Groundwater recharge and salinization in Senegal coastal semiarid regions:

Implication of climate change

S. FAYE, M. DIAW, S. NDOYE, R. MALOU & A. FAYE

Univ. Ch. A. Diop, Dakar, Senegal

OBJECTIVE

Overview of Potential impacts of global climate change and climate variability on:

- **groundwater resources,**
- **the interactions between unconfined aquifers and rivers**
- **and recharge vs. water table levels shifts as first response.**

Case studies and methodologies

Based on **4 case studies** within geo-climatic regions comprising low lying coastal areas and coastal zones in Senegal

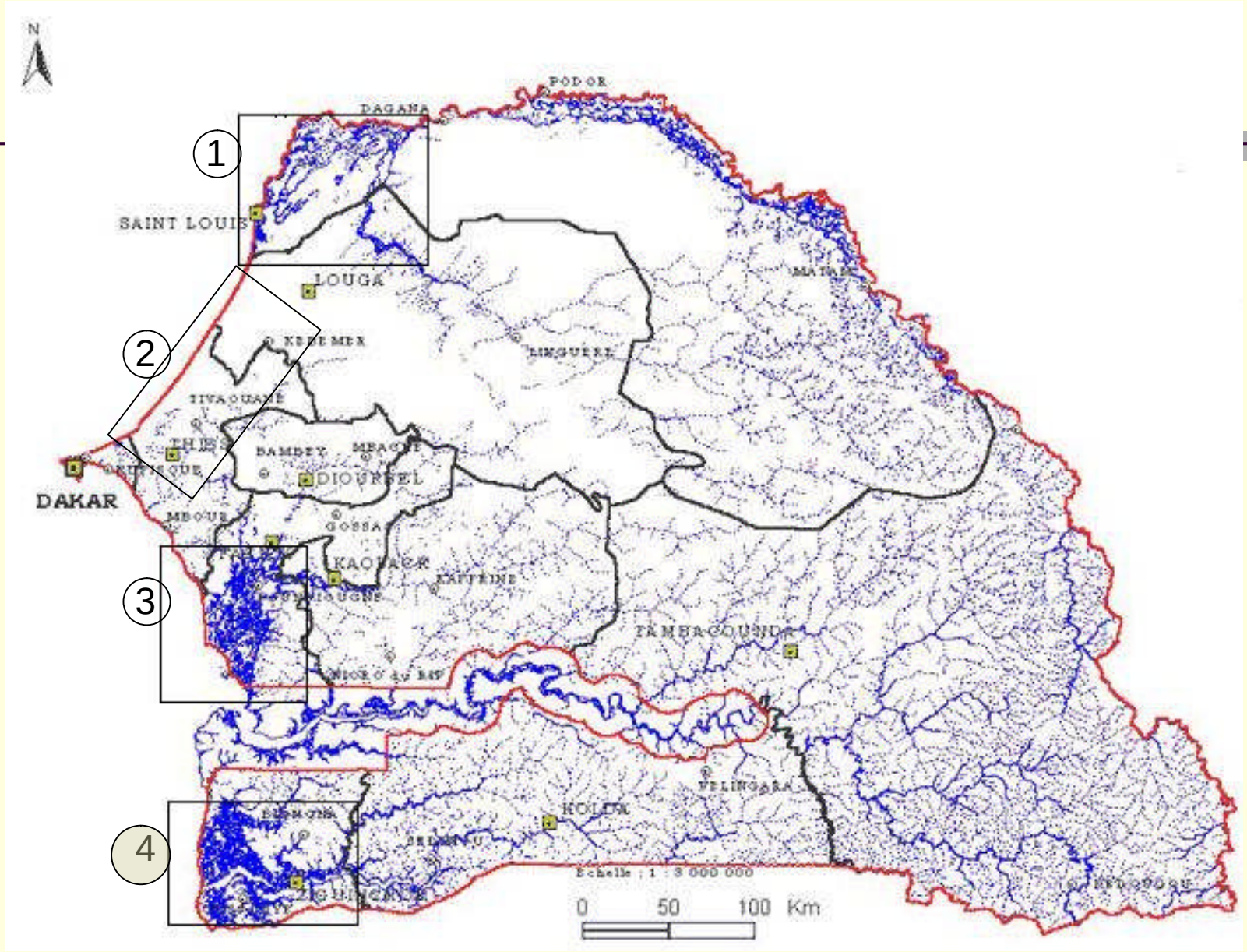
Projects (investigations and results) on estimates of aquifer **recharge**, **groundwater flow and salinization processes** are used to assess sensitivity to CC

Methodology

groundwater flow model

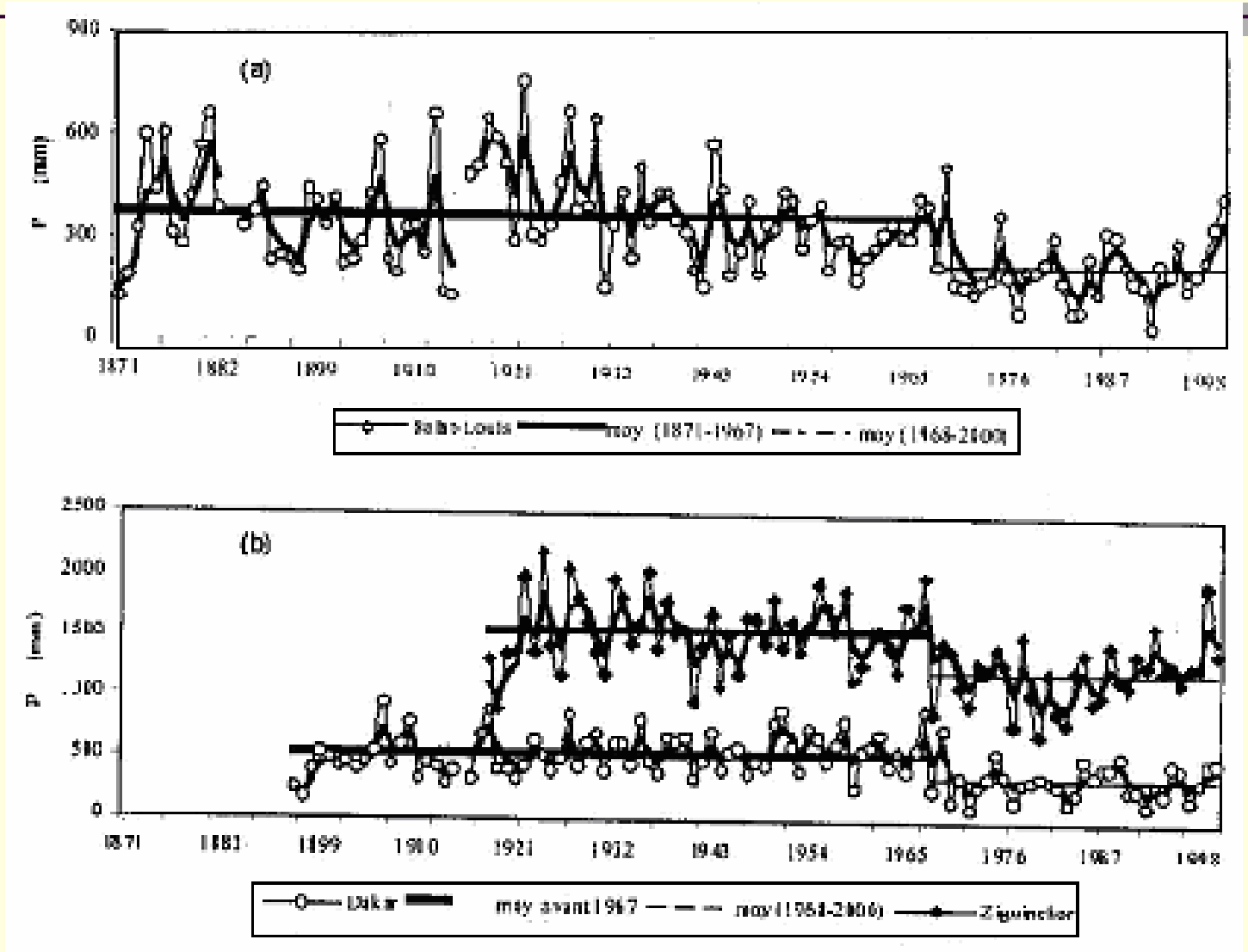
Water table fluctuation method

Geochemical and isotopic approach to explore surface water / GW interactions


N
1
2
3
4
SAINT LOUIS
LOUGA
DAKAR
DIOURBEL
KAOLACK
TAMBACOUNDA
KOLDA
ZIGUINCHOR
0
50
100 Km

Study areas

Precipitation pattern

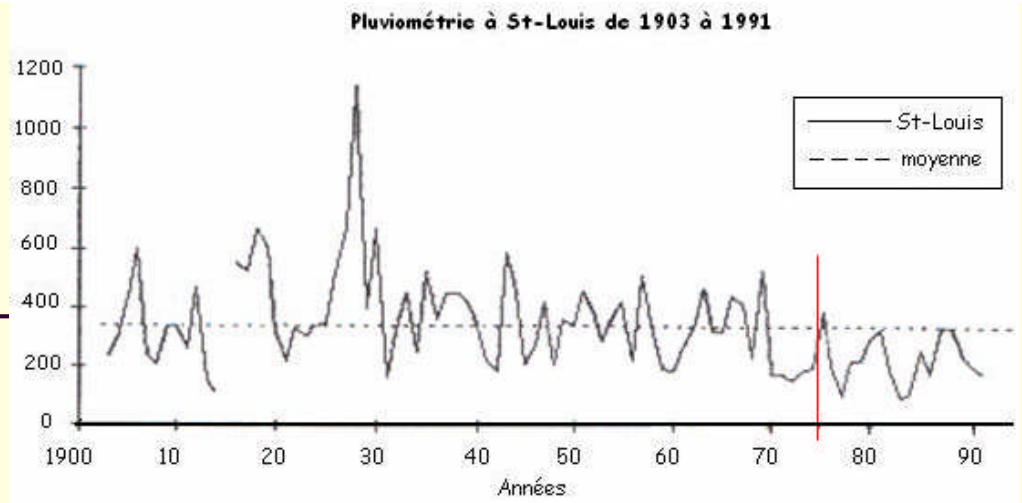


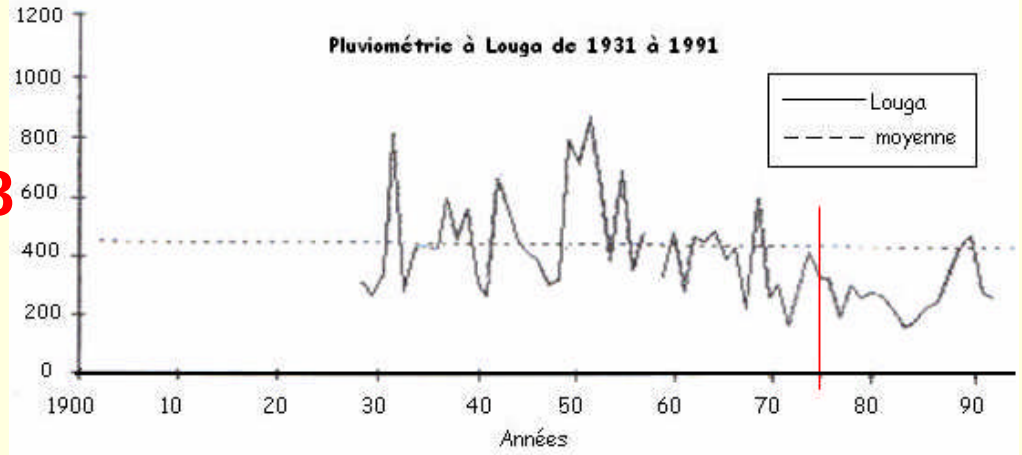
Precipitation pattern

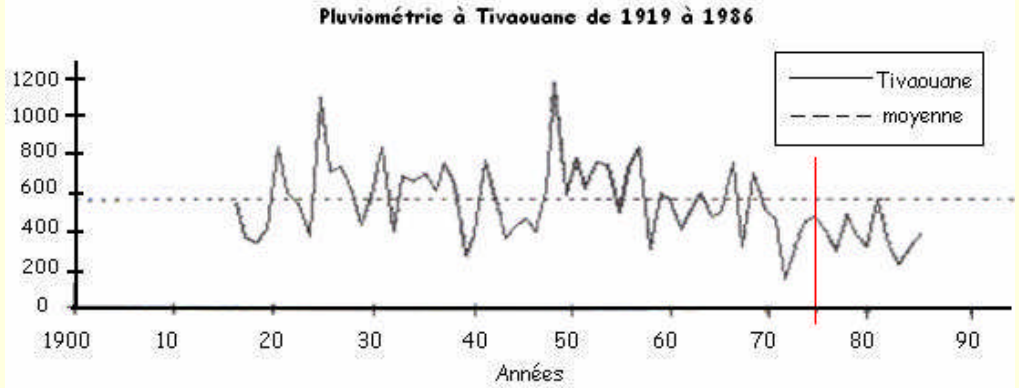
- **Records back to 1876**
- **Two distinct periods /1968**
- **Deficit between 20 to 30%**

Prediction using climatic Model IS92a

T° rise 1-2°C and
Prec. decrease 5-15%







Senegal river delta system

Context

Part of **CORUS** program aimed to:
Understand and justify **recharge mode**
Possibilities to identify surface water/GW using geochemical and isotopic tools

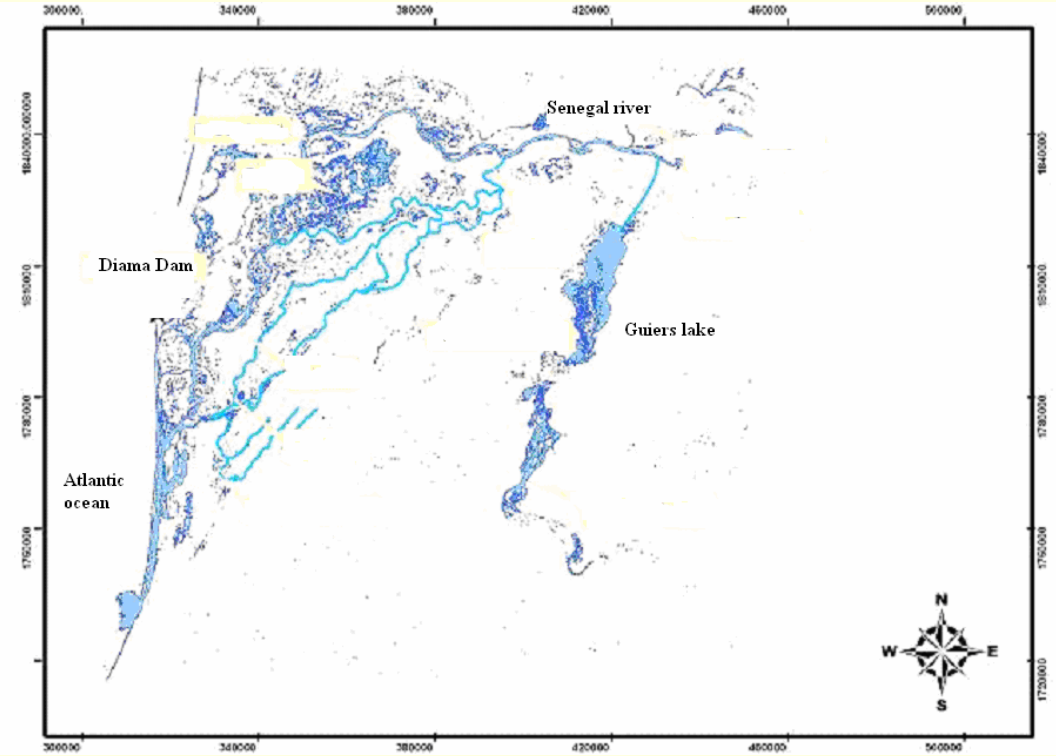
Settings:

Complex hydrological system

Delta and lower valley

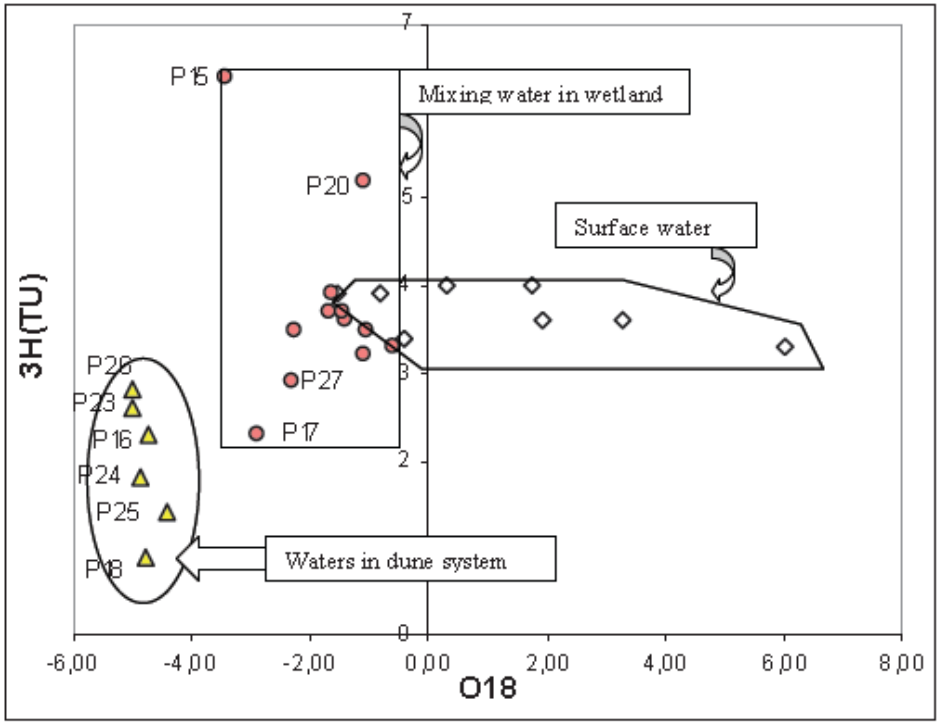
Alluvial and sand dune formation

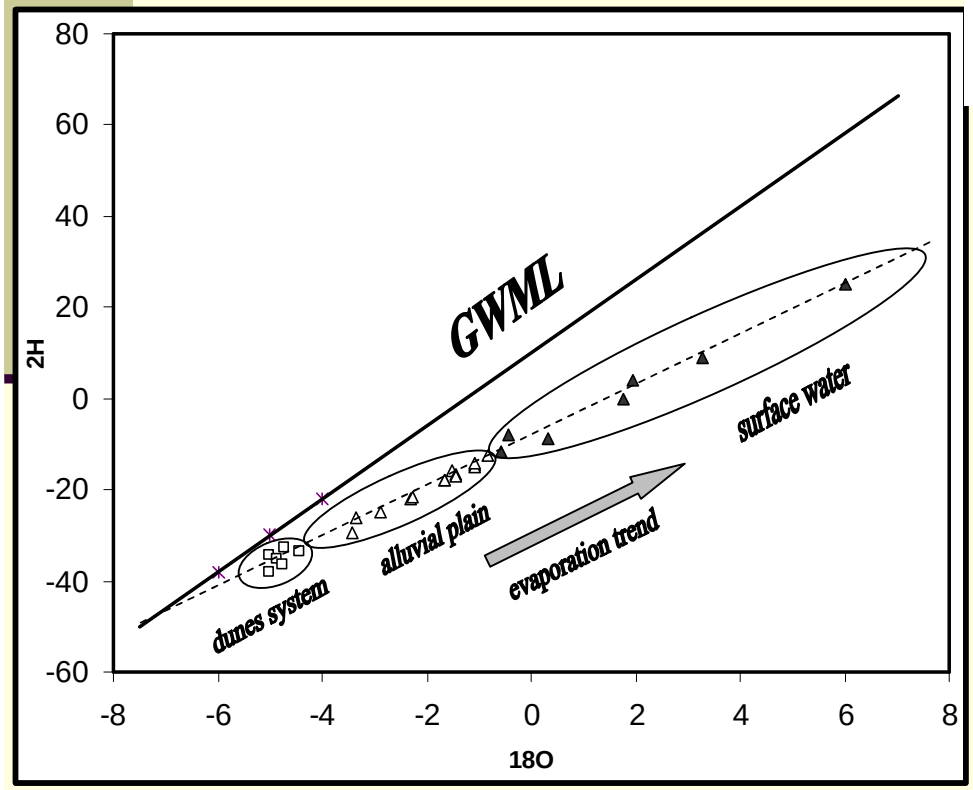
Saline and fresh GW of types: Ca-HCO3, Na-HCO3, Na-SO4, Ca-Cl and Na-Cl



Groundwater & Climate in Africa,
Kampala 24-28 June 2008

Isotopes Results





3 groups according to distribution and geomorphologic setting:

1. **Surface water**: enriched
2. GW in **alluvial plain**
3. GW below **sand dunes**

Climate change implication

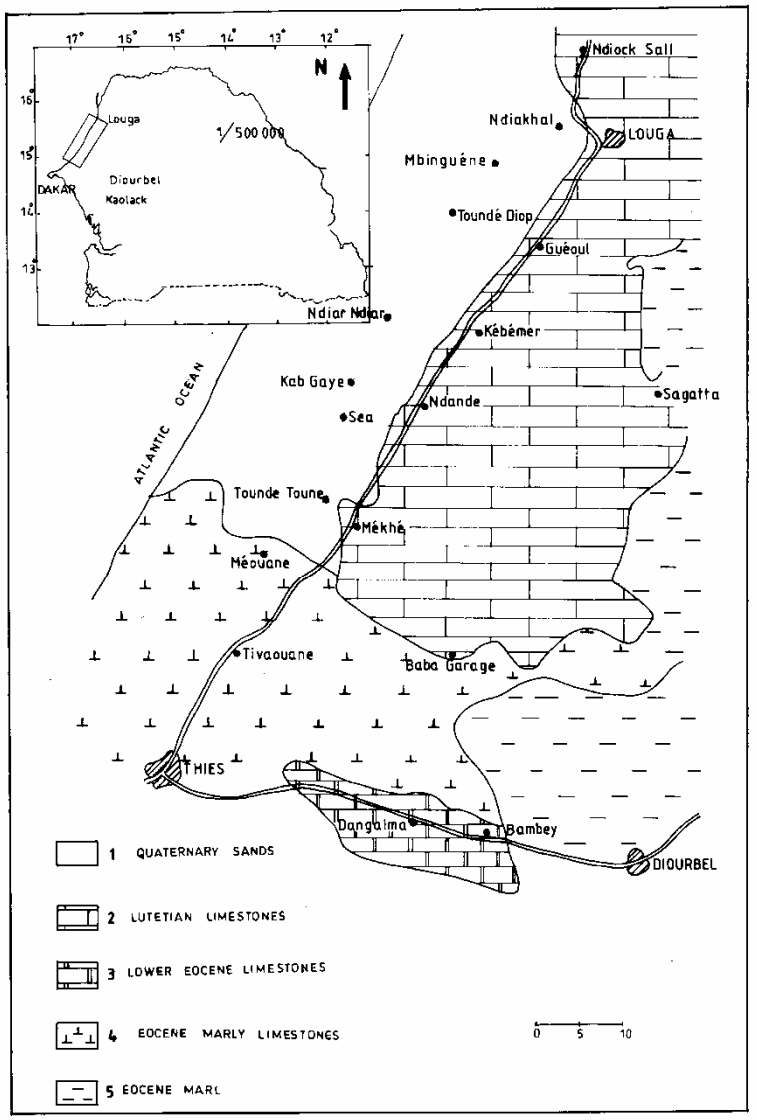
- Difference in sensitivity and variably impacted with regard to geomorphologic setting
- Quick response in sand dunes area due to faster infiltration
- Variably impacted in alluvial plain due to interconnection with wetland, seawater intrusion and dam regulated flow

Littoral Aquifer in North coast

Context

2 main reservoirs: sands (20 to 160m /
karstic limestones (60m)

P: 290-485mm
E: 1500-1800mm
Rainfall infiltration and
discharge through ocean and evaporation



Method and Results

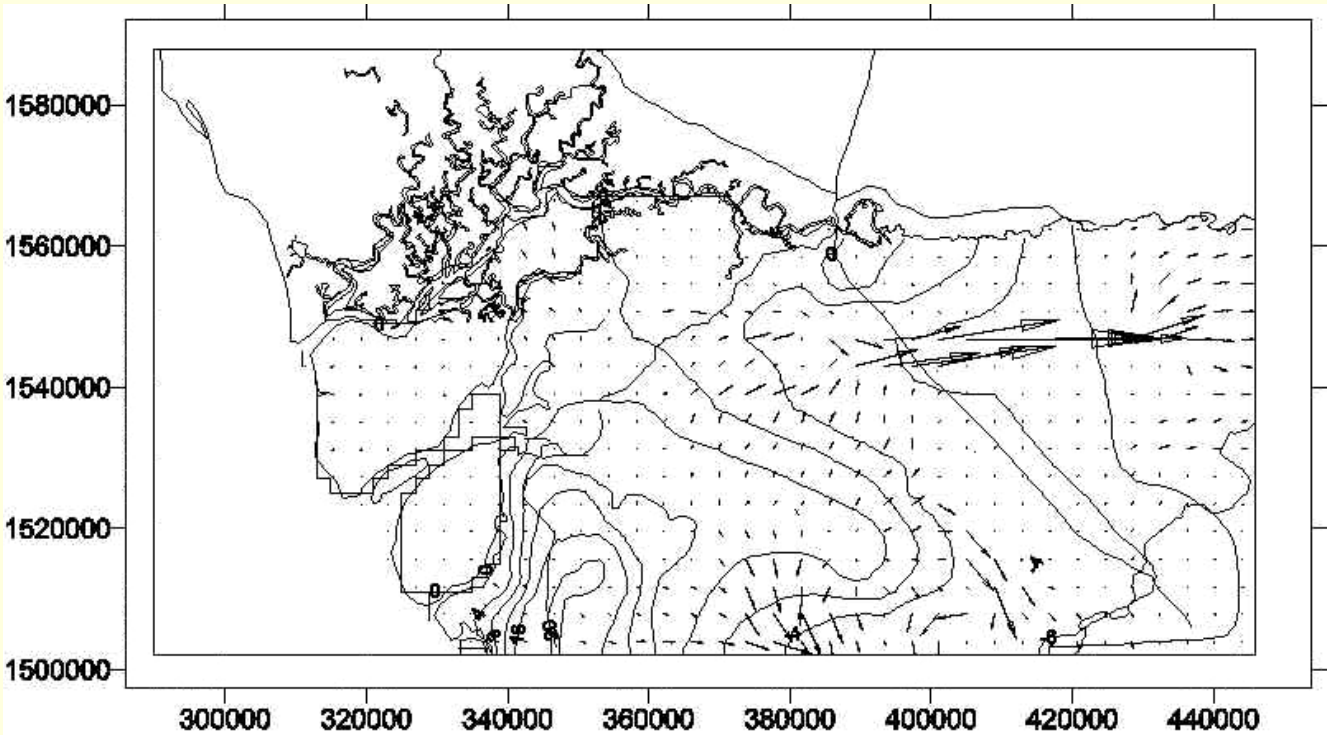
- Groundwater flow model revisited and
- Sensitivity analysis carried out on recharge
- With a reduction of 25% of the imposed values
- During a period of 20 years.

- RESULTS: water table lowering variably from
- 1.2m in the piezometric mound located south
- 0.3 m at intermediate level
- 0 m in low groundwater head located North

Saloum delta system

CONTEXT

Low lying coastal plain with estuary and river Saloum , tributaries
Inverse estuary with salinity gradient towards uptream 36-90‰
Climate soudano-sahelian type: P 600-800mm / E 1500-2500mm/yr
Continental terminal detrital aquifer bearing fresh to saline groundwater
Groundwater flow model using Visual Modflow

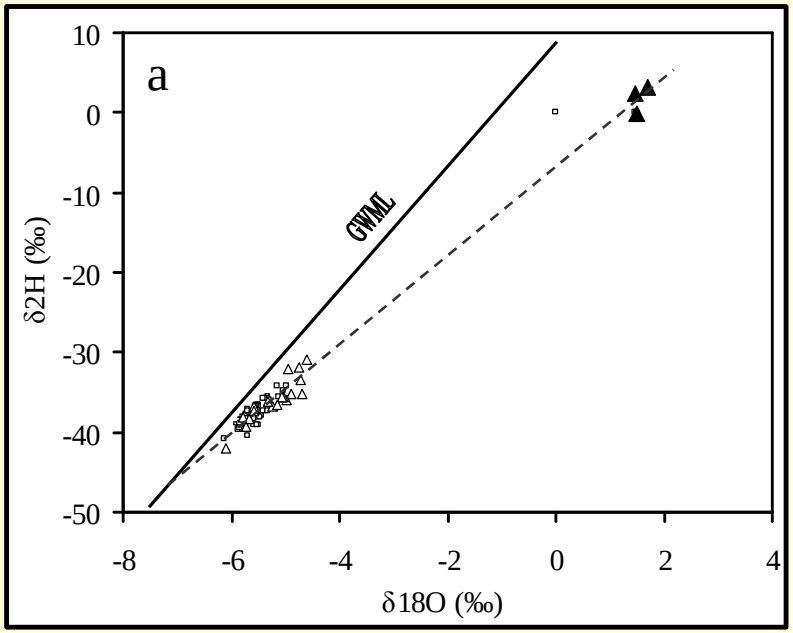


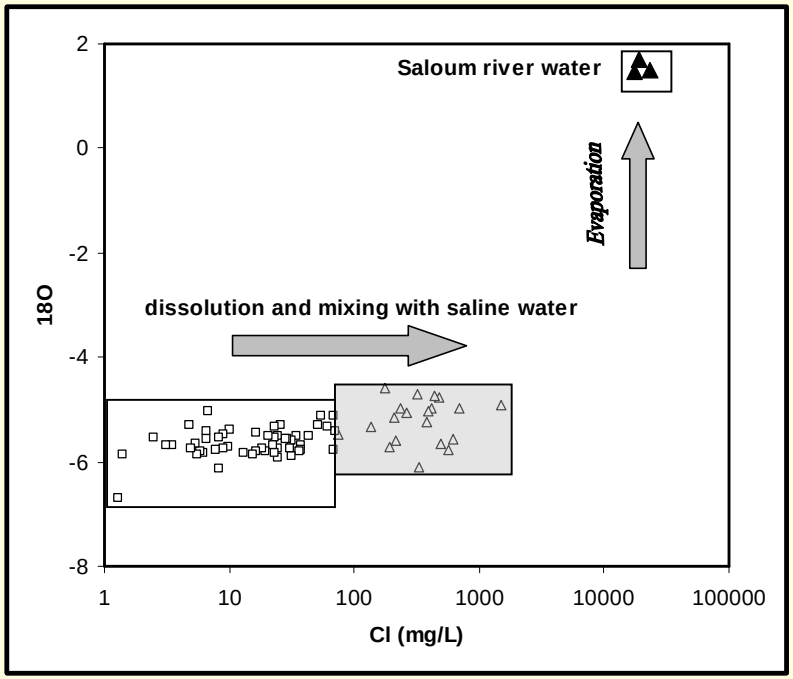
Groundwater flow model using Visual Modflow

Infiltration 34.100 m3/d
Discharge through limits: 31.180 m3/d with main discharge areas located south and east

SENSITIVITY ANALYSIS
By reducing 10 to 25% recharge value
2 to 3m GW decline in high water table zone
1 to 1.5 m at intermediate water table zone
less 1 m where GW level is relatively low (5m)
This pattern will have more pronounced effects on the salinization process due to high evaporation and mixing with the saline surface water

Evidences of mixing as dominant process





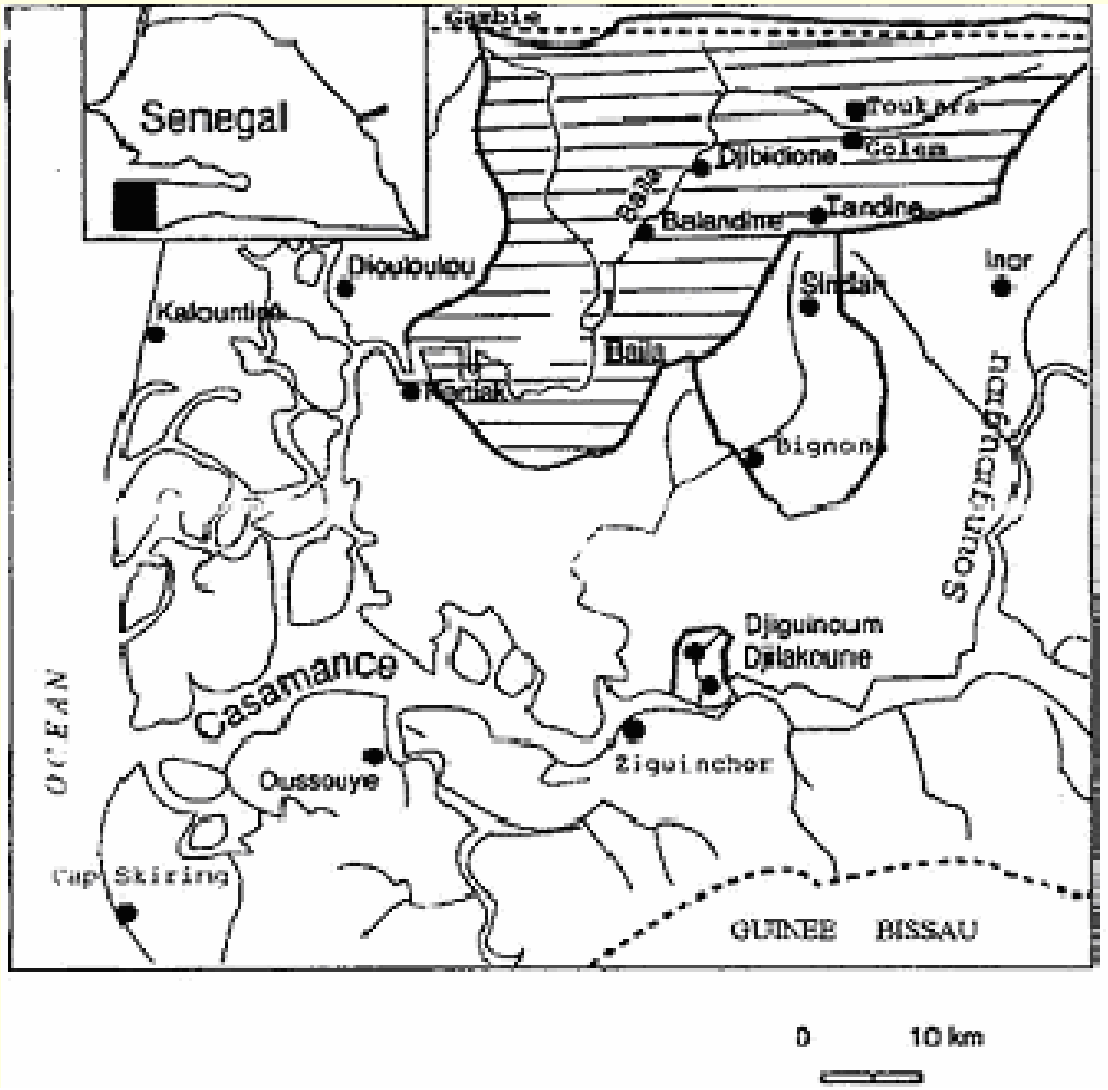
Lower Casamance system

Context

Sudanian climate zone
P: >1.000 mm/yr
T° 28°C
E: 2.000 mm/yr
Low relief
Mangroves ecosystems
Marshes and saltflats
Hypersalinity (up 170‰)

Aquifer reservoir:
Continental terminal

Geomorphology:
Continental plateau
Marine terraces
Depressions zones



Groundwater & Climate in Africa, Kampala 24-28 June 2008

WTF method using
Record between 1987-1990

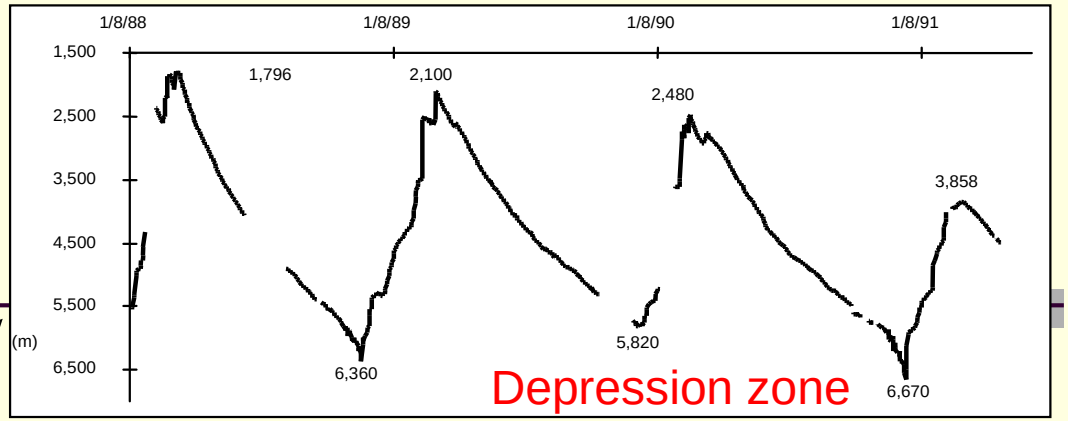
Depth 5-10m
Amplitude 4-5m
Gross recharge 80-100 mm/yr

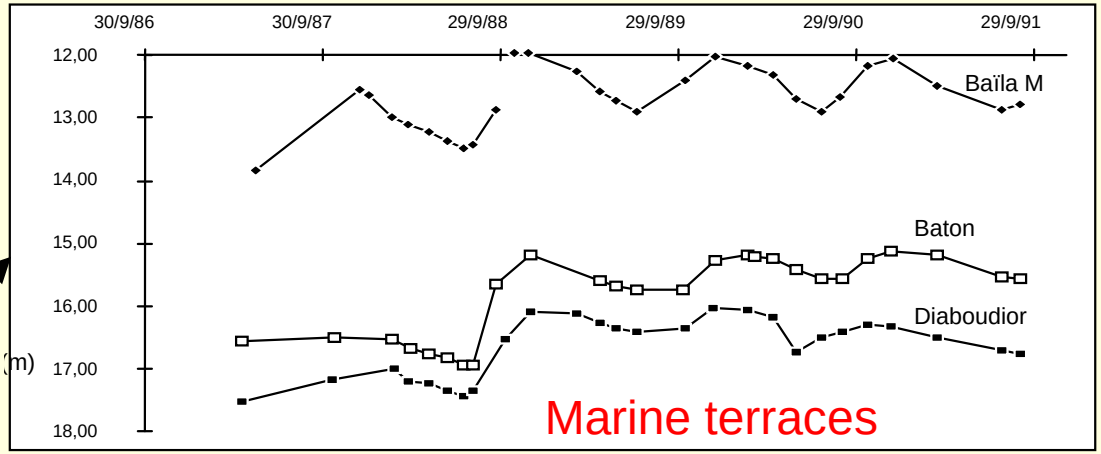
quickly-responding

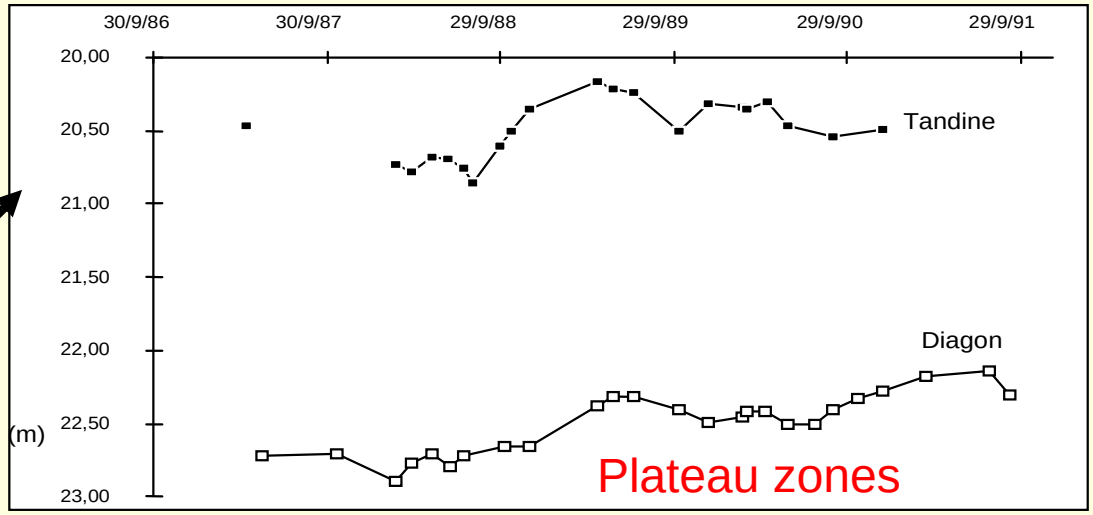
Depth 10-15 m
Amplitude 1.5-2 m
Gross recharge 25-40 mm/yr

slowly-responding

Depth greater 20m
Cyclical trend tends to
Disappear less 1 m
Recharge less 20 mm/yr







Implication on climate change

Recharge: variably depends on geomorphologic Setting (depression, marine terraces, plateau)

River discharge

Salinization due to low lying region

Conclusion

Variable impact depend on:

- High altitude relief
- High piezometric mount
- Geomorpholgy in alluvial, delta system

Decrease in hydraulic gradient

Decrease in GW seepage and river baseflow

Salinity increase in river and saltwater intrusion in coastal aquifer

recommendations

- Potential vs. assessment ⟹ Uncertainties
- **assess the uncertainties**

- Lack of dedicated research CC / GW

- CC vs. human change : parameters like recharge, quality, storage ….