NEPAD African Networks of Centers of Excellence

Introduction to Scientific Topics

ACE WATER phase II

Water Resources Unit
Joint research Centre, Italy

OBJECTIVE

Introduce main scientific pillars of interest:

- CC/V (Climate Change/Variability)
- WEF (Water-Energy-Food) nexus
- Groundwater
- Water Governance and Diplomacy
- WCC (Water Crisis and Cooperation) dynamic atlas

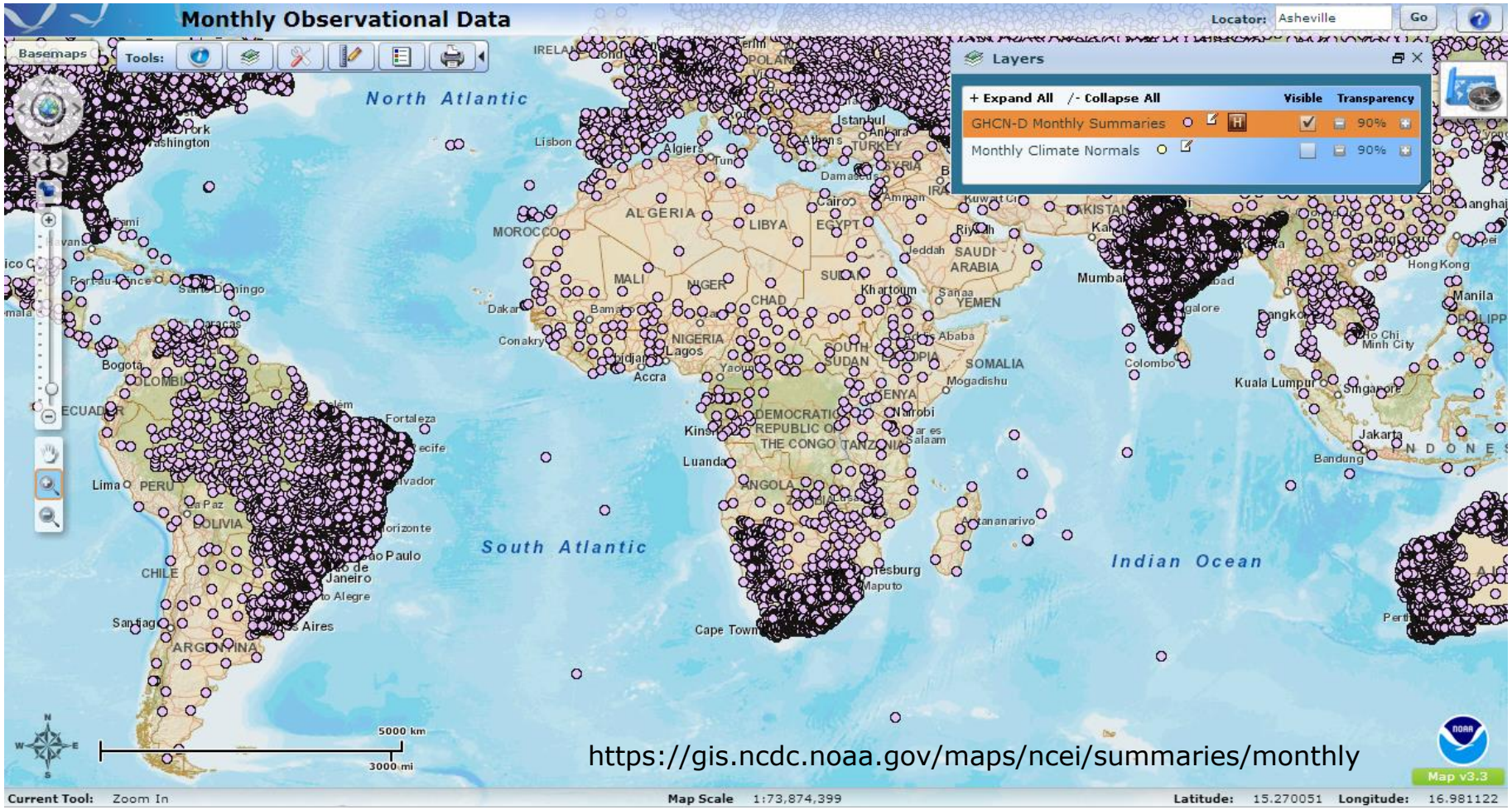
Themes are briefly discussed with reference to sample case studies, methods and tools in the framework of past and ongoing research at JRC. Specific session and discussion on Water Governance and Diplomacy on Wednesday, November 2nd.

REFRAN CV (CLIMATE VARIABILITY)

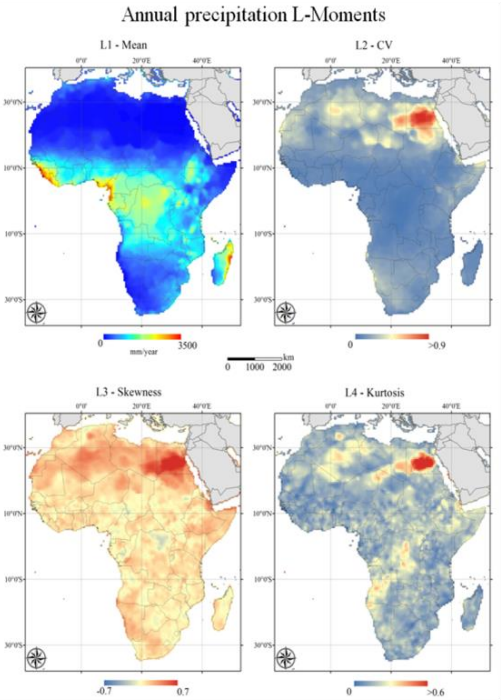
REFRAN is a tool for climate variability analysis, based on following principles:

- A homogeneous region is considered as an area within which rescaled variables in different sites have approximately the same probability distributions;
- All sites can be described by one common probability distribution after the site data are rescaled by their at-site mean;
- Homogeneous regions (grouping of sites/gages) can be determined based on the similarity of the physical and/or meteorological characteristics of the sites (done by performing cluster analysis);
- Hosking and Wallis (1997) proposed a statistical test for testing the heterogeneity of the proposed homogeneous regions;
- L-moment statistics can then used to estimate the variability and skewness of the regional data and to test for heterogeneity as a basis for accepting or rejecting the proposed region formulation.

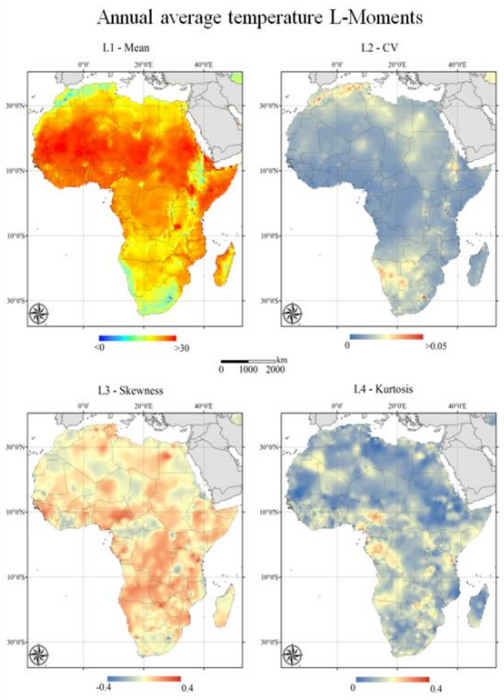
REFRAN CV: case study with NOAA Climate Data



REFRAN CV: YEARLY FREQUENCY ANALYSIS



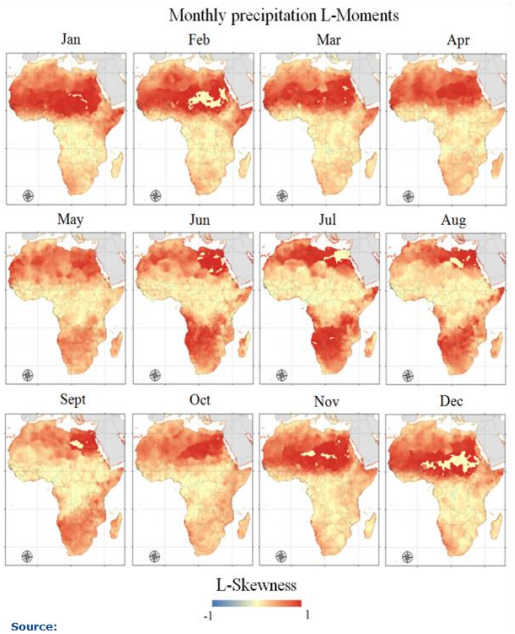
Available at monthly or annual scale



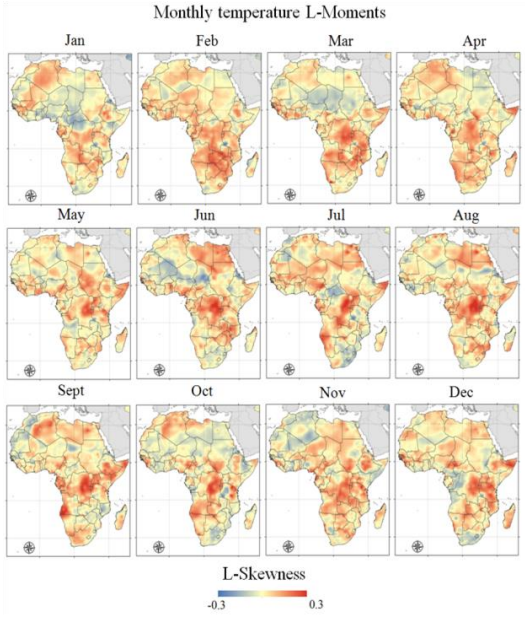
L-moment ratio (L-cv) measures a variable's dispersion, L-skewness the asymmetry of the samples distribution, L-kurtosis whether the samples are peaked or flat relative to a normal distribution

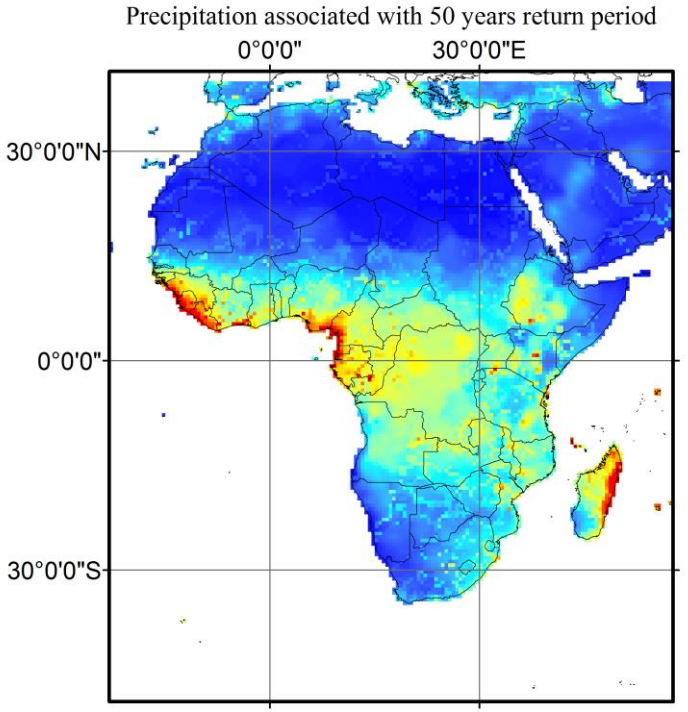
- Maeda, E.E., Arévalo, J., Carmona-Moreno, C. (2012). Characterization of global precipitation frequency through the L-moments approach. *Area-Royal Geographical Society*. doi: 10.1111/j.1475-4762.2012.01127.x JRC66941 http://onlinelibrary.wiley.com/doi/10.1111/j.1475-4762.2012.01127.x/abstract
- Hosking, J. R. M., and Wallis, J. R. (1997). Regional frequency analysis: an approach based on L-moments. Cambridge University Press, Cambridge, U.K.

REFRAN CV – MONTHLY FREQUENCY ANALYSIS



Source:
Maeda, E.E. et al "Characterization of global precipitation frequency through the L-moments approach". AREA- Royal Geographical Society





Return periods can be generated for both excess and deficit (flooding and drought risks) conditions and analysis of climate scenarios performed over 20-30 years time horizon

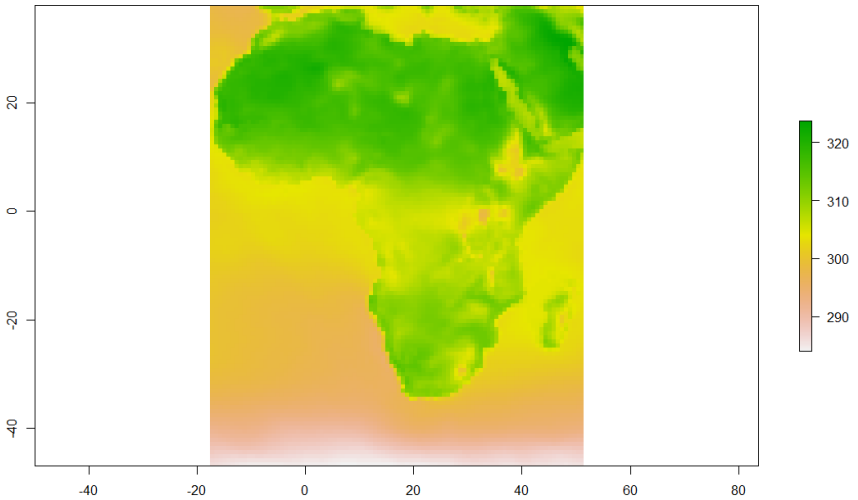
REFRAN CV – RELEVANCE AND ADVANTAGES

- Main objective of Refran-CV is to process time series of data from ground meteorological stations (precipitation data), in order to generate spatially-explicit products (return period maps) based on the L-moments statistics.
- This tool and the associated products at local and regional scale can be used in the development planning process and, concretely, to prepare investment in multi-purpose (irrigation, flood and drought prevention, environment protection) hydraulic infrastructure. L-moments statistics are used to estimate the probability distribution function of precipitation data.
- The L-moments have the advantage of being less susceptible to the presence of outliers and performing better with smaller sample sizes. This is of particular interest in the case of datasets where the time series lengths are heterogeneous.

HEAT WAVE MAGNITUDE INDEX (HWMId)

- The Heat Wave Magnitude Index daily (HWMId), recently defined by Russo et al. 2015, has been employed to detect heat waves for the period 1981-2015 across Mekrou river basin (transboundary – Benin, Burkina Faso, Niger - right tributary of Niger river).
- The HWMId is a simple numerical indicator that takes both the duration and the intensity of the heat wave into account. Basically, the magnitude index sums excess temperatures beyond a certain normalized threshold and merges durations and temperature anomalies of intense heat wave events into a single indicator, according to the methodology described in Russo et al. 2015.
- The HWMId is defined as the maximum magnitude of the heatwaves in a year. Specifically, a heatwave is defined as a period ≥ 3 consecutive days with maximum temperature above a daily threshold calculated for a 30-year long reference period. The threshold is defined as the 90th percentile of daily maxima temperature, centered on a 31 day window.
- The HWMId computations requires at least a 30-year time series of daily temperature records.

Temperature: ERA-INTERIM dataset



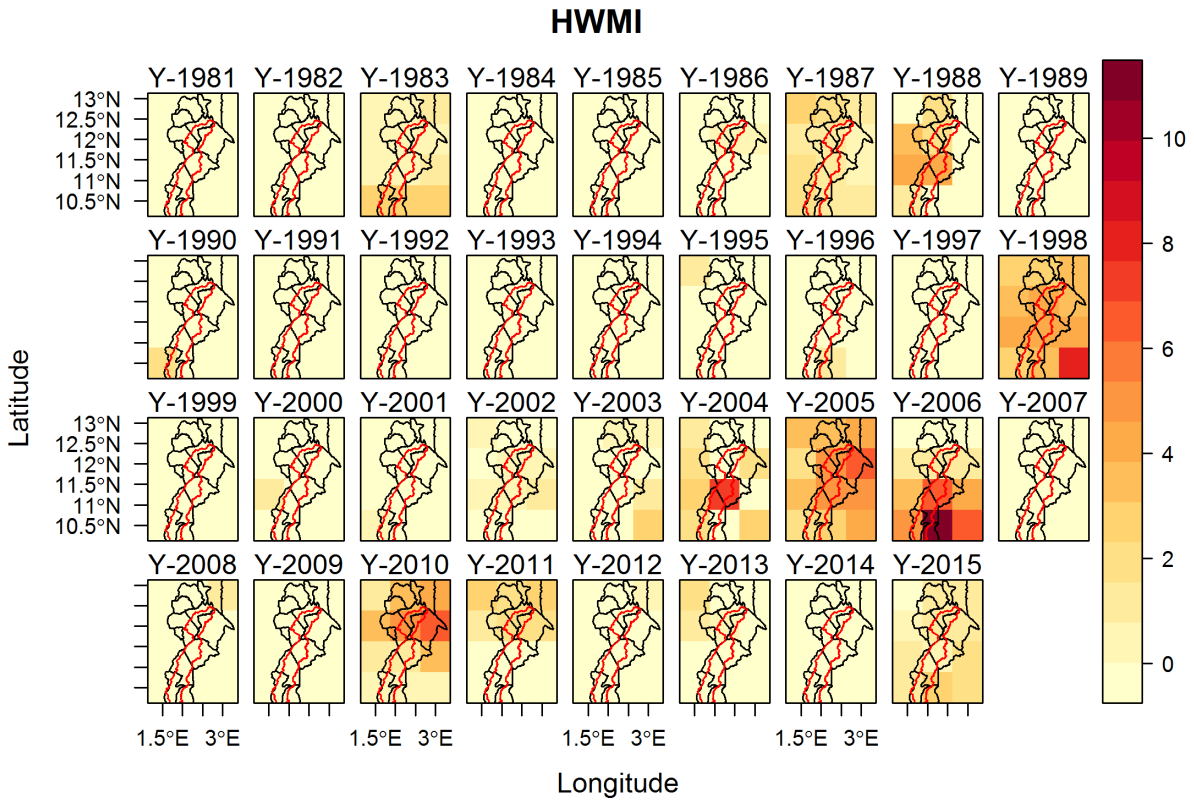
ERA-INTERIM is a combination of observations and climatological models to produce a single, uniform global data set, thus enabling a homogeneous coverage of Africa.

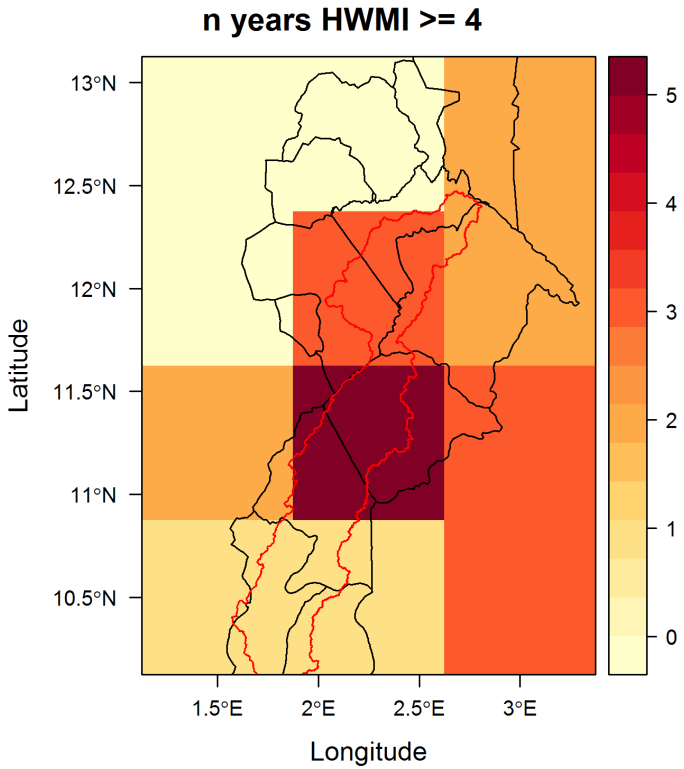
Temporal resolution = 1 day

Spatial resolution = 80 km

Timespan = 30+ year

ANNUAL HEAT WAVE MAGNITUDE INDEX FOR MAXIMUM DAILY TEMPERATURES





Mekrou transboundary basin

Joint Research Centre

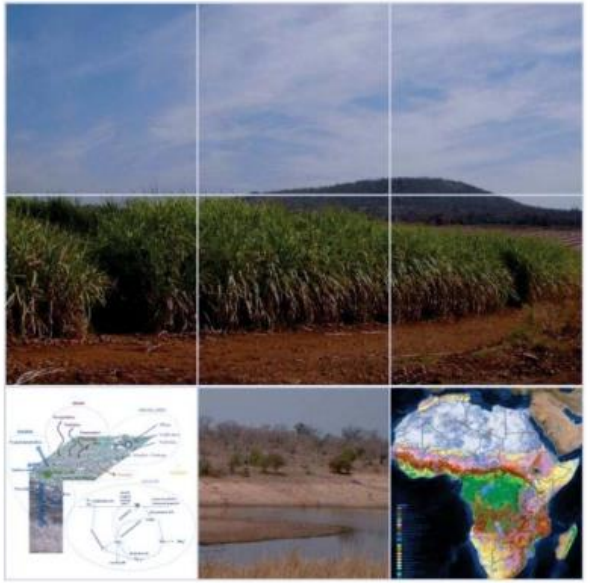
WEF – GISEPIC AFRICA

JRC Scientific and Technical Reports

GISEPIC AFRICA: A modeling tool for assessing impacts of nutrient and water use in African agriculture

Database, Model and GIS System development and testing

Marco Pastori, Fayçal Bouraoui, Alberto Aloe, Giovanni Bidoglio



2 November 2016

WEF – GISEPIC (EPIC-ARCGIS COUPLING)

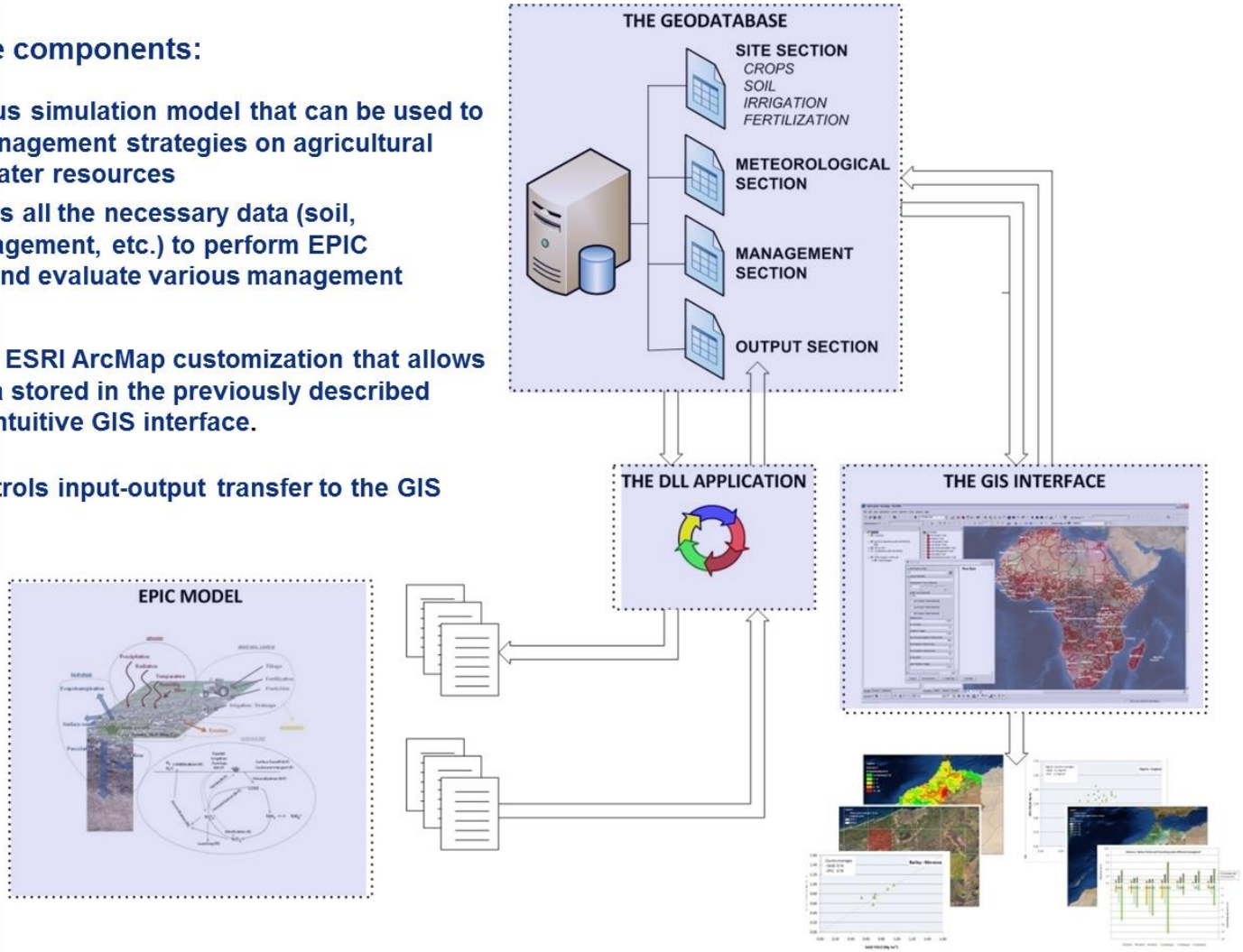
It is composed of three components:

EPIC model: a continuous simulation model that can be used to determine the effect of management strategies on agricultural production and soil and water resources

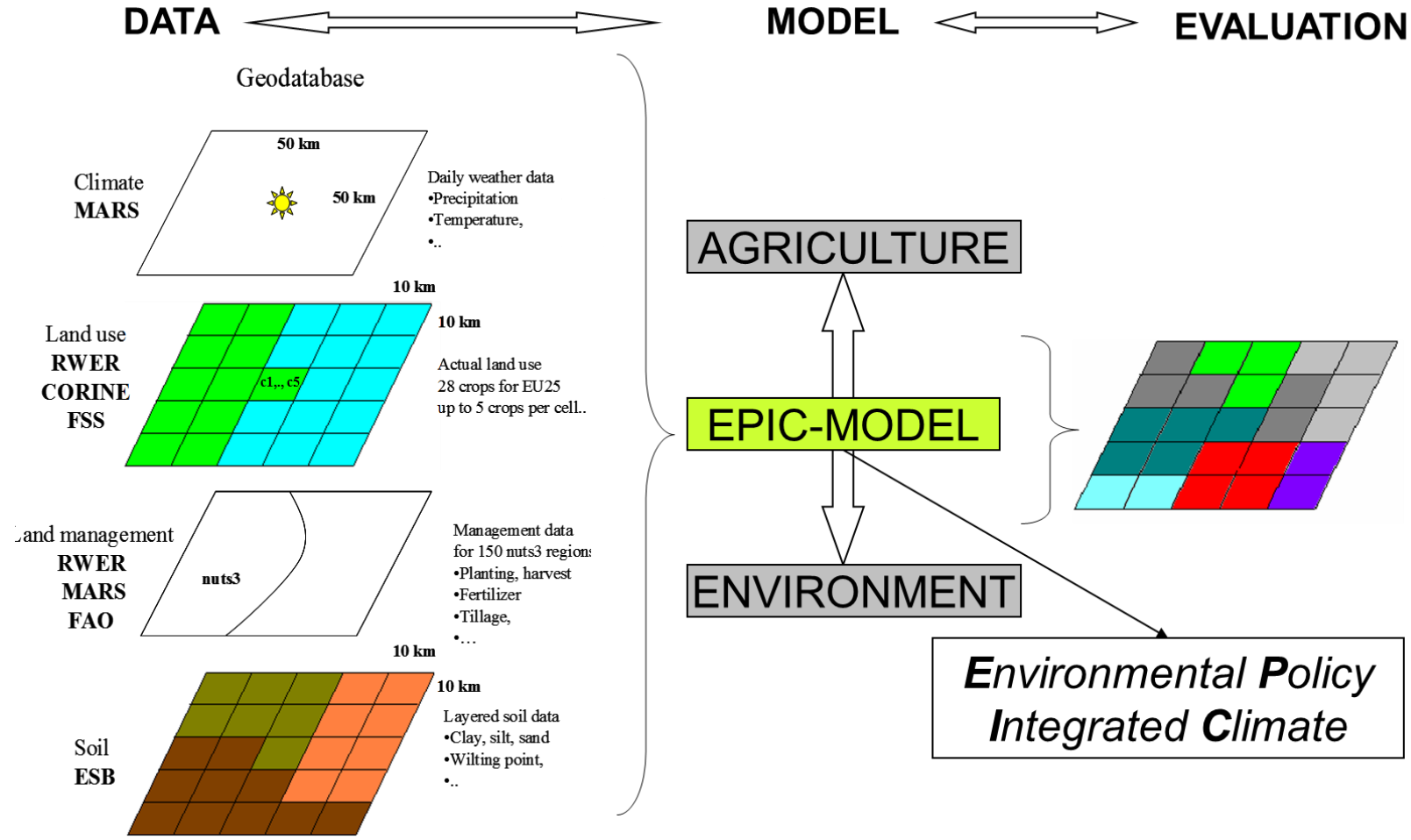
The Geodabase: it holds all the necessary data (soil, meteorological, crop management, etc.) to perform EPIC simulations to formulate and evaluate various management scenarios

GIS Interface. This is an ESRI ArcMap customization that allows the use of EPIC using data stored in the previously described geodatabase through an intuitive GIS interface.

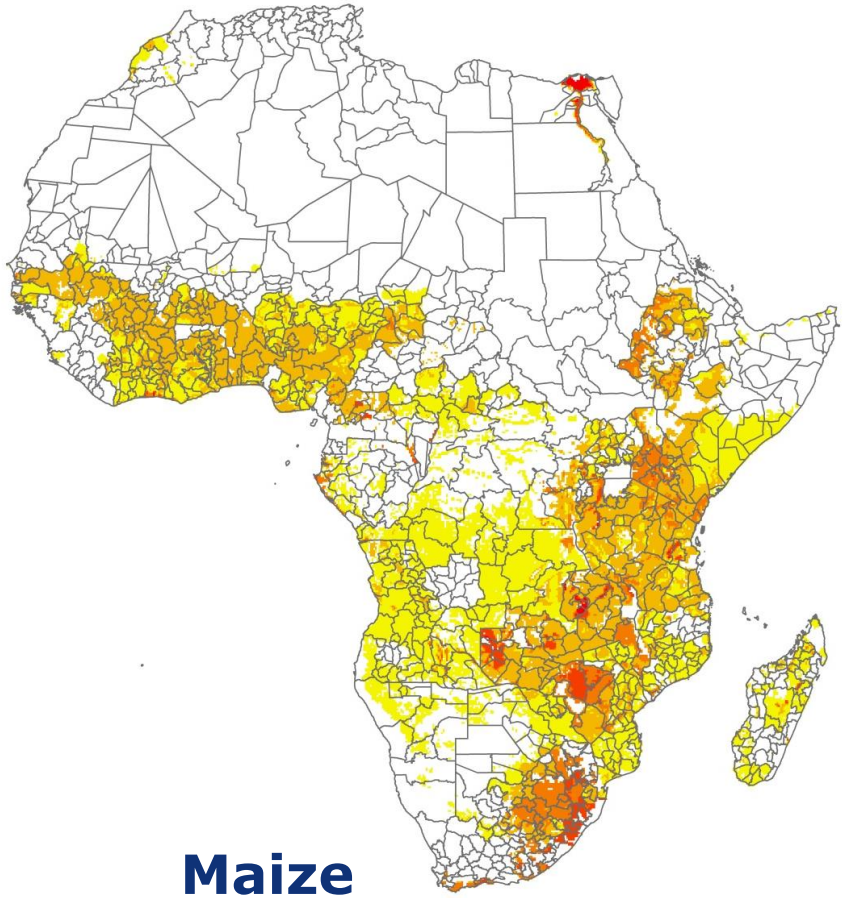
A dll component. It controls input-output transfer to the GIS



WEF – GISEPIC CONCEPTUAL FRAMEWORK



GISEPIC – YIELD PREDICTION



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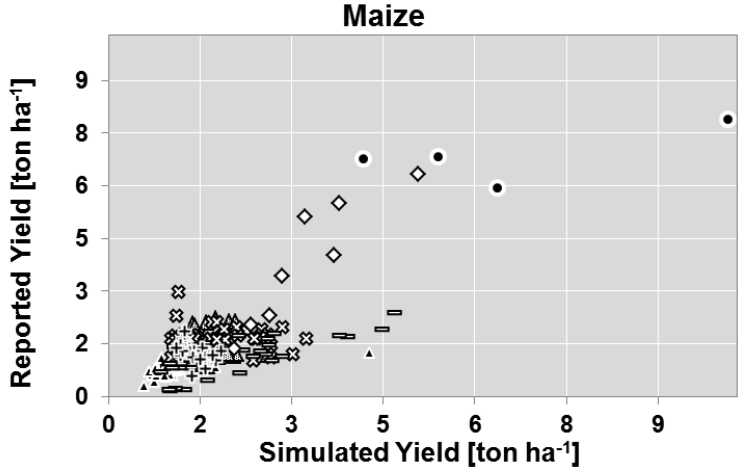
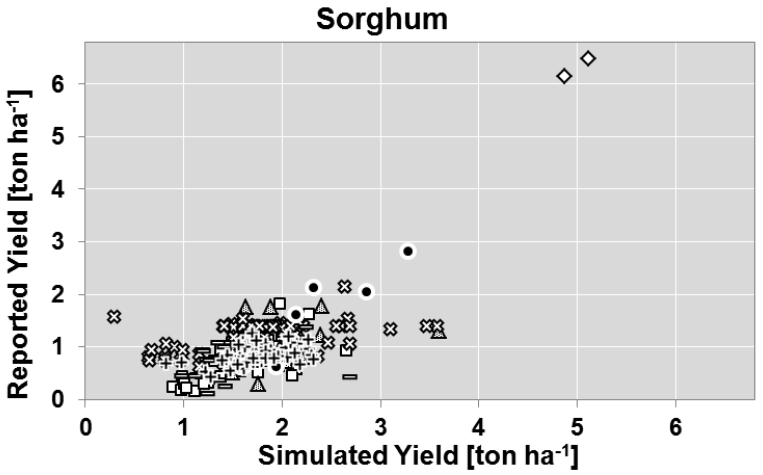
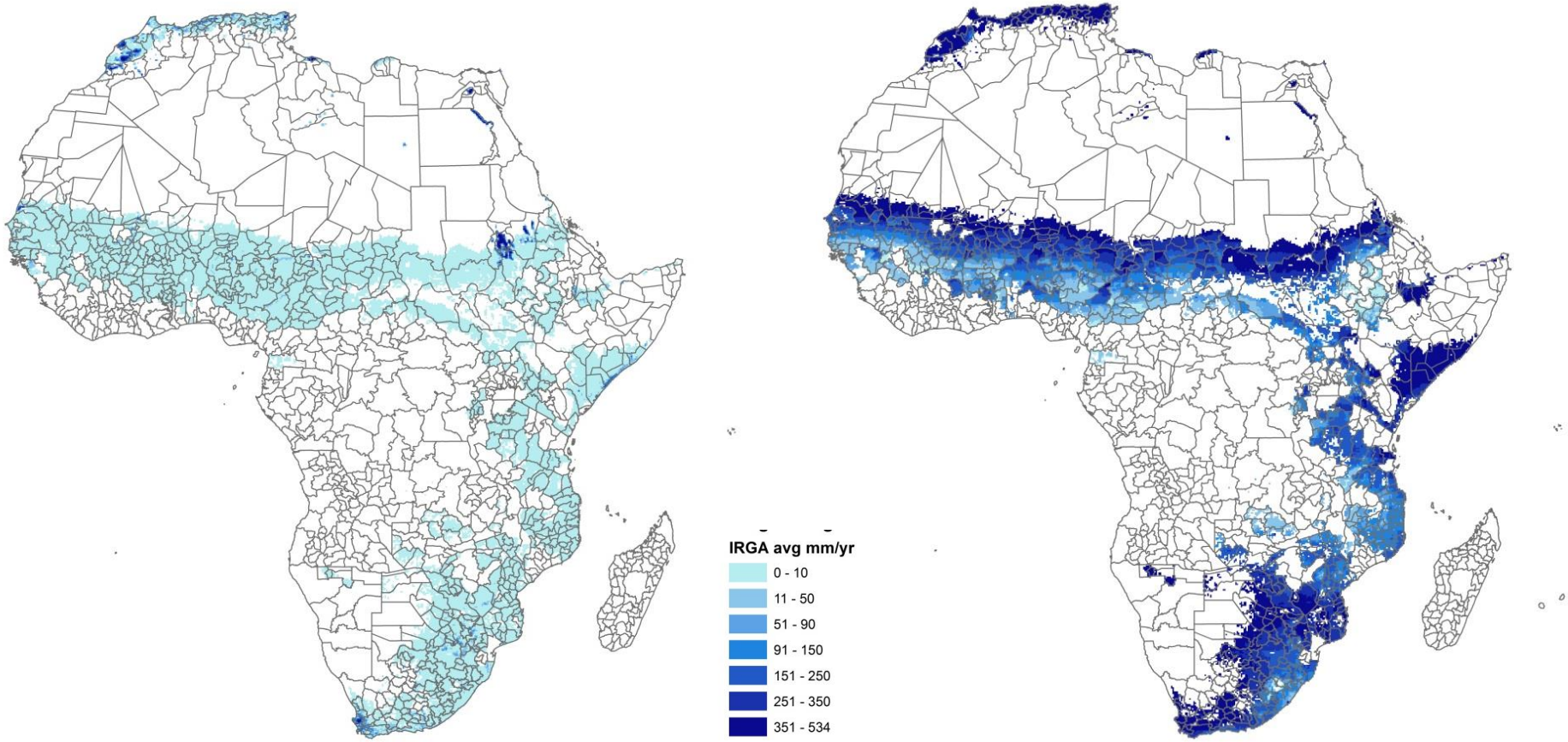




GISEPIC – CROP IRRIGATION DEMAND



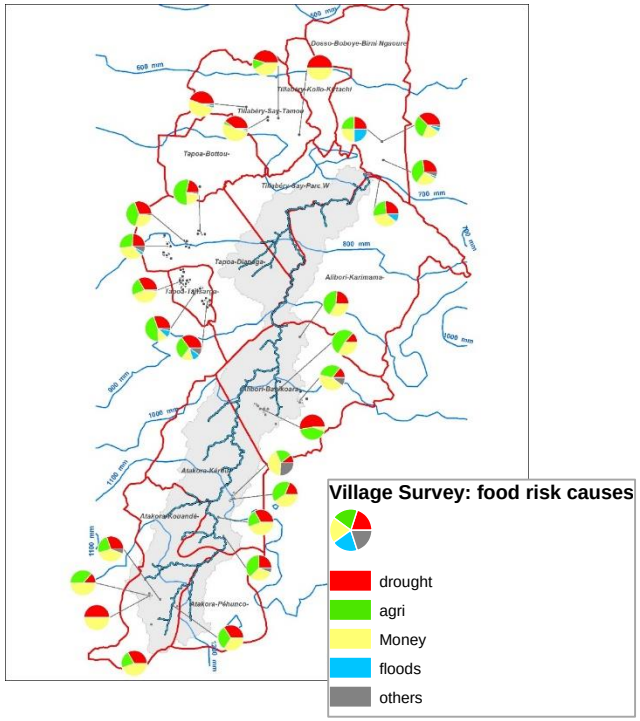
Current scenario

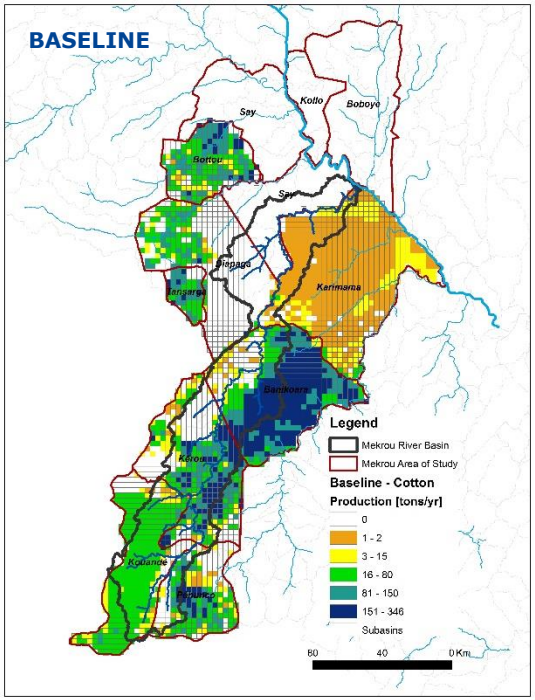
Potential scenario

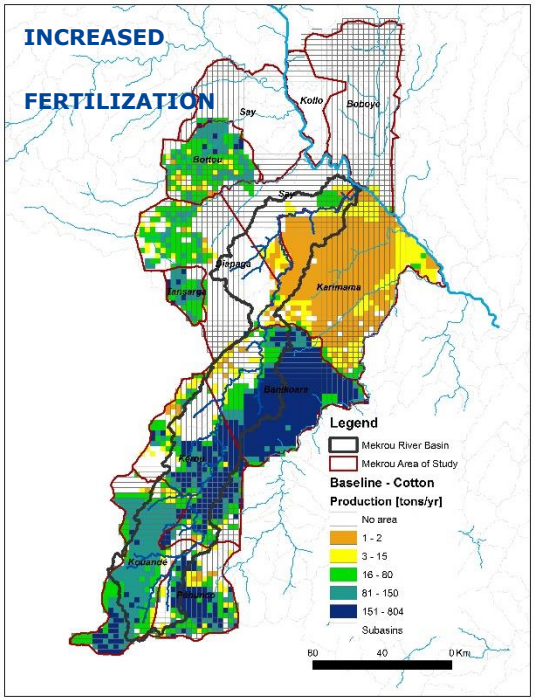
EPIC: LOCAL SCALE SCENARIOS ANALYSIS

IDENTIFICATION OF AREAS WITH LOW PRODUCTION CONTRIBUTING TO FOOD INSECURITY

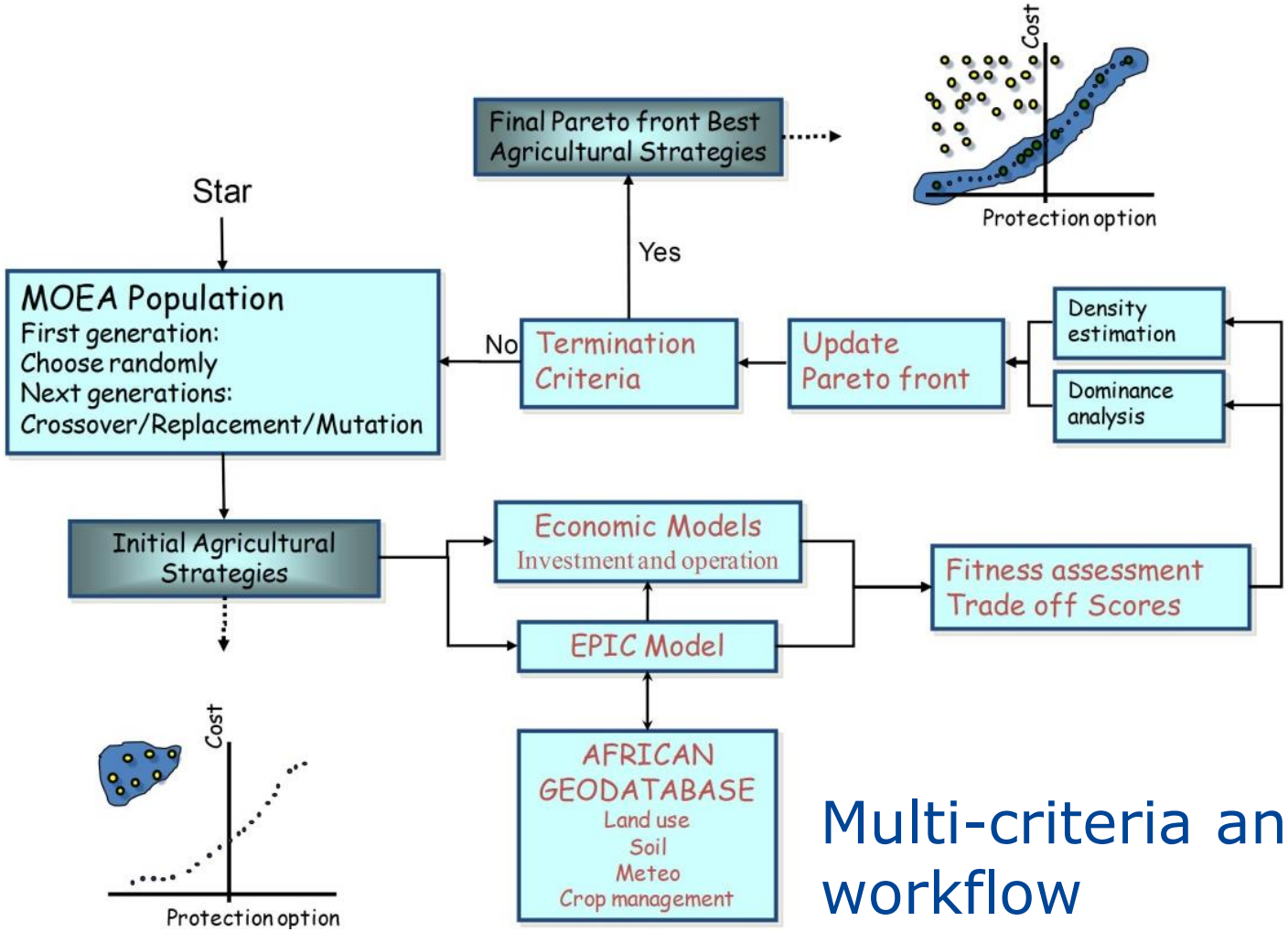
CROP PRODUCTION AS AFFECTED BY DIFFERENT MANAGEMENT STRATEGIES (Mineral-Organic Fertilization, Irrigation)





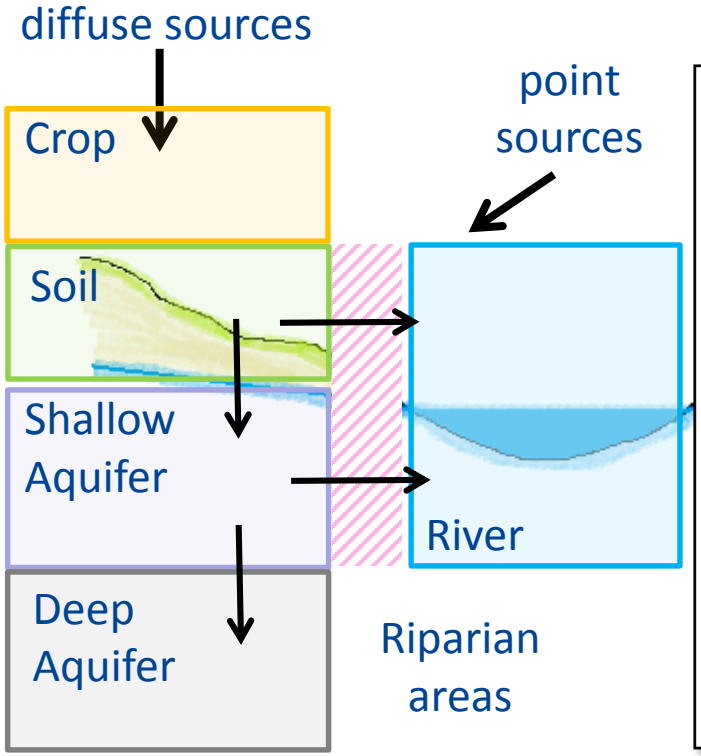


GISEPIC: SCENARIOS OPTIMIZATION ANALYSIS



Multi-criteria analysis workflow

WEF – SWAT GENERAL FRAMEWORK



Input Best Management practices

HRU/SUBBASIN

- Conventional tillage, irrigation and fertilization,
- Cover crops,
- Residue management,
- Conservation tillage,
- Terracing/contouring
- Tile drainage system

HRU/SUBBASIN border

- Riparian land

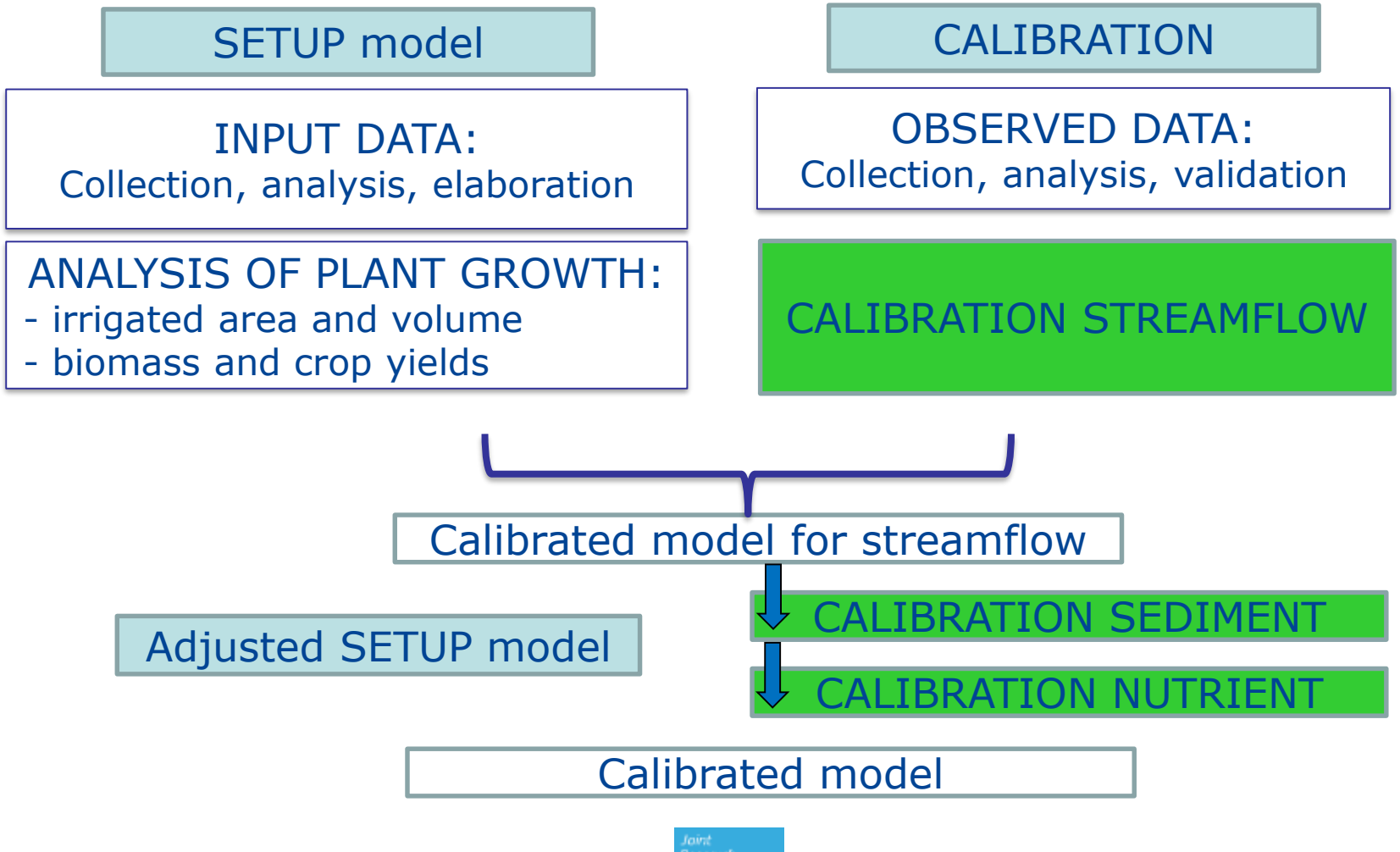
RIVER

- Point sources
- Reservoirs
- Stream bank protection

- Semi-distributed watershed scale simulation model
- Application in large river basins, as well as in local basins (i.e. Mekrou, Niger tributary)
- Continuous time model (daily time step)

Arnold et al. (1998)

WEF – SWAT MODEL DEVELOPMENT WORKFLOW

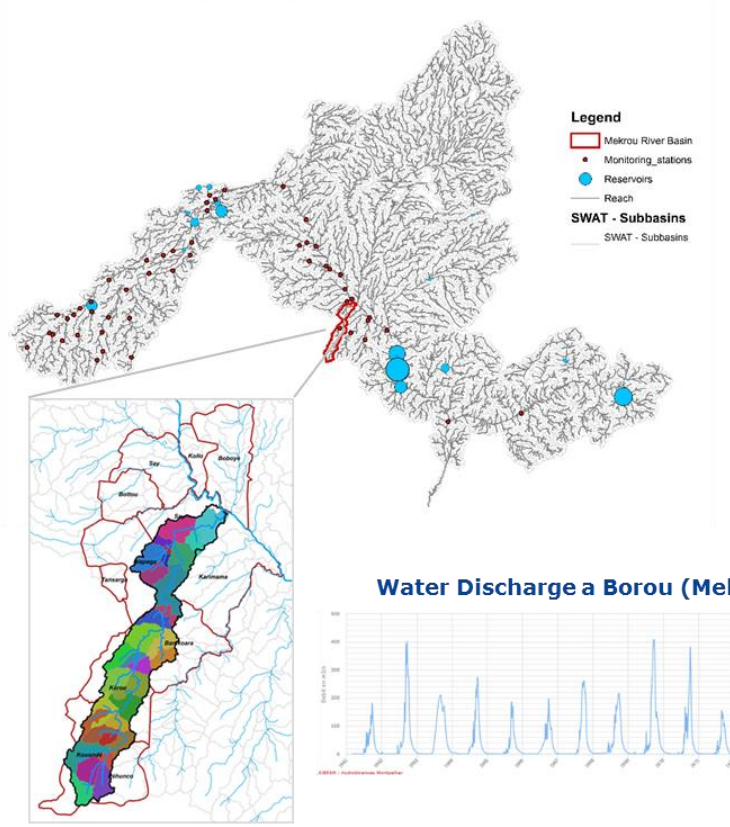


WEF – SWAT SAMPLE CASE STUDIES (NIGER-MEKROU)

SWAT HYDROLOGICAL MODEL

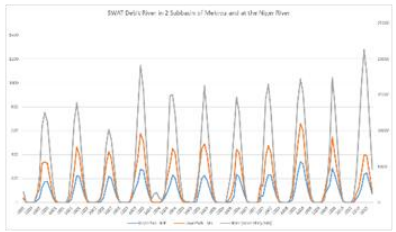
SWAT SETUP FOR NIGER RIVER BASIN

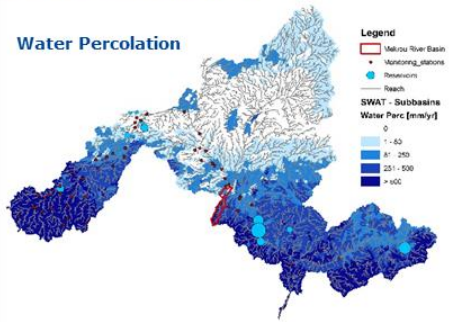
WITH A DOWNSCALE FOR THE MERKOU RIVER BASIN



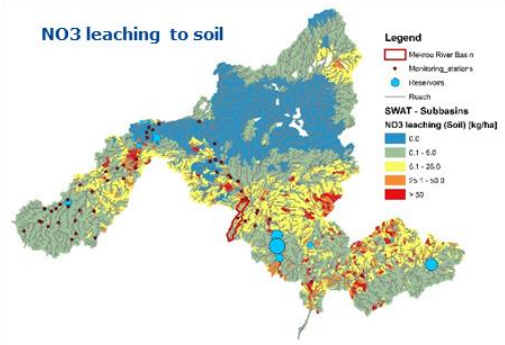
Water Discharge a Borou (Mekrou)

WATER QUANTITY : RIVER DISCHARGES AS AFFECTED BY DIFFERENT SCENARIOS (Climate, Crop management, Landuse changes)

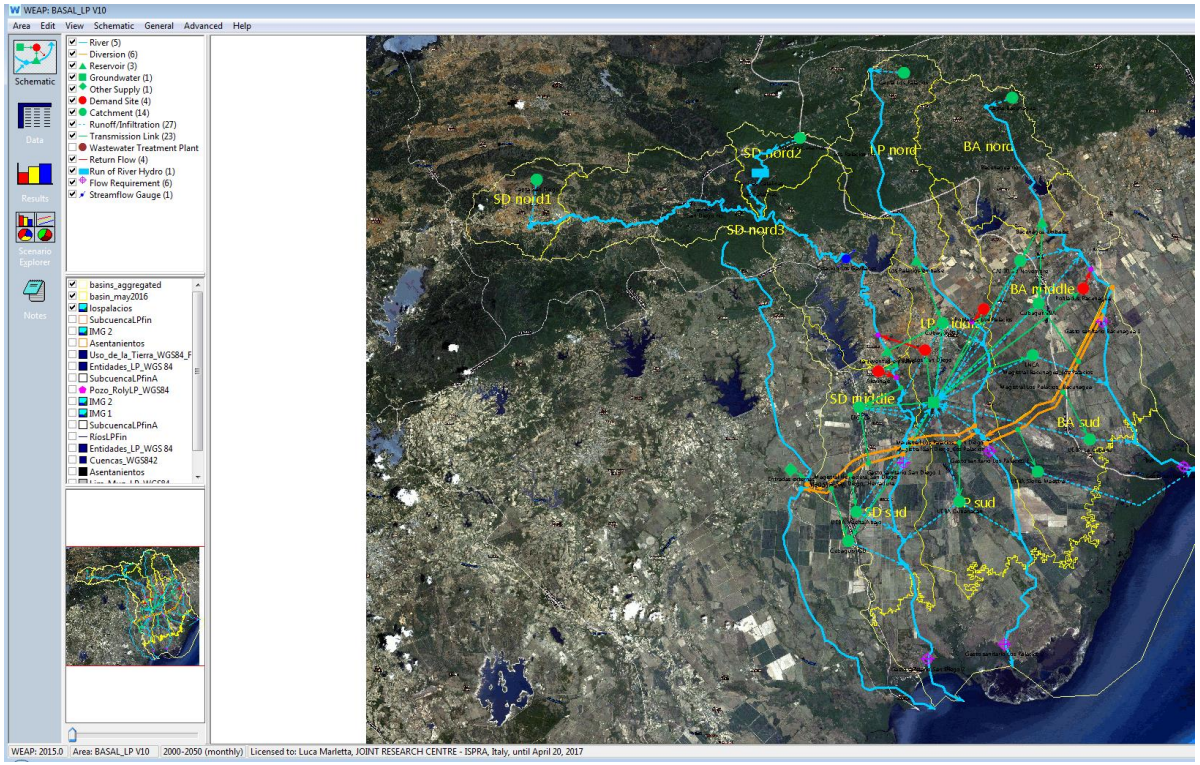




WATER QUALITY : RIVER AND SOIL QUALITY AS AFFECTED BY DIFFERENT SCENARIOS (Climate, Crop management, Landuse changes)



WEF – WATER ALLOCATION ANALYSIS



BASAL project
Case study in Los Palacios, Cuba

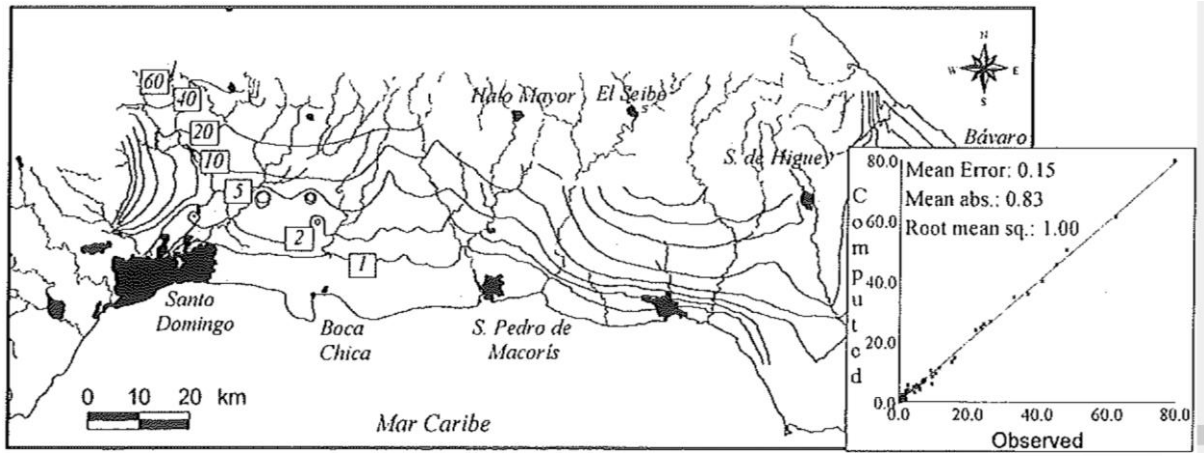
Competing uses, human made infrastructures (dams, channels), increment of rice production for food security and self-sufficiency in a low density populated area but of high production relevance

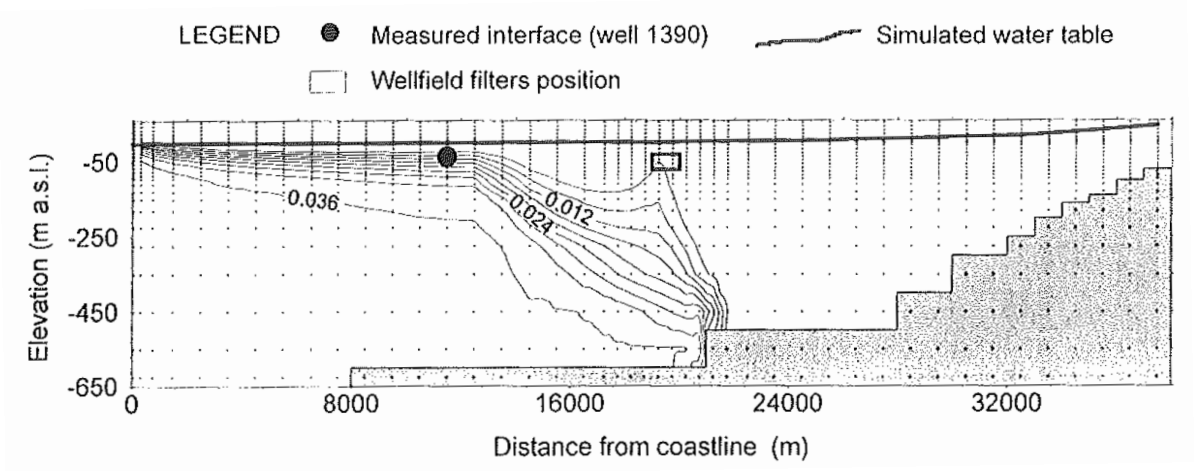
GROUNDWATER – SOURCE OF SUPPLY

Case study from rio Ariguanabo in Guira de Melena, Cuba. The river flows to groundwater system along karstic conducts, surface water drainage network being poorly developed downstream with limited and/or no flow. Problems: over-exploitation, aquifers (and soils) salinization, ecological impacts on mangroves, increasing water supply demand.

GROUNDWATER – AQUIFERS SALINIZATION

Case study of karstified fractured limestones aquifer in Planicie Costera Oriental (Dominican Republic) and modelling of salt water upconing due to overexploitation of wells fields for water supply.
Geological framework and problems close to those of Guira de Melena





WATER CRISIS AND COOPERATION

Theoretical framework based on the following question:

- Is **water scarcity** (low supply and/or high demand) likely to increase international **conflicts** in transboundary basins? (Malthusian)

OR

- Are **shared waters** likely to be catalyst for international dialogue and **cooperation** for more efficient allocation of the resource? (Cornucopian)

OR MAYBE

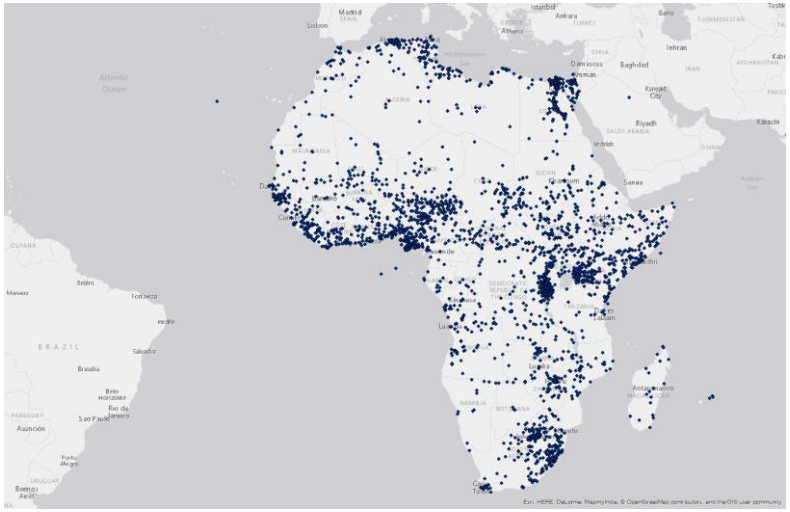
- Are **both** conflicts (usually non-violent) and cooperation likely to occur in the context of **water allocation**?

- We look at:
  - Impacts of **water stress** on the relations between countries in the river basin;
  - Determinants of **water demand** for human consumption, food, energy, and ecosystems;
  - Implications of geographical, socio-political and economic factors.

WCC ATLAS: MEASURING CONFLICTS & COOPERATION

Global International Rivers Cooperation and Conflict (IRCC), ETH Zurich

- Most extensive and recent event dataset on international river basin cooperation and conflict worldwide
- Their dataset covers 264 international river basins from 1997 to 2007.
- Information on water related events from news through BBC Monitoring (http://www.monitor.bbc.co.uk/).
- Most international river basins in their dataset are shared by 2 countries, some by 3 or 4 and only very few by 5 or more countries.



Social Conflict in Analysis Database, Univ. Texas at Austin (not focused on water)

- Protests, riots, strikes, and other social disturbances
- 1990-2013
- >12,000 events

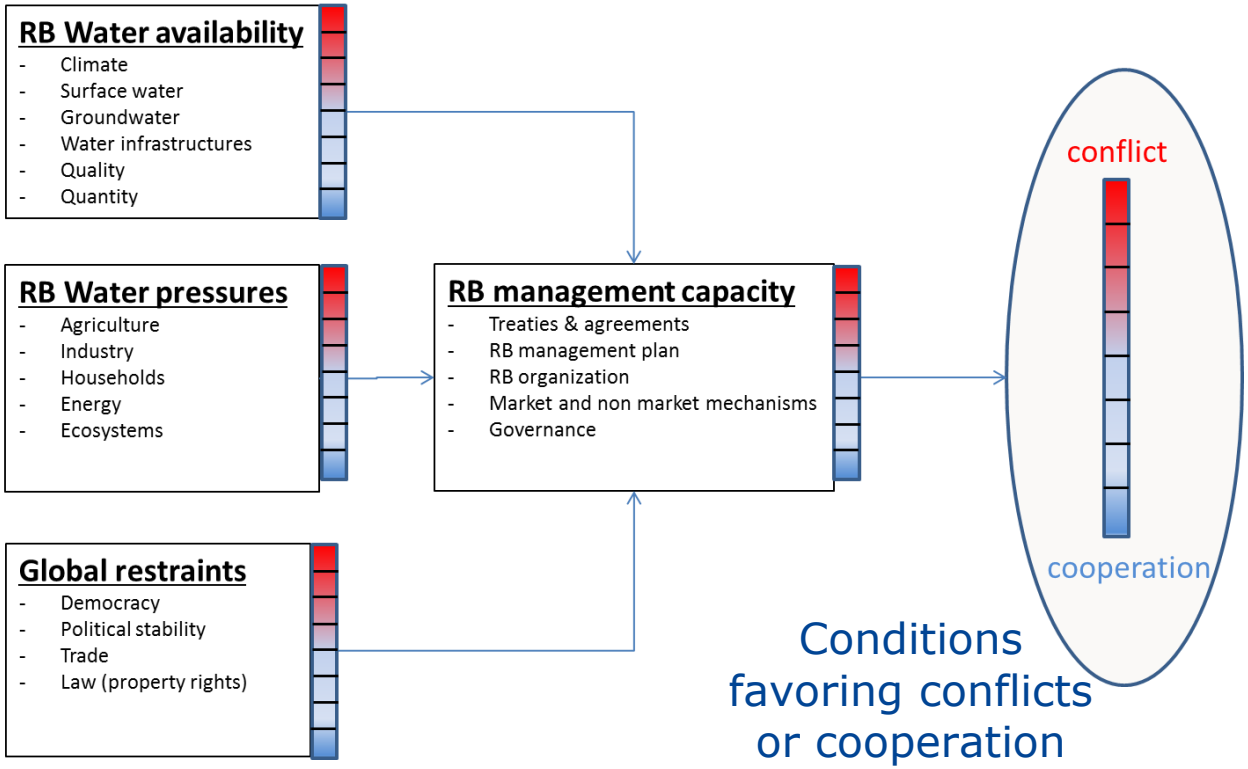
WCC ATLAS – A CONCEPTUAL FRAMEWORK

Biophysical variables
SUPPLY SIDE

Water use estimates
DEMAND SIDE

Endogenous factors

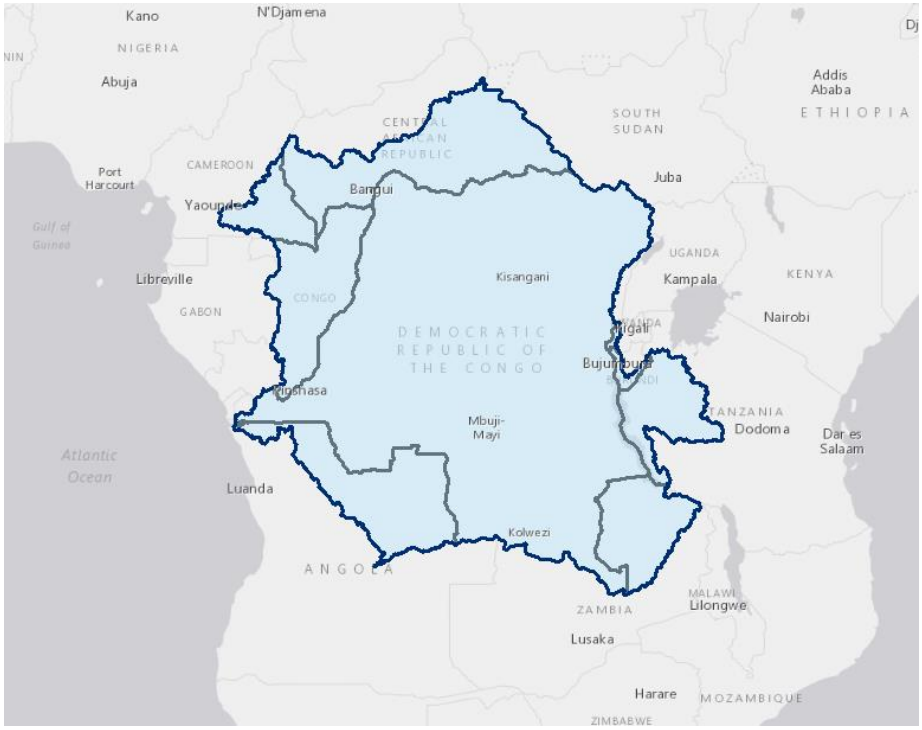
(legal, socioeconomic, and cultural context)

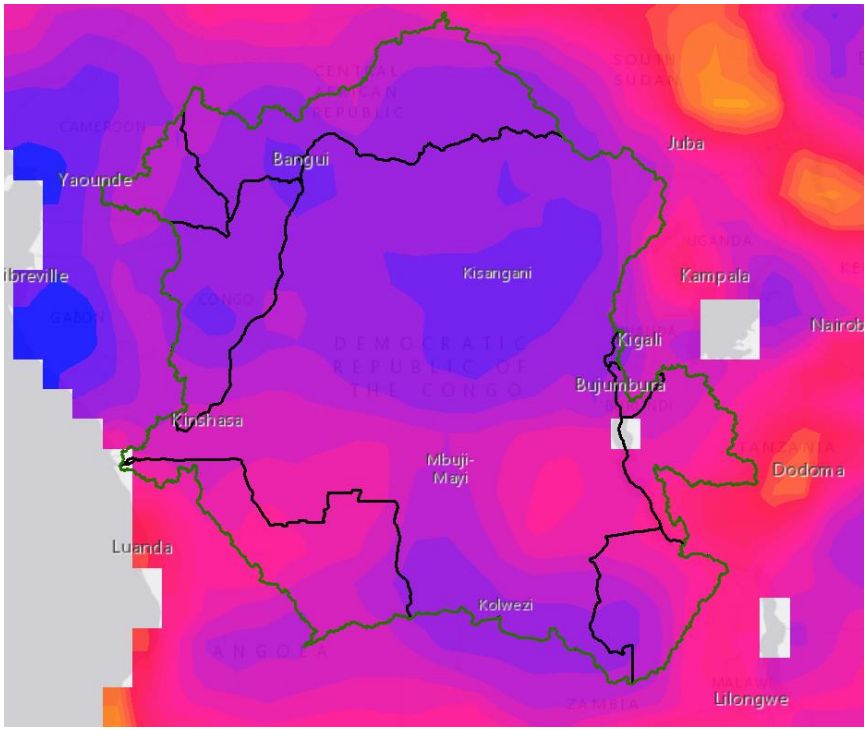


Conditions favoring conflicts or cooperation

Note: We use 'restraint' in the political sciences and economic context, identifying the factors that impact on capability to mitigate escalating conflicts or enhancing cooperation (Bohmelt et al, 2014)

WCC ATLAS – GEOVISUALIZATION





Possibility to interactively display biophysical and socio economic factors potentially impacting WCC at basin/country scale.
Detailed spatial resolution and **dynamic** temporal evolution.

CLIMATE, WEF AND WCC ATLAS INTERPLAY