

*Groundwater Resources in the Aquifer Systems
of the Iullemeden and Taoudeni /Tanezrouft Basins
-- Sahelo-Saharan Region --*

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N°abstract **1405**

Contents

Context & Objectives

- *Geography, Geology, Climate*
- *Groundwater Resources Assessment*

Methodology & Innovative Approach

- *Overview*
- *Development of **Innovative Technics** for Data Processing*
 - *Potentiometric Maps*
 - *Recharge*
- *Modelling*

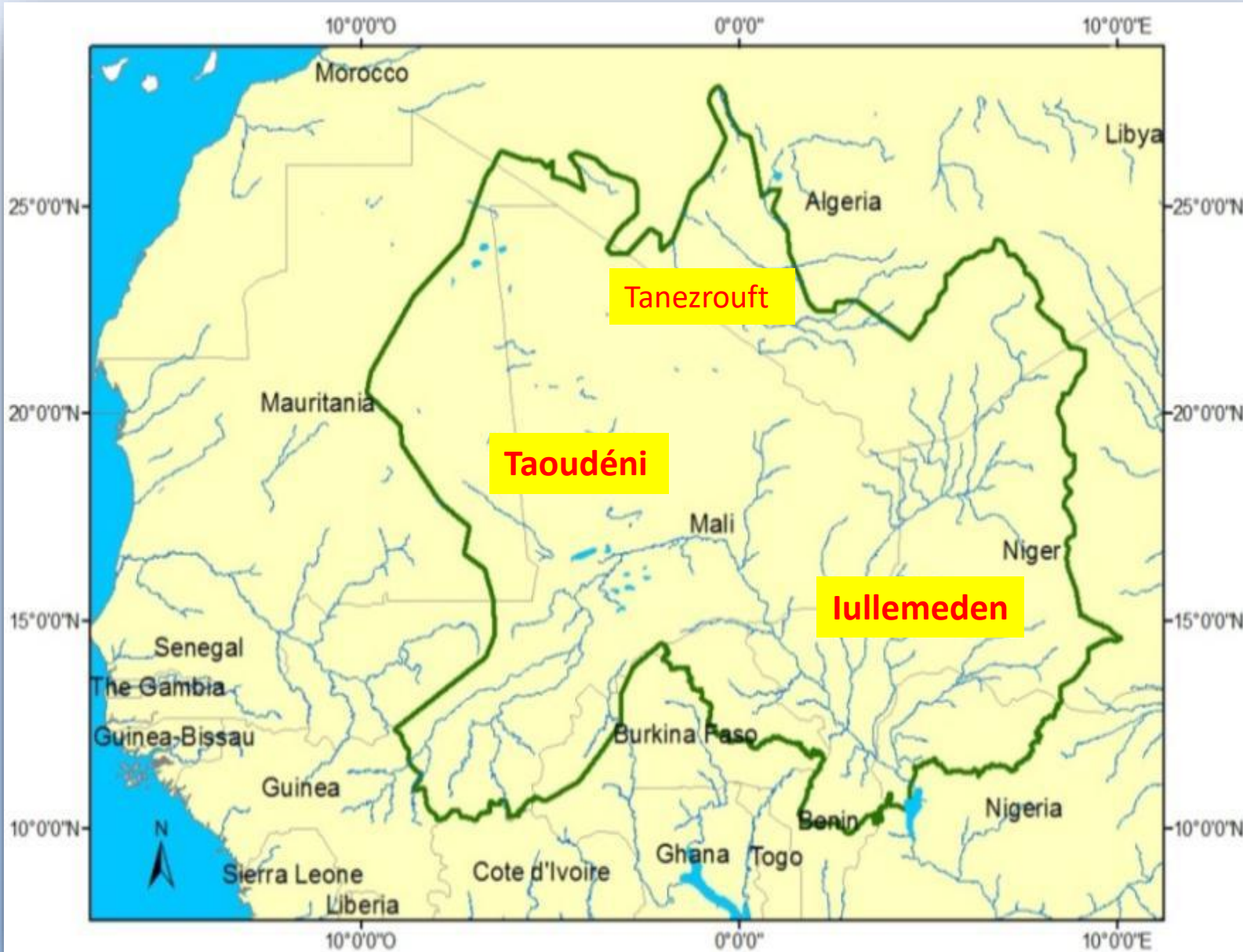
Findings on Water Resources

- *Overall **High Potential** on Groundwater Resources*
- *Slightly Sensitive to **Climatic Changes** and to **Pollutions***
- *Under-exploited*

Specific Findings

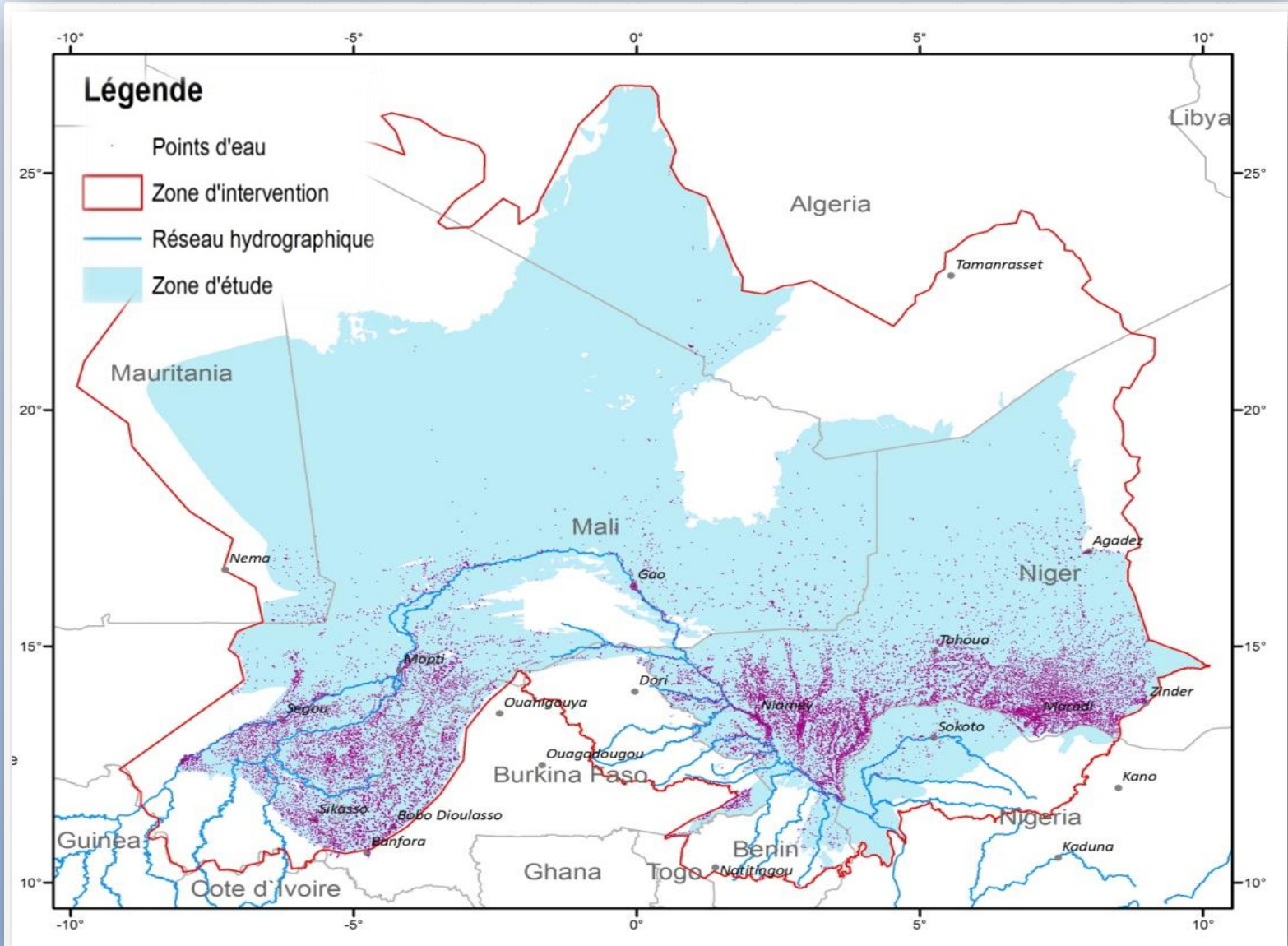
- ***Very High Potential** Areas on **GWR***
- ***Exfiltration Areas***
- ***Gao Strait Enigma** (Taoudeni ↔ Iullemeden)*

Studied Area



Hydrogeological Maps

Water Wells Distribution



Objective

Overall goal

- Assessment of Groundwater Resources of the ***Iullemeden*** and ***Taoudeni/Tanezrouft*** aquifers systems under arid and semi-arid climatic conditions
- Better understanding of
 - ✓ Relationship between the aquifers systems and the Niger Riv.
 - ✓ Connection between the two aquifers

Population in the studied area

> 25 millions inhabitants (over 7 countries)

Project duration and team

13 months (2012-2013)

Team

- 10 international experts
- 35 regional and national experts

Methodology

Global Approach

Actions leading to the elaboration of a groundwater flow numerical model, a major tool to:

- Understand better the aquifers behaviour*
- Assess groundwater vulnerability*
- Manage water resources in the decades to come*

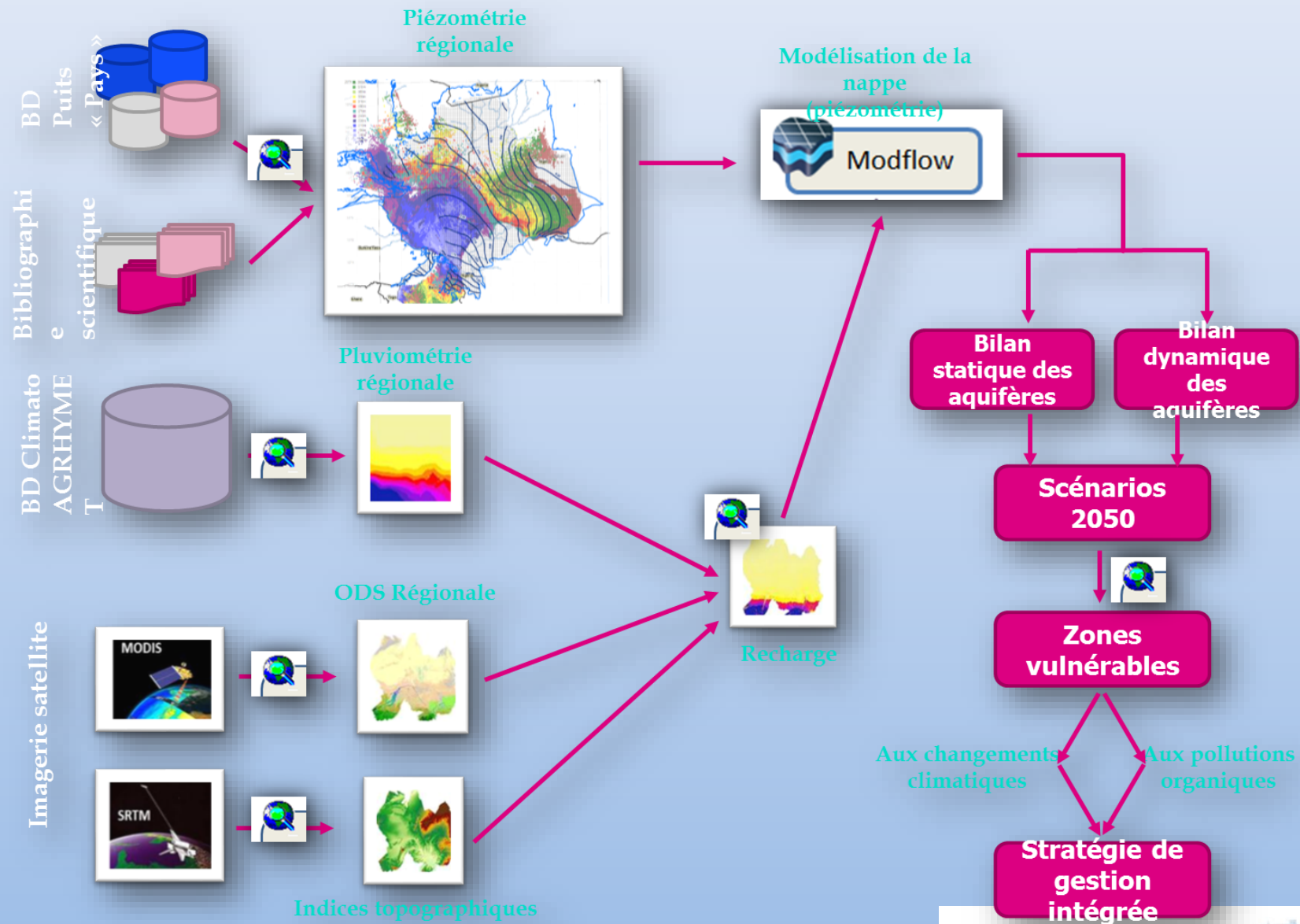
Data processing → Input to the GWF model

- ✓ *Potentiometric Maps (innovative approach)*
- ✓ *Digital Elevation Model*
- ✓ *Landuse Maps*
- ✓ *Aquifer Recharge Model (innovative approach)*

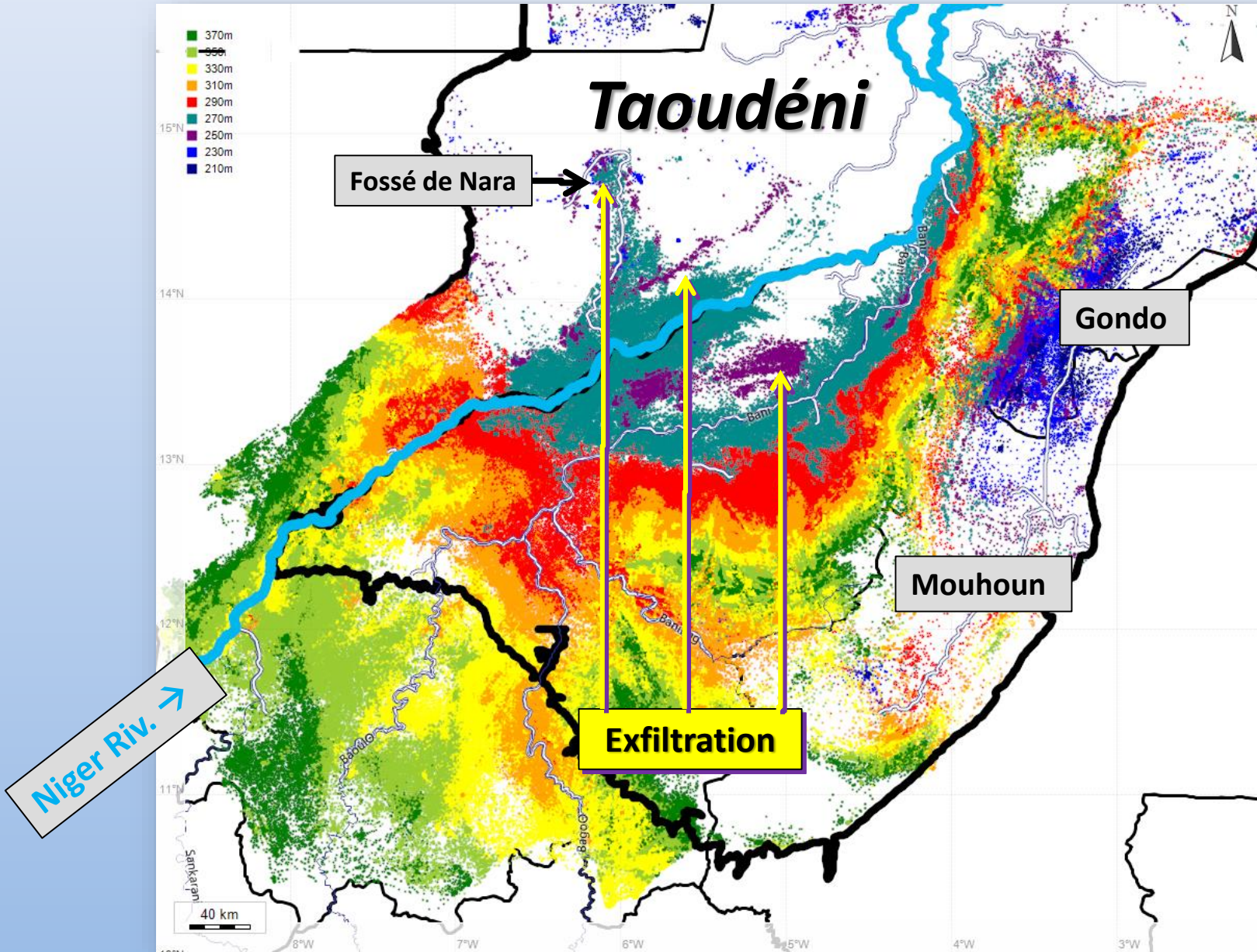
Ground Water Flow Model

- *Concept, Development and Calibration*
- *Model Simulations (→+ 2050) under climatic changes and withdrawals exponential raise*

Methodology Scheme

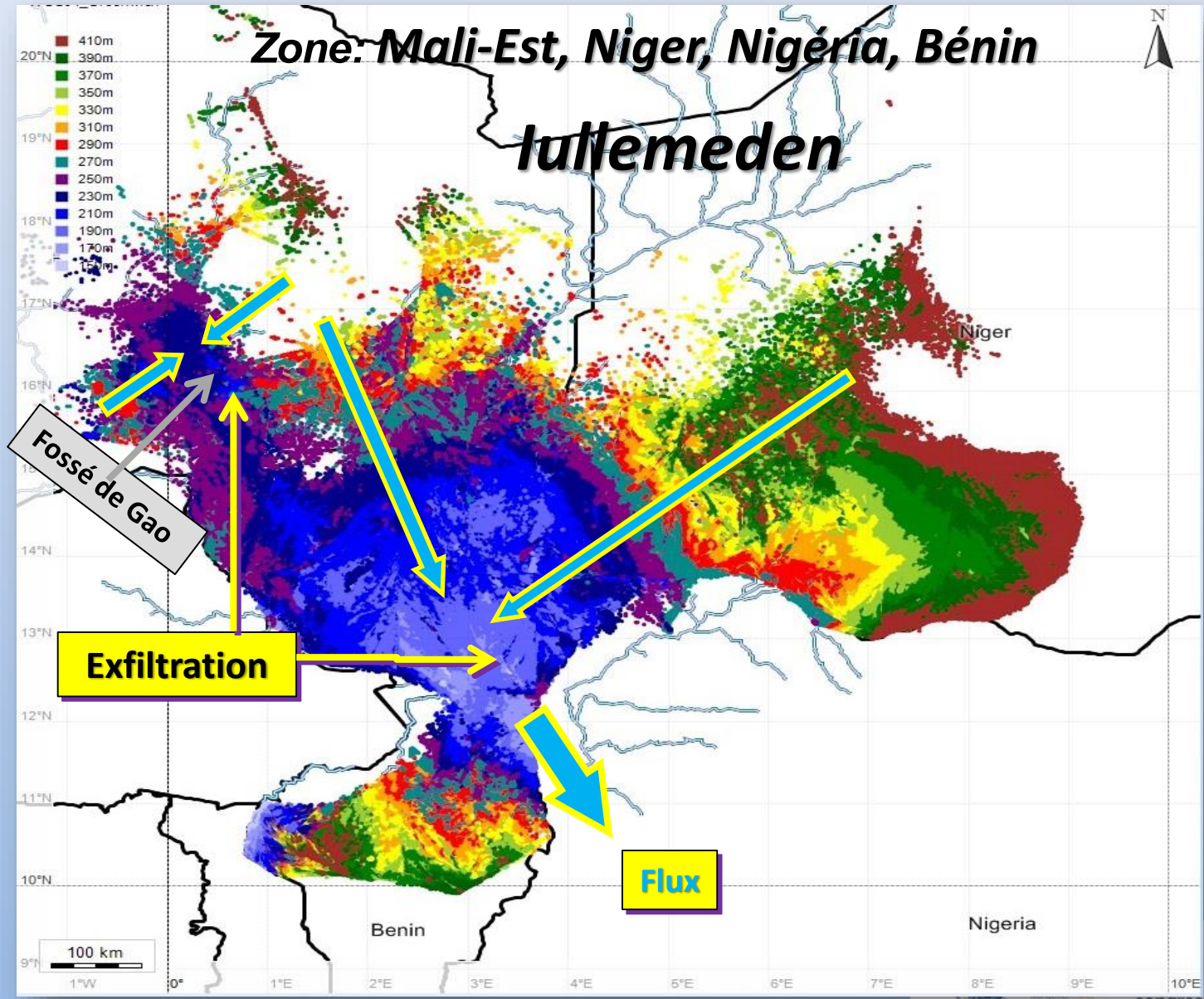


Developed Algorithm for Setting up Potentiometric Maps (1/2)



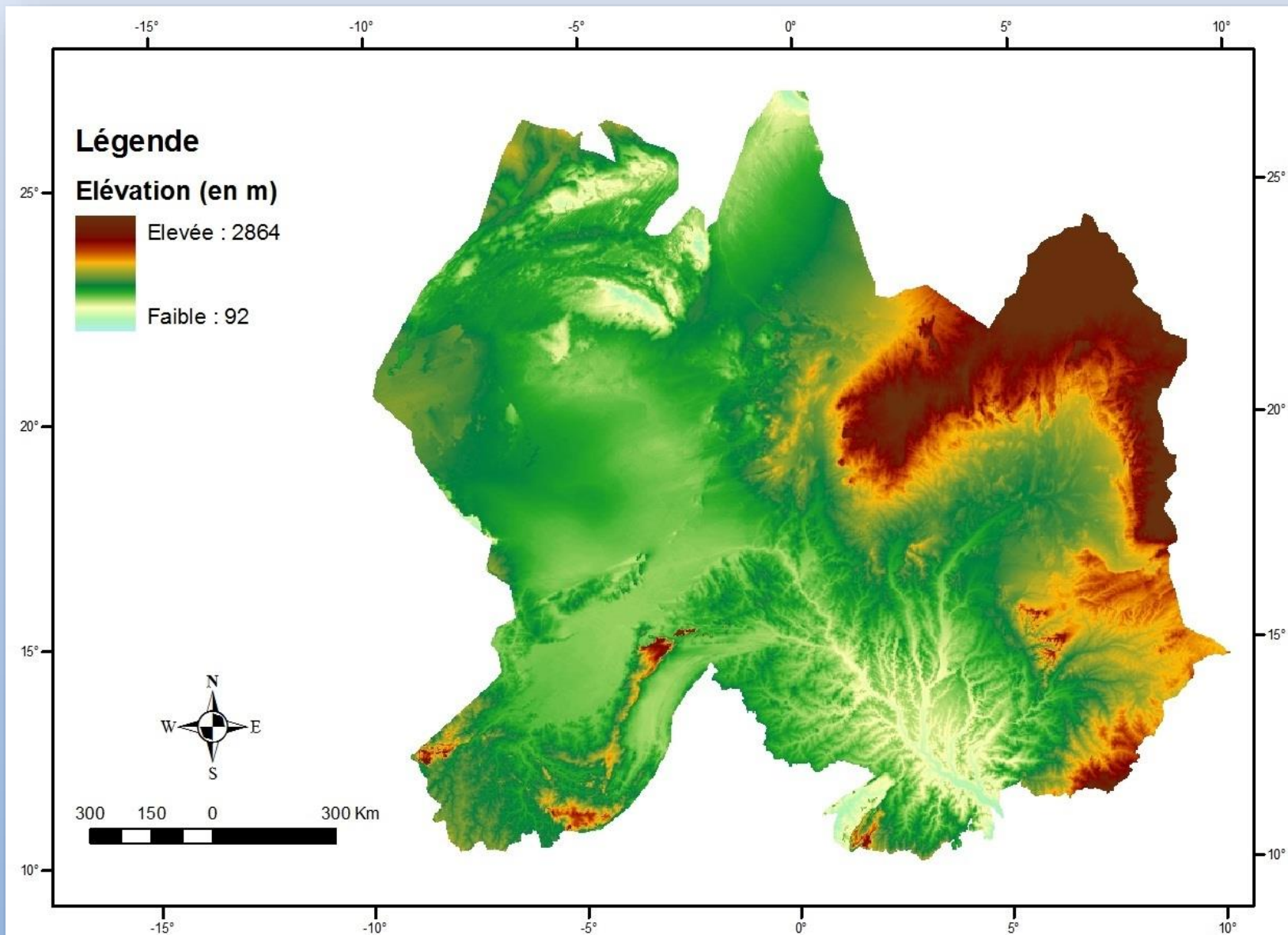
Data Processing : Groundwater Levels

Developed Algorithm for Setting up Potentiometric Maps (2/2)



Data Processing : Satellite Images

Digital Elevation Model - DEM-90m (corrected)



Landuse Map



OBSERVATOIRE DU SAHARA ET DU SAHEL
SAHARA AND SAHEL OBSERVATORY



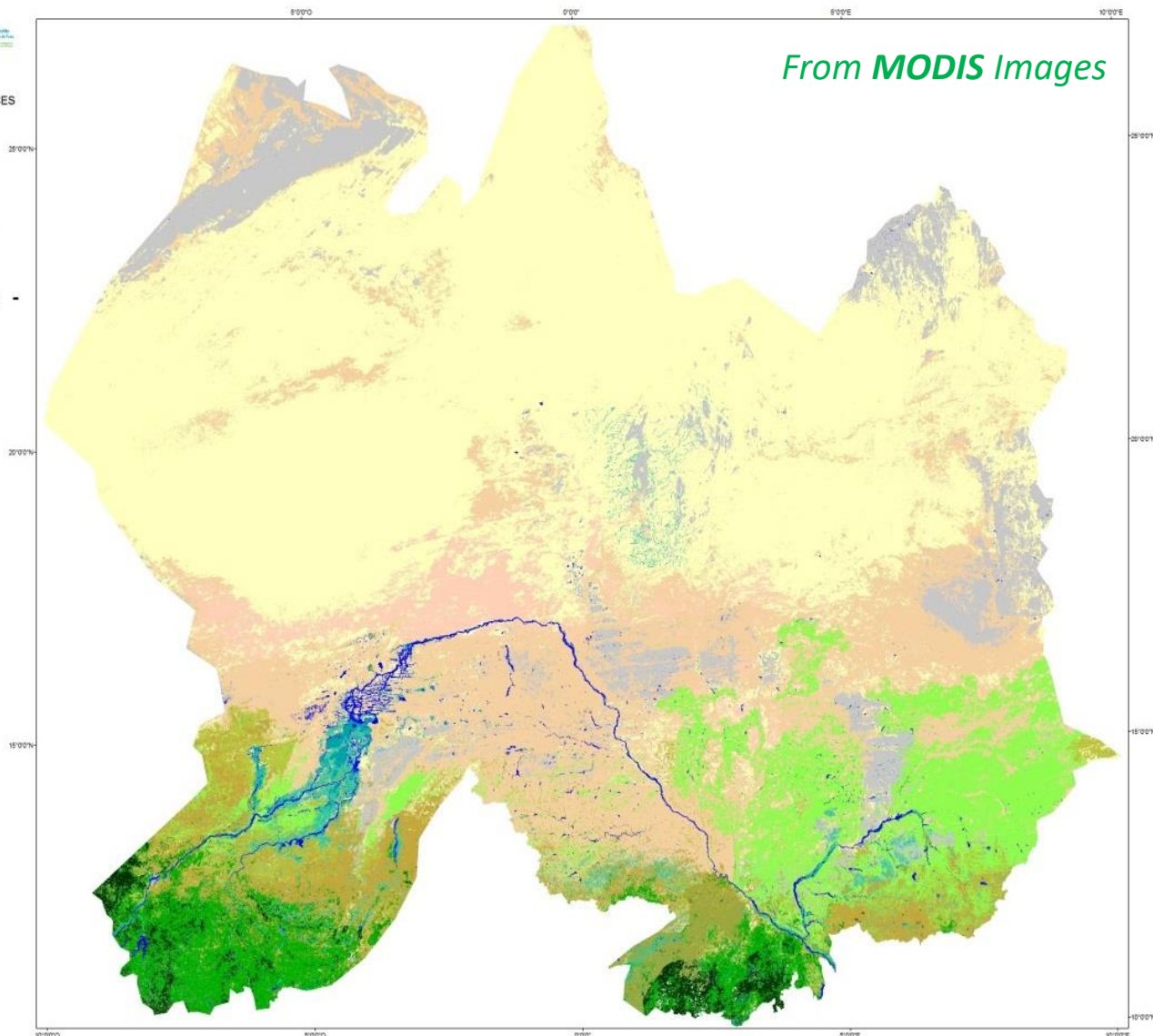
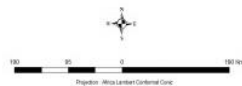
PROJET GICRESAIT
GESTION INTÉGRÉE ET CONCERTÉE DES RESSOURCES
EN EAU DES SYSTÈMES AQUIFÈRES
D'ILLEMEDEN, DE TAOUJENITANEZROUFT,
ET DU FLEUVE NIGER »

Carte d'occupation des sols en Septembre 2011 - zone d'intervention -

Légende

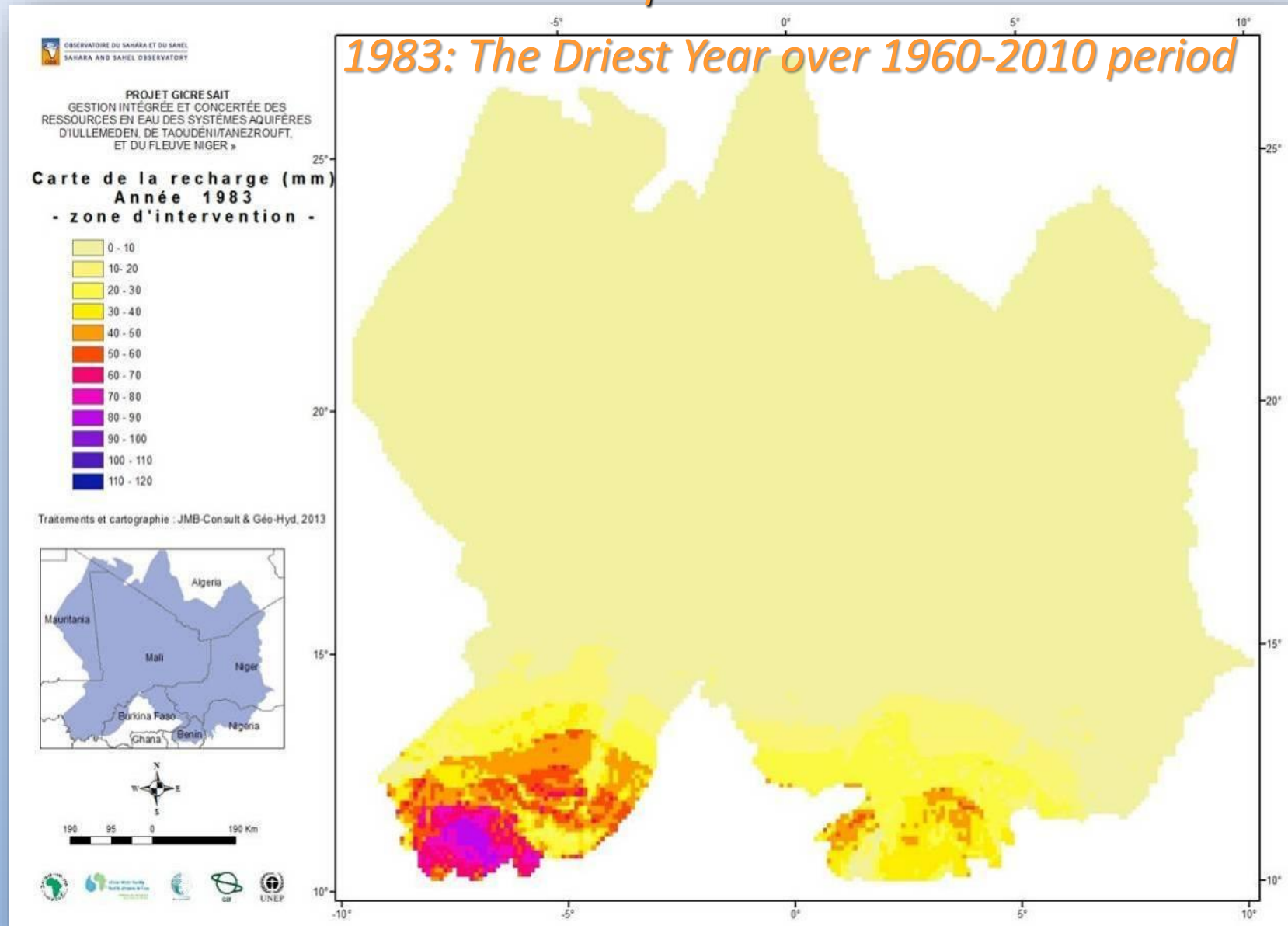
- Zones de cultures
- Déserts et sols nus
- Roche et sols nus
- Forêts claires
- Forêts denses
- Eau
- Savanes arborescentes et/ou arbustives
- Savanes boisées
- Savanes herbacées
- Steppes
- Végétation en zone inondée ou humides
- Végétation claire en zone inondée ou humide
- Mosaïque savane boisée et cultures

Source : Scènes MODIS - septembre 2011
Traitements et cartographie : Géo-Hyd, 2012



From MODIS Images

Outputs



Ground Water Flow Model

(Modflow™)

Construction & Calibration *(under Steady & Unsteady State conditions)*

Modelling the Two Aquifers Systems *(Taoudeni & Iullemeden linked by the Gao Strait)*

- Fixed Fluxes : Rivers (flux exchange *Aquifers* $\leftarrow \rightarrow$ *Rivers*)
- Exfiltration Zones : (Aquifer outlet = Evaporation)

Exploitation : Simulation of 2 scenarios 2010 \rightarrow +2050

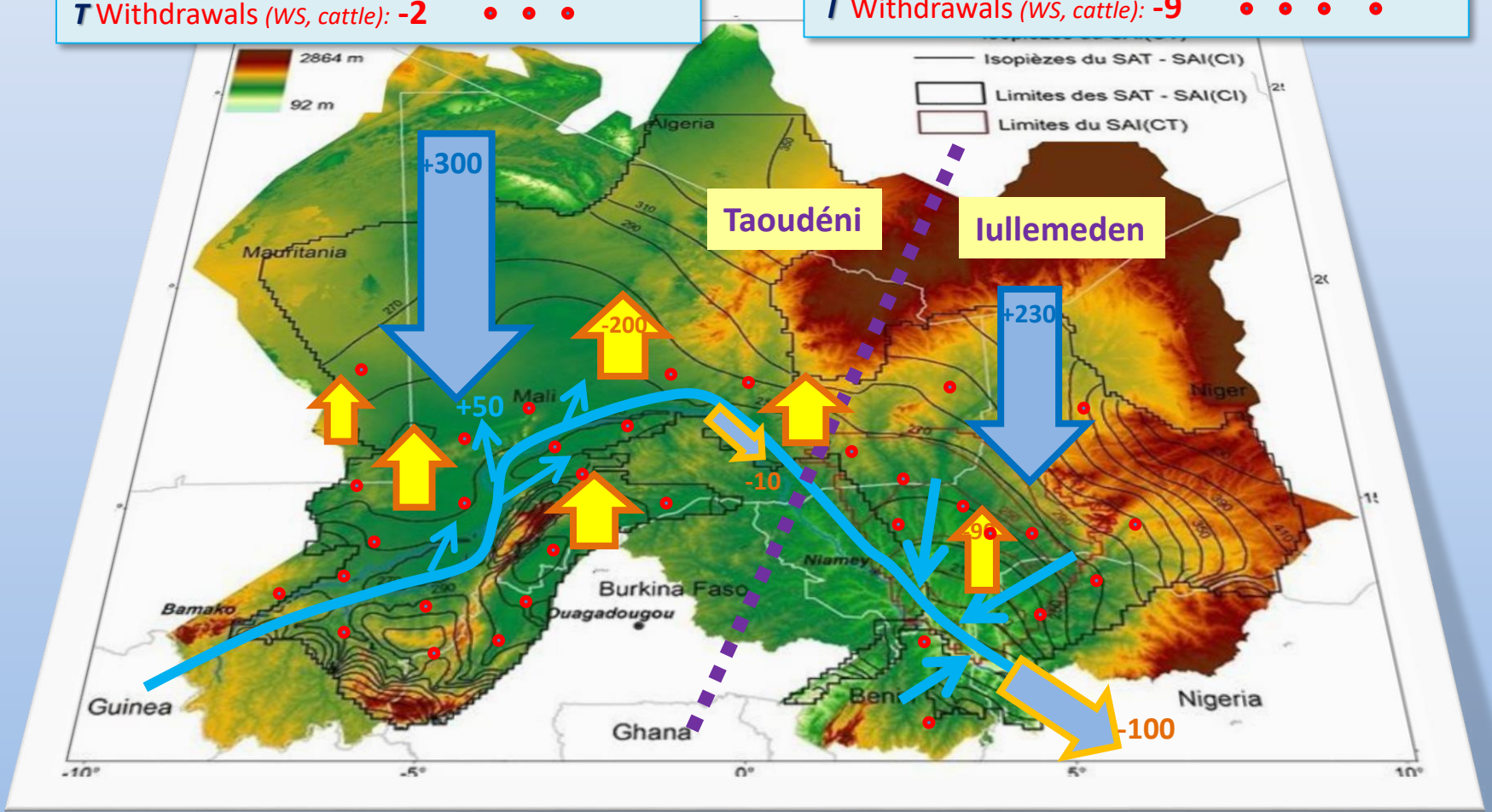
- Scenario 1: climate 2010 \rightarrow 2050 = climate 1960 \rightarrow 2000
- Scenario 2 (pessimistic) : climate 2030 \rightarrow 2050 = climate (1980 \rightarrow 1990)x2
- Withdrawals increase vs Population growth (doubling every 20 years)

GWF Model Outputs

Flux Balance (m³/s)

S Recharge frm Rain: **+300** frm Riv.: **+50**
A Exfiltration: **-200** Drainage by Riv.: **-10**
T Withdrawals (WS, cattle): **-2** ● ● ●

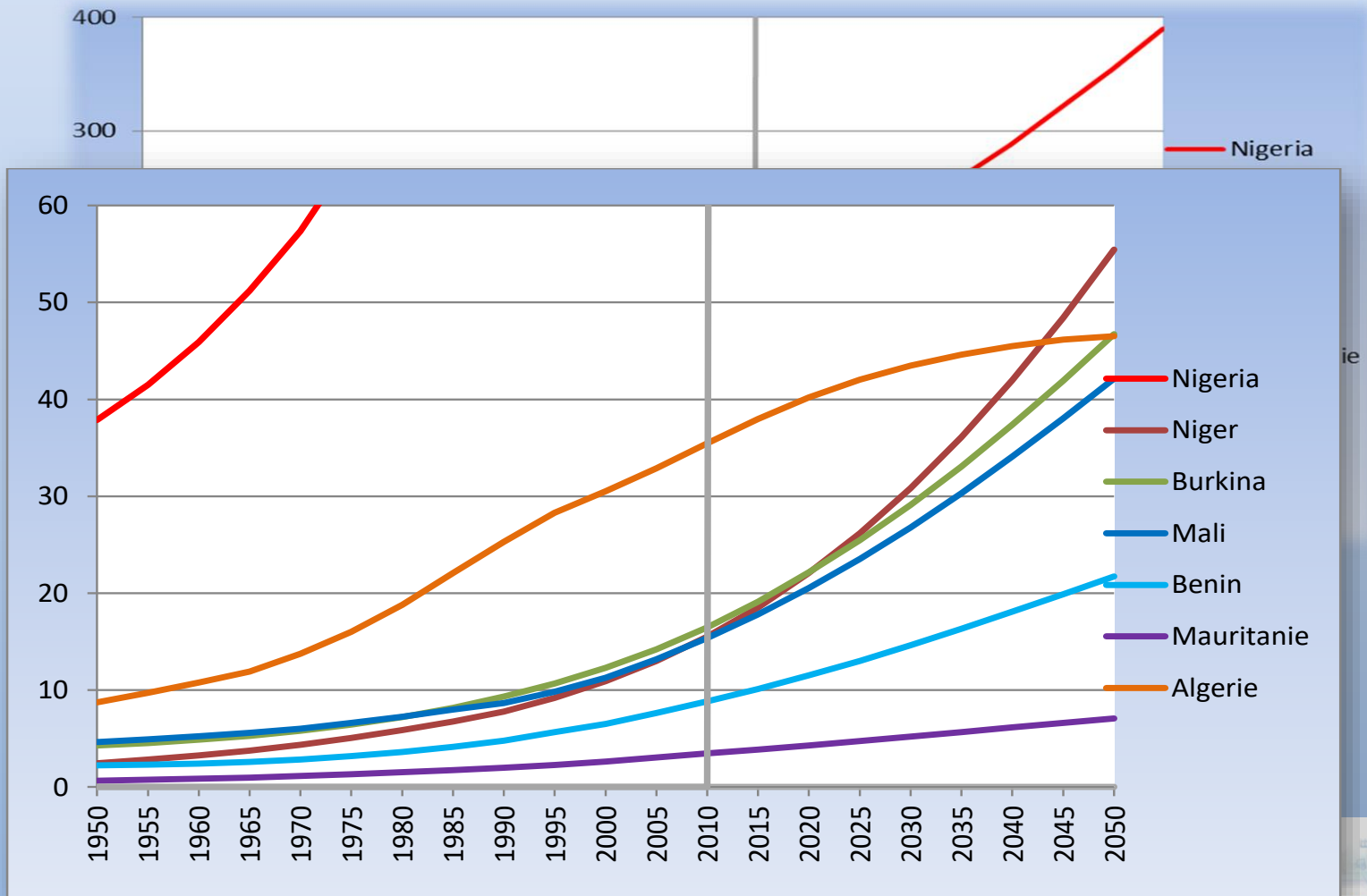
S Recharge frm Rain : **+230** frm Riv : **+14**
A Exfiltration: **-90** Drainage by Riv : **-100**
I Withdrawals (WS, cattle): **-9** ● ● ● ●



GWF Model Scenarios

Climate Changes & Population Growth

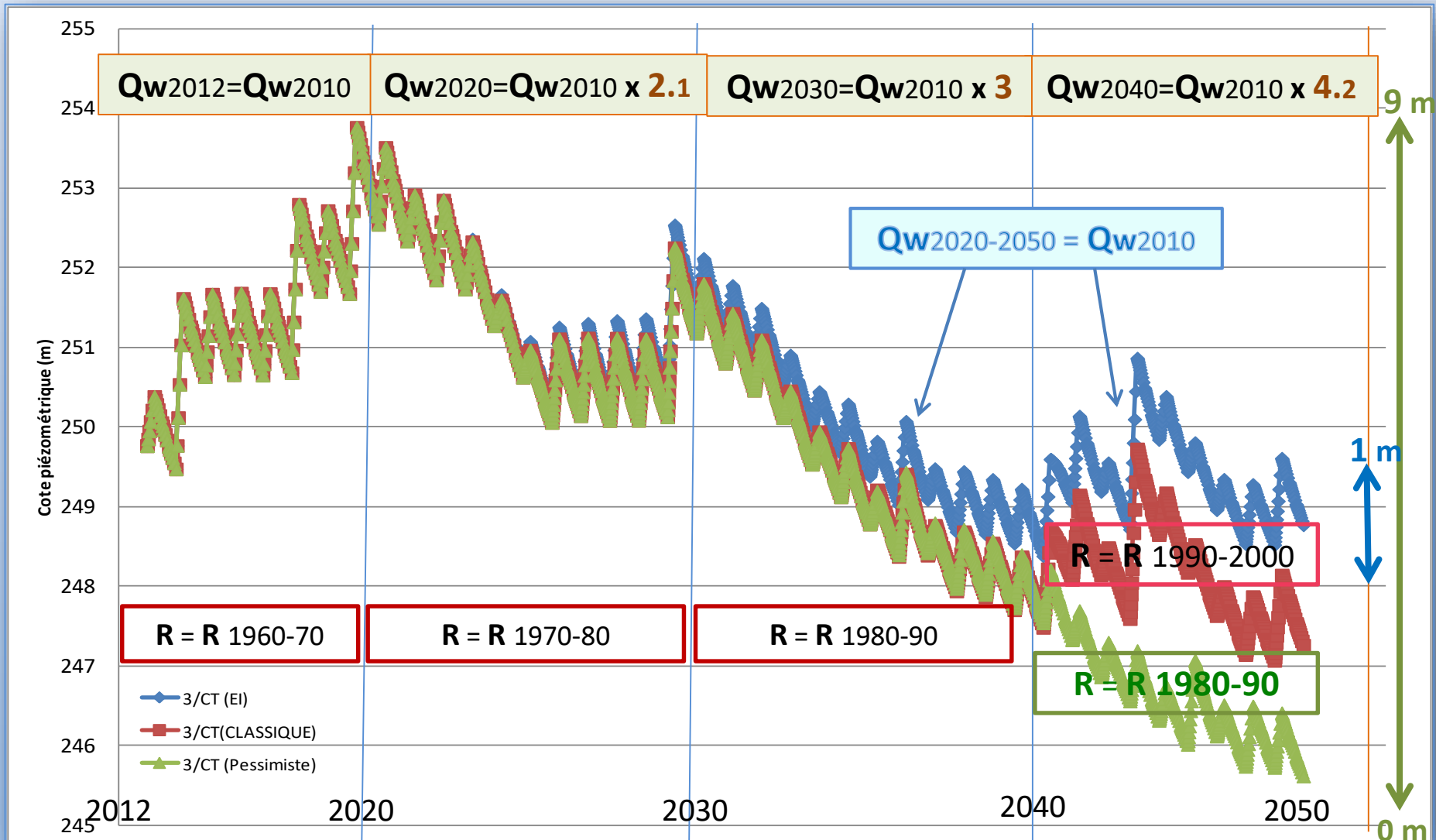
- Simulated Period : 2010-2050 with Climate = Climate 1960-2000
- Demography →→→ Water Withdrawals ↗ ↗ ↗



Model Simulation : 2012-2050

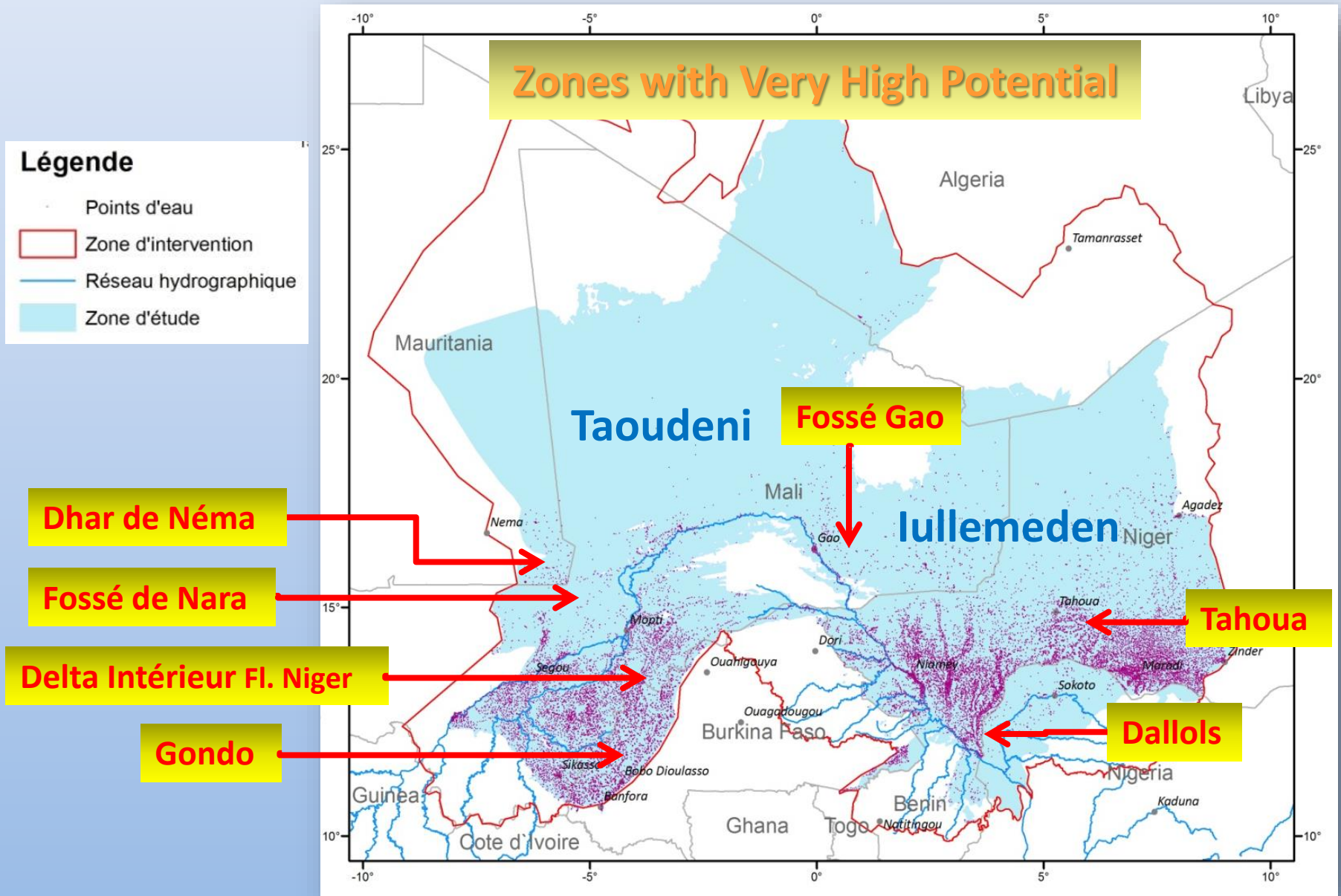
Water Level Variation (on Populated Area)

Parameters: Withdrawals (**Qw**) – Climate (**R** recharge)



Findings: Taoudeni & Iullemeden Aquifers

A Huge Groundwater Reservoir (2.5M km²)



Findings: Low Vulnerability



PROJET GICRESAIT
GESTION INTÉGRÉE ET CONCERTÉE DES
RESSOURCES EN EAU DES SYSTÈMES AQUIFÈRES
D'ILLEMEDEN, DE TAOUËNI/TANEZROUFT,
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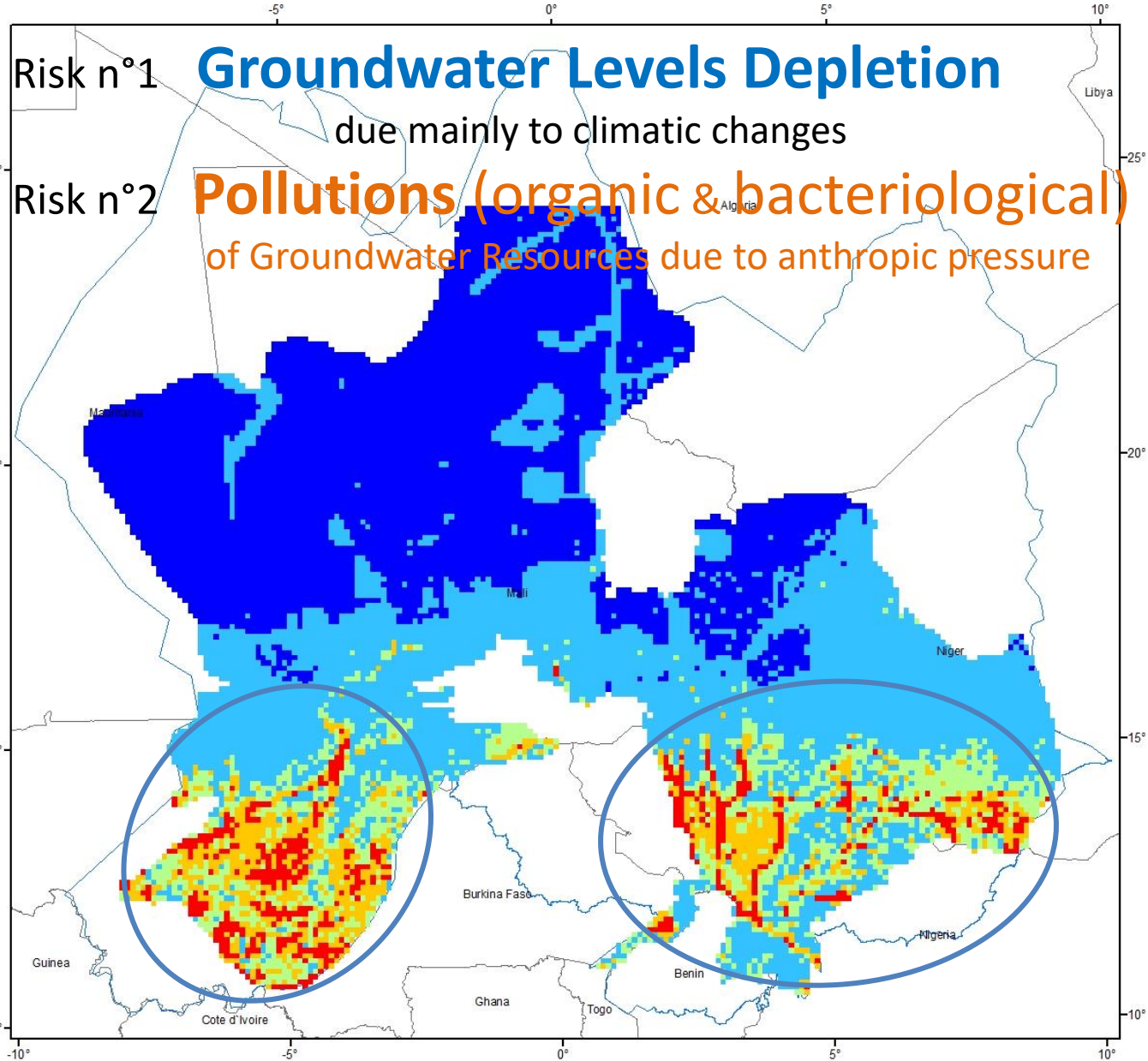
Cartographie du risque de
contamination organique et
fécale des eaux souterraines

- Risque très faible
- Risque faible
- Risque moyen
- Risque fort
- Risque très fort

Traitements et cartographie :
JMB-Consult & Géo-Hyd, 2013



200 100 0 200 Km



Risk n°1 **Groundwater Levels Depletion**
due mainly to climatic changes

Risk n°2 **Pollutions (organic & bacteriological)**
of Groundwater Resources due to anthropic pressure

Findings : Gao Enigma

Gao Strait : Taoudeni \leftrightarrow Iullemeden Aquifers Connection

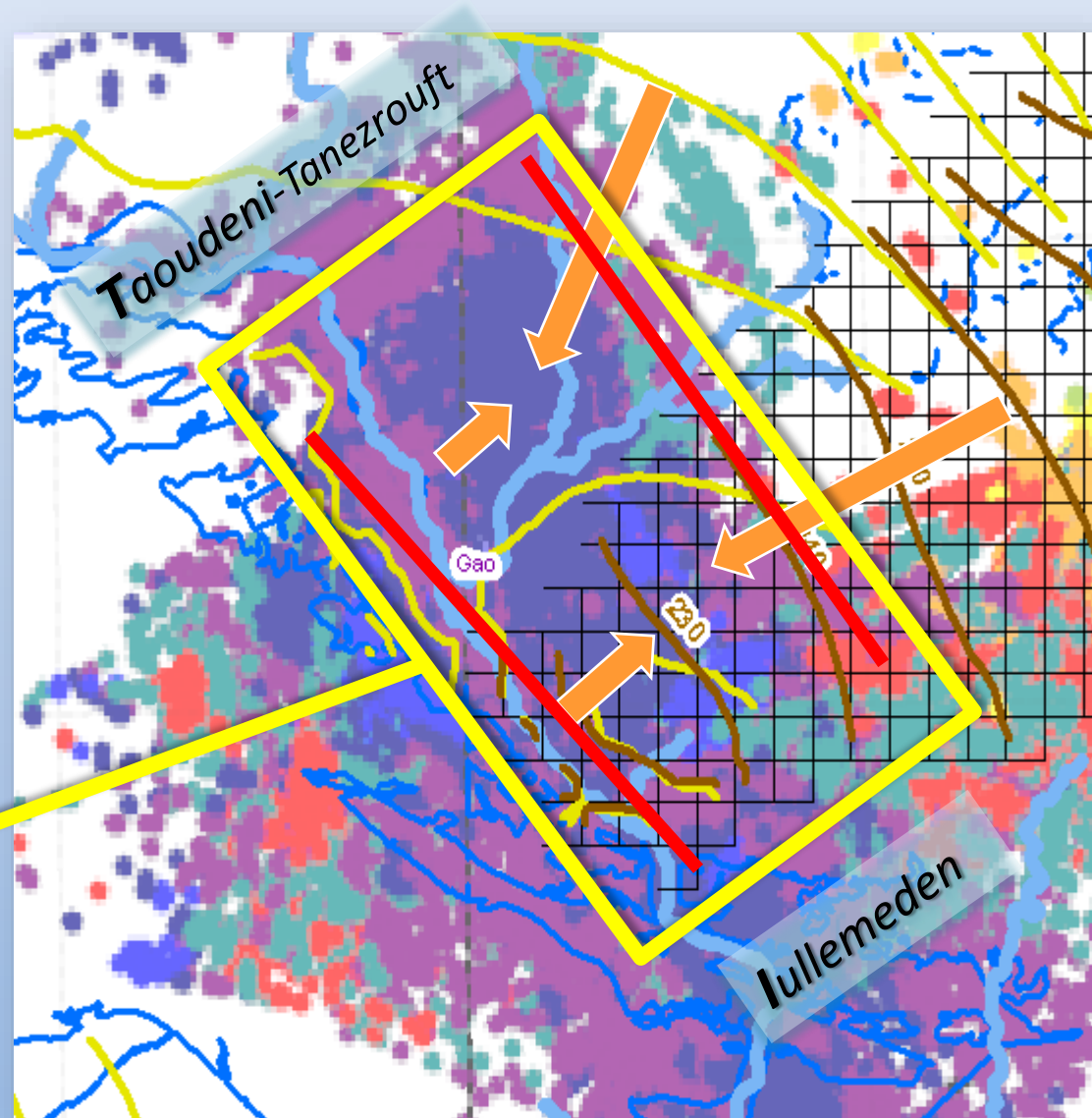
Taoudeni-Tanezrouft and Iullemeden Aquifers Systems linked through Gao Strait

However

Almost No Fluxes

through the Gao Strait (radial groundwater flow only - perpendicular to the Gao Strait axis)

It's an Exfiltration zone



Overall Findings

Gorgeous Groundwater Resources

Negligible Water Level Depletion towards 2050
despite Climate Change and Water Demand growth

*Moreover, One single year of Rainfall in excess can
replenish Water Level Depletion
induced by several years of drought
(wherever Recharge is significant)*

An Under-Exploited Sustainable Resource
which can play a **Buffer Role**
against the irregular Surface Water Resources
(during severe droughts)



Photo: J-M BARRAT, 2013

