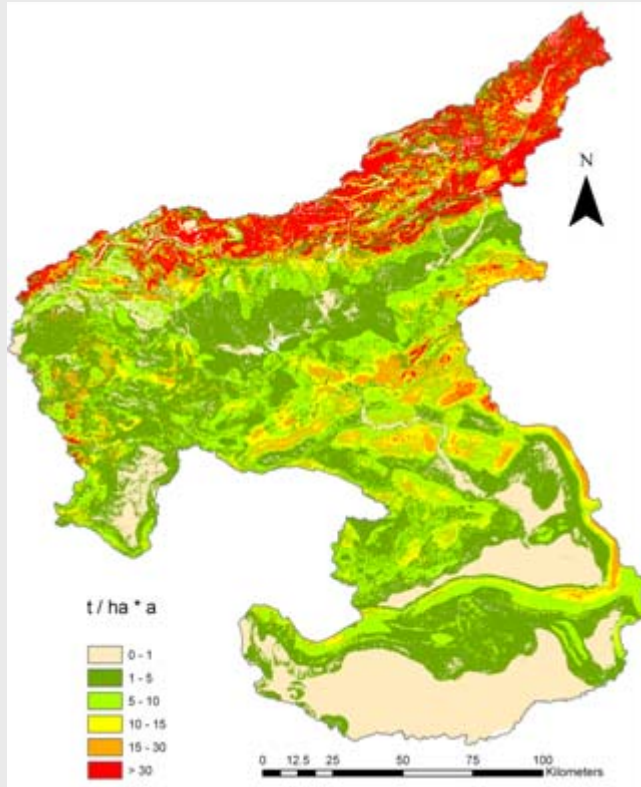
Source: Judex and Thamm, IMPETUS



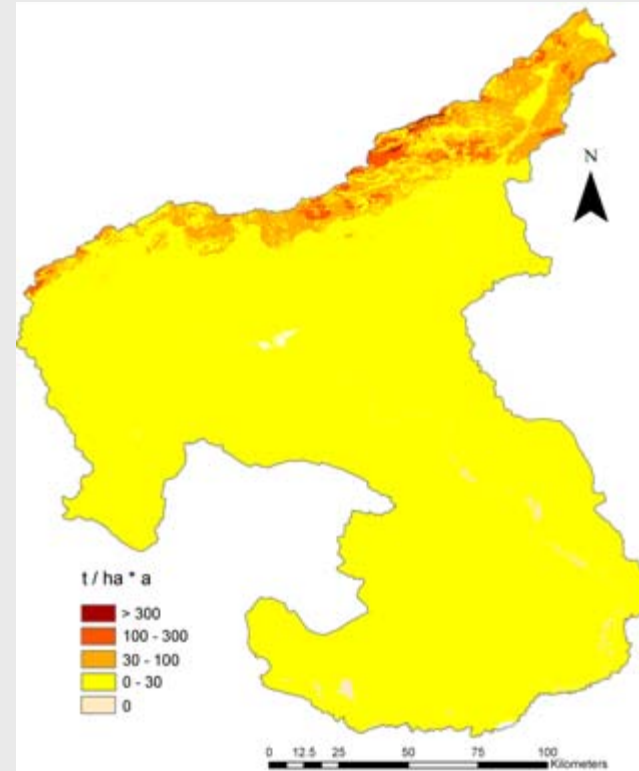
- Modeled increase in agricultural area and a high rate of deforestation near cities and along roads
- Substantial differences among the IMPETUS socio-economic scenarios

Soil Erosion Risk in the Drâa Valley

Status Quo



Increased precipitation variability



Source: Klose and Diekkrüger, IMPETUS

Intervention scenario: Afforestation of 2% of the Upper Drâa catchment with the highest erosion risk yields a reduction of erosion of 1/3.



**What has the IMPETUS
approach achieved in the
subject area “Food Security”?**

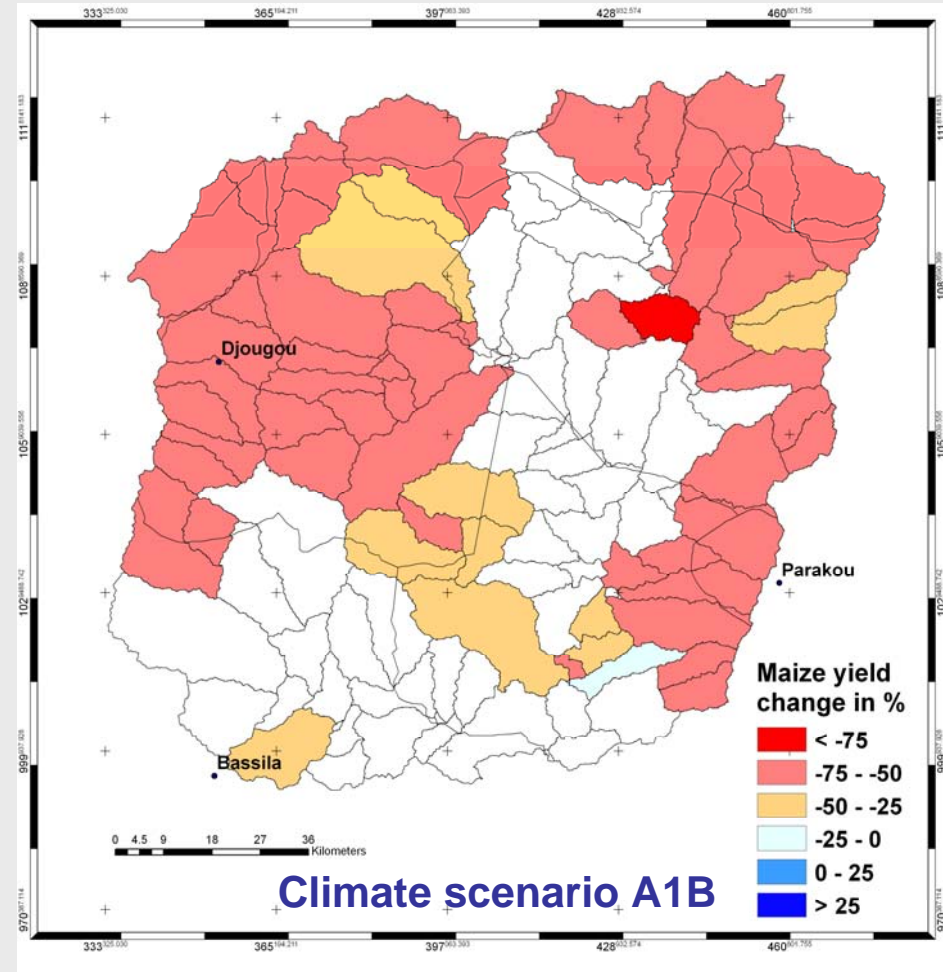
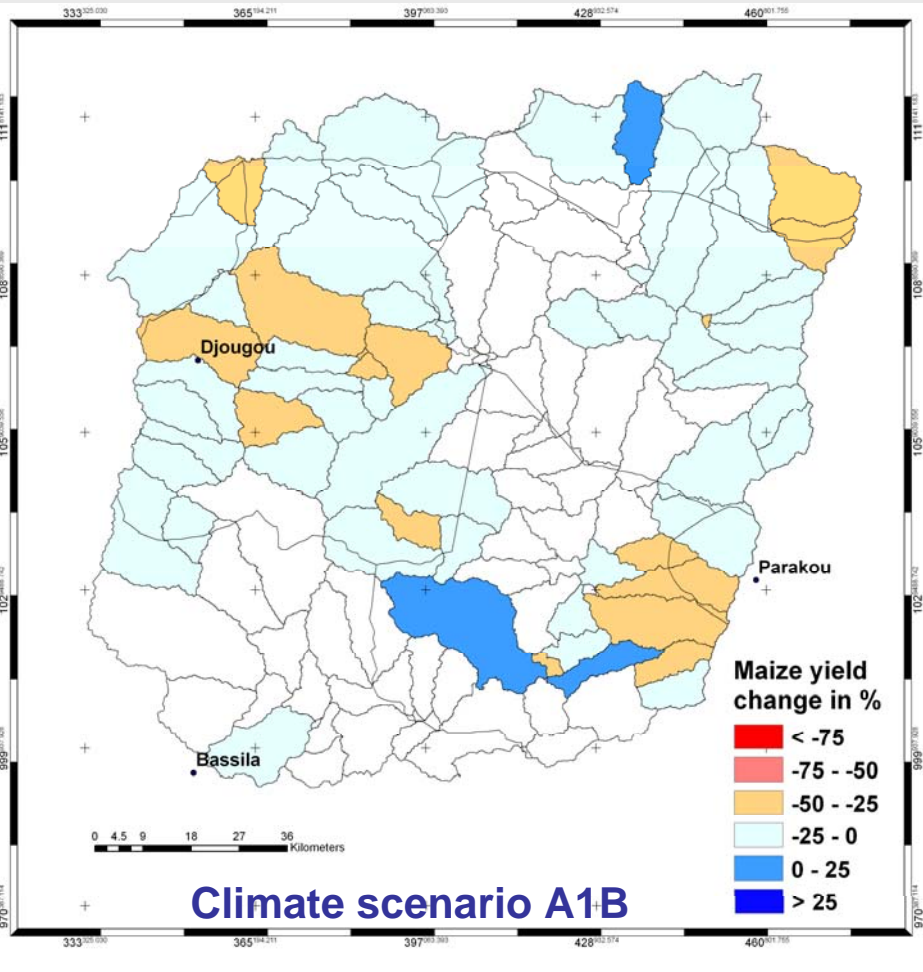


Projections of Maize Yield

(Base period: 2001–2010)

2021–2030

2041–2050



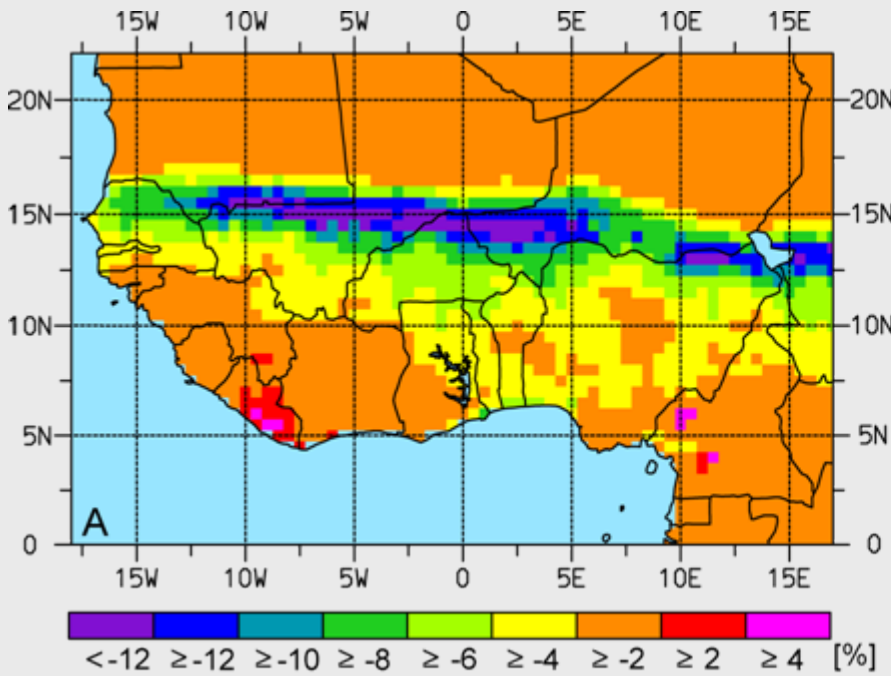


**What has the IMPETUS
approach achieved in the
subject area**

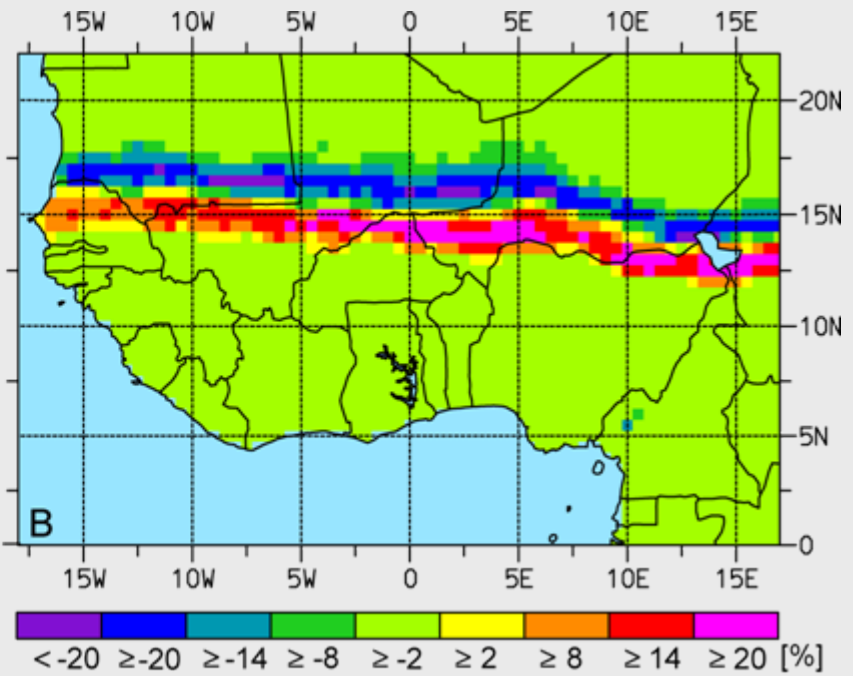
“Society and Health”?

Malaria Occurrence and its Seasonal Variation

Change in prevalence



Shift in epidemic belt



Source: Fink & Ermert 2008, IMPETUS Atlas

- The malaria belt in West Africa will retreat southward
- The epidemic belt moves into the more densely populated, presently endemic area where people may lose their partial immunity



Partners and Research Collaborations

Collaboration with:

- more than 16 (23) partner organizations in Benin (Morocco)
- the major national and international development agencies, as well as with NGOs
- several major (inter-)national research activities
 - HELP
 - AMMA and WARDA in Benin
 - CBTHA and BIOTA-Maroc in Morocco



Stakeholder Dialogue and Capacity Development

- Multi-level stakeholder dialogue
- Sustainable implementation of the achieved knowledge & tools
- Capacity development at various levels
- In total 54 capacity development measures with 891 participants
- About 38 colleagues from partner institutions visited German counterparts or graduated from a German university



Methods and Cooperation: Lessons Learned

- The IMPETUS approach was successful
- Perception of IMPETUS in Benin and Morocco as a “showcase project” of interdisciplinary research
- The IMPETUS approach can be applied to other catchments but it has to be adapted to the local conditions
- Multi-level capacity development of political decision makers, of academic users, and of individuals



Impact of IMPETUS: Past, Present, and Future



Examples of results already applied:

- Agricultural consultants in Benin used the IMPETUS results to enhance potato farming and to identify suitable locations for micro-reservoirs
- HELVETAS constructed several pump wells in Benin – an immediate response to the IMPETUS finding of the large biogeochemical contamination of traditional wells
- IMPETUS climate projections were utilized by the “GTZ” in Benin



Impact of IMPETUS: Past, Present, and Future



Present activities:

- Intense capacity development in both countries in collaboration with our partners to implement and fine-tune the about 30 SDSS/IS/MT
- Handing over the unique bio-geochemical laboratory in Parakou to DGEau to meet their identified demand for this infrastructure in northern Benin

Future:

- Need of sustainable implementation and further development of the IMPETUS SDSS and the models embedded therein



Long-lasting project heritage

- About 30 SDSS/IT/MT
- The digital and print versions of the IMPETUS atlases
- The rich IMPETUS data base mirrored in the partner countries
- Expertise and education gained among African partners



Thank you for your attention

A warm thanks to the numerous IMPETUS colleagues and research partners in Morocco and Benin without whom these achievements would not have been possible



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