Assessing trade-offs and vulnerabilities to global changes in the Senegal River basin

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Partners

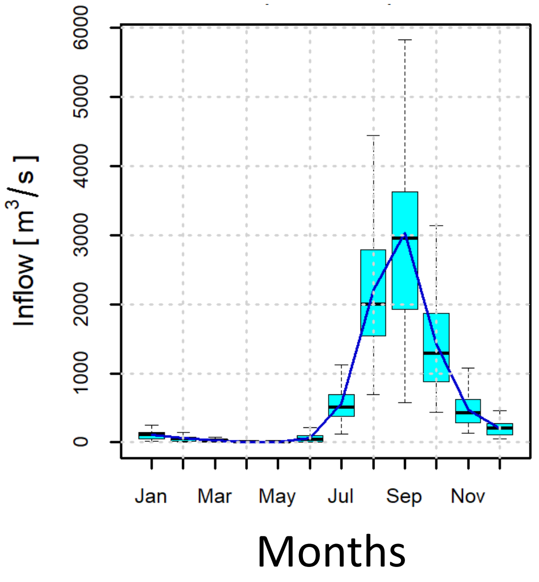
Scientific production

Summary:

1. Background: The Senegal River basin and Objectives
2. Climate trajectories for the XXIth century
3. Hydrological projections production
4. What hydro-economic future for the basin ?

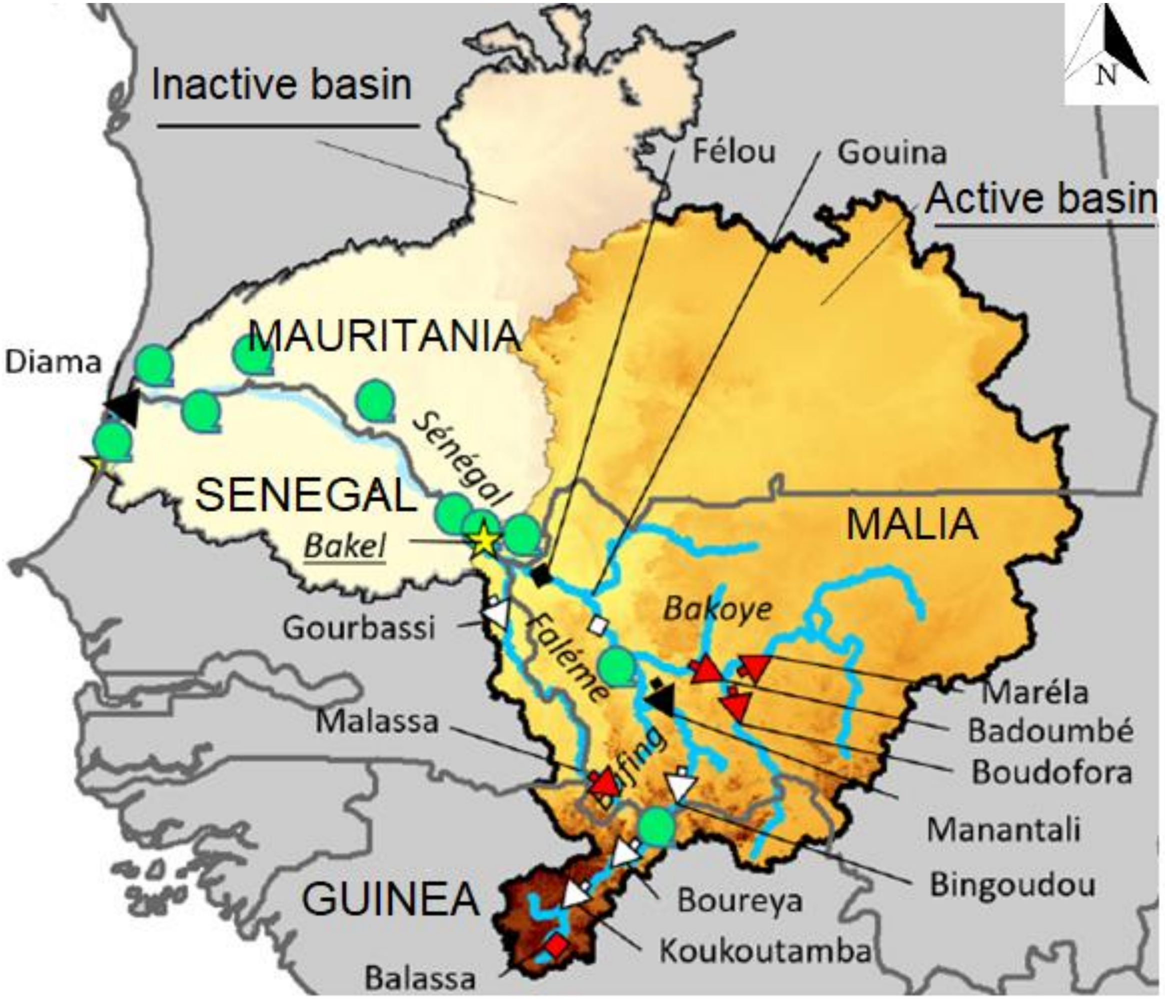
The Senegal River basin

Annual cycle
(1904-2011)



(Data from Bader et al, 2014)

- ▲ Existing dams
- ■ Existing hydropower plants
- △ 2nd generation dams
- □ 2nd generation hydropower plants
- ▲ 3rd generation dams
- ■ 3rd generation hydropower planst
- ● Irrigation



Main water uses:

- ➢ Flood recession agriculture
- ➢ Hydropower generation
- ➢ Fishing
- ➢ Irrigation
- ➢ Navigation

Scientific purposes and objectives

OMVS
ORGANISATION POUR LA MISE EN VALEUR DU FLEUVE SÉNÉGAL

Main mandates: *OMVS (2011)*

- Food and energy production, navigation
- Preserve the balance of ecosystems
- Accelerate development
- Reduce the vulnerability of economies

Allocation policies

Water demand
New infrastructures ?

Water availability
Climate change impacts ?

Scientific purposes and objectives

Objectives of our study:

- Quantifying Climate Change
- Derive potential alterations of the flow regime
- Assess the hydro-economic impacts of these alterations
- Quantify the vulnerability of water uses in the basin for different development and management scenarios

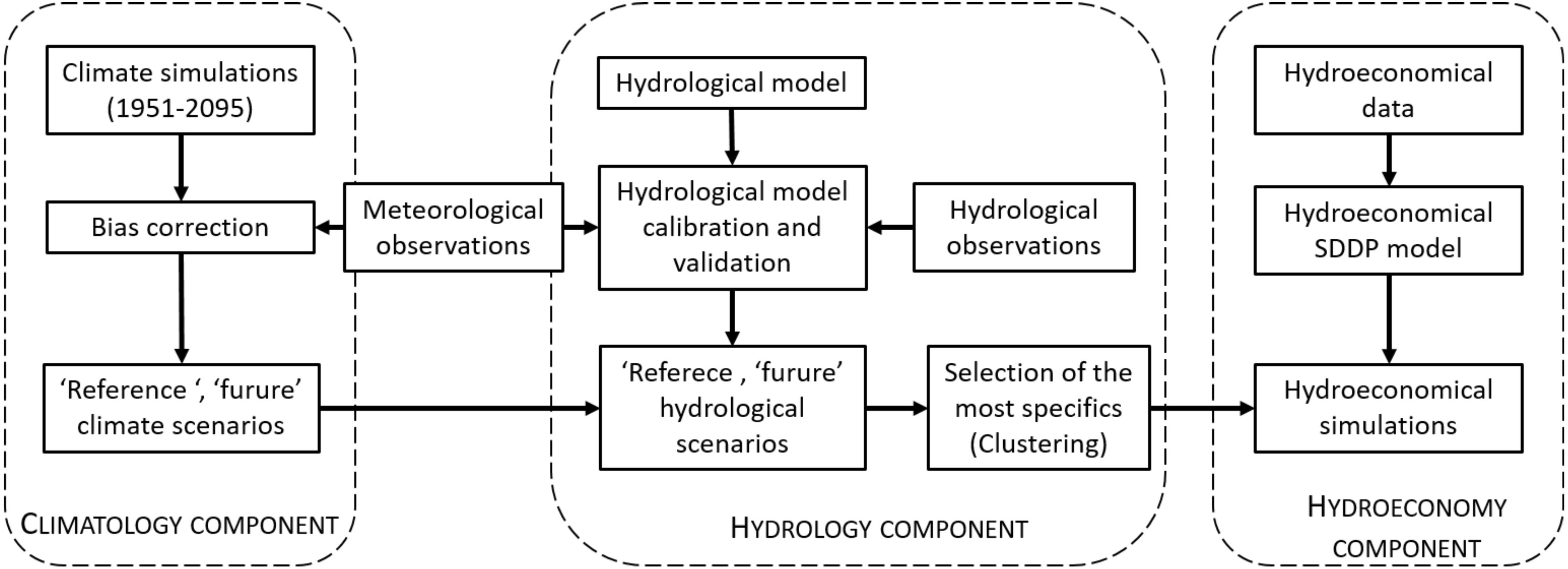
Future allocation policies

Future water demand

Future water availability

Designing of the modeling chain

- Three components



Hydro-economic model

SDDP

Hydrological model

(lumped and monthly)

GR2M

Climate informations

Precip. + Pot. Evapotransp.

Climate observations and climate simulations

Precipitations

➢ Observations:

SIEREM (Dieulin et al., 2019)		
0.5°	Monthly	1940-1998

➢ Simulations: 55

CORDEX-AFR (Giorgi and Gutowski, 2015)		
~0.5°	Monthly	1951-2099

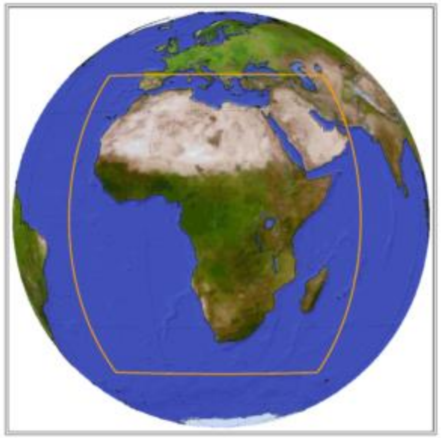
Pot. Evapotranspiration

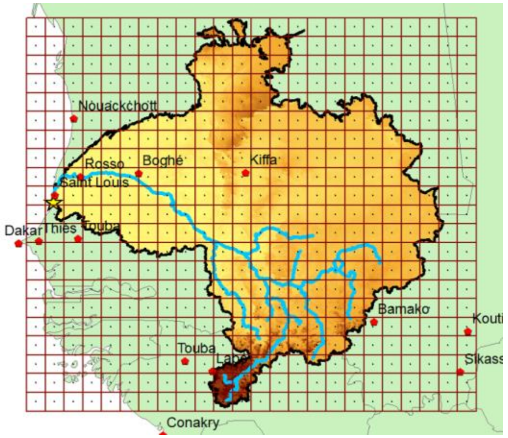
➢ Observations:

CRU (Harris et al., 2020)		
0.5°	Monthly	1901-2018

➢ Simulations: 22

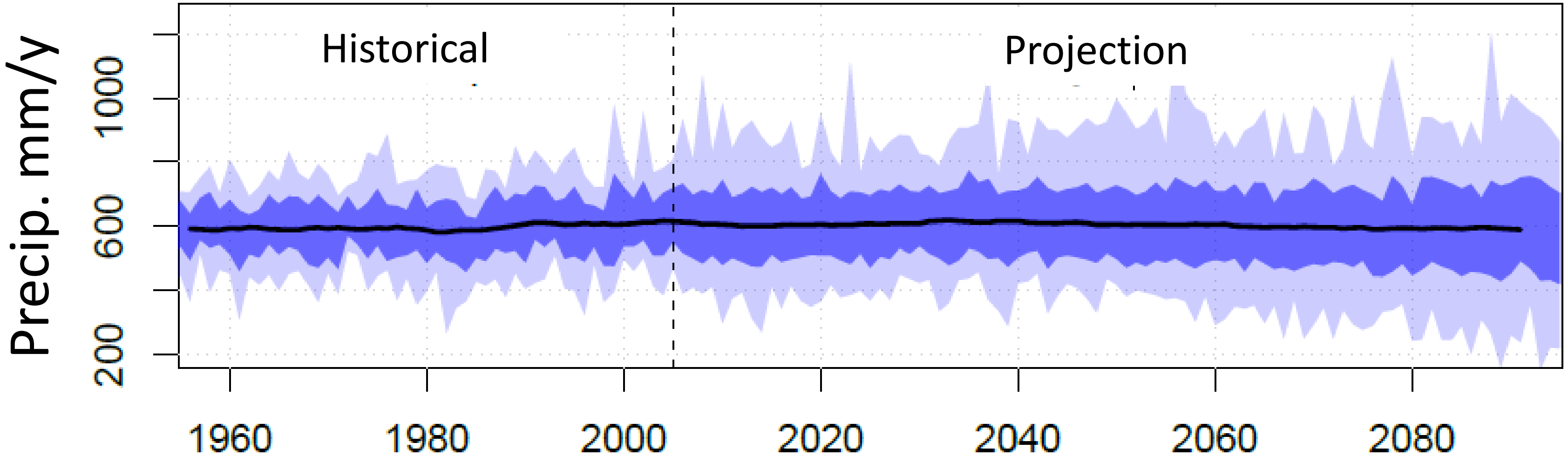
CORDEX-AFR (Giorgi and Gutowski, 2015)		
~0.5°	Monthly	1951-2099



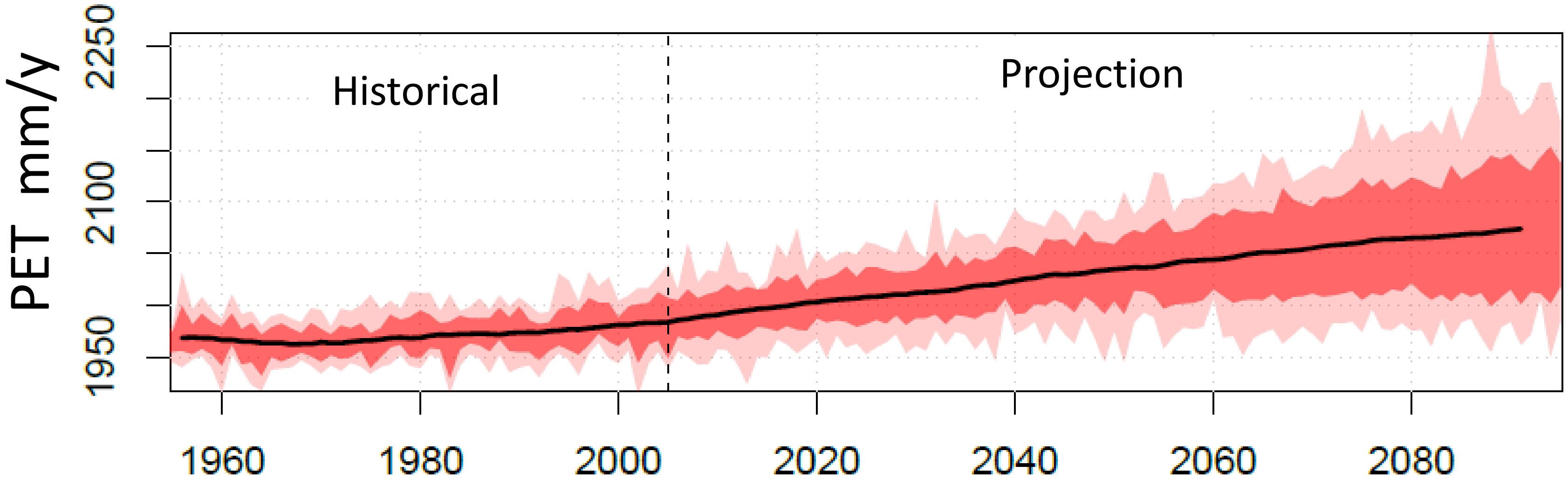


Climate scenarios production and future trajectories

Bias correction method ➔ Empirical quantile mapping (Wood et al., 2004)



➔**Precipitation**:
No clear trend, and very large divergence



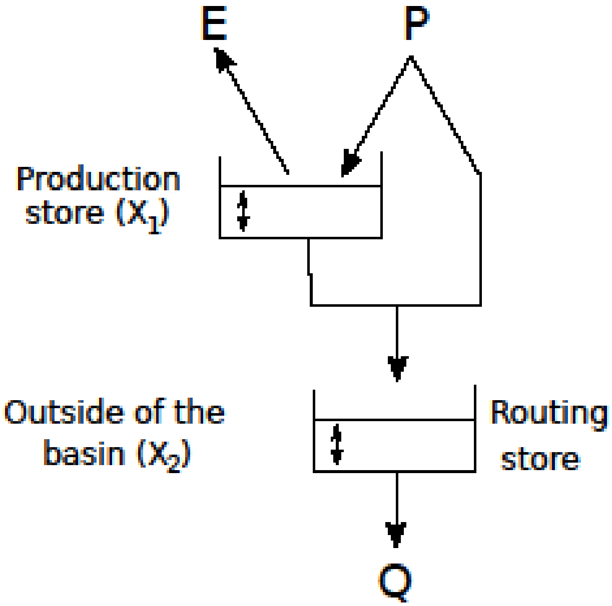
➔**PET**:
+2.5% (from 2000 to 2040) and +6% (from 2000 to 2100),

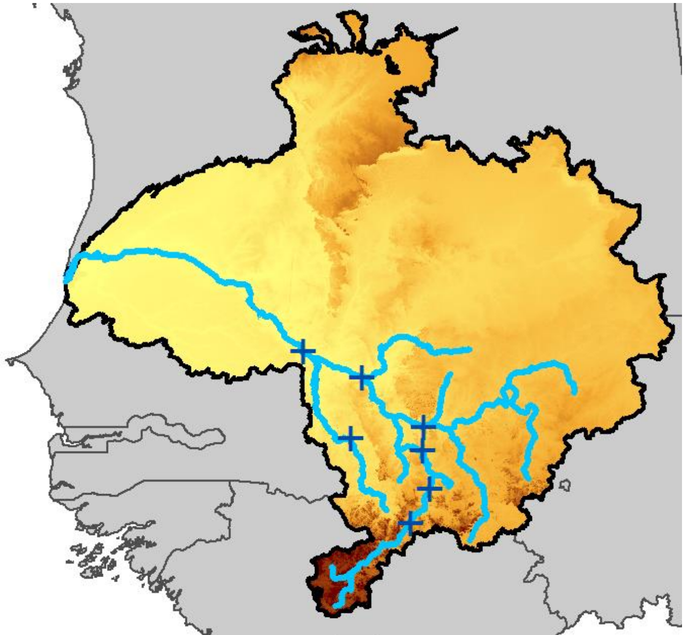
The climate future is highly uncertain

Hydrological modeling of the Senegal River Basin

(Mouelhi et a

GR2M





- 6 outlets modeled
- Calibration procedure:
  - Observations

Precip	SIEREM
PET	CRU
Inflows	Bader et al, 2014

  - Hidden Markov Model classification and differential split sample test (Guilpart et al 2021)

Hydrological projections in the Senegal River Basin

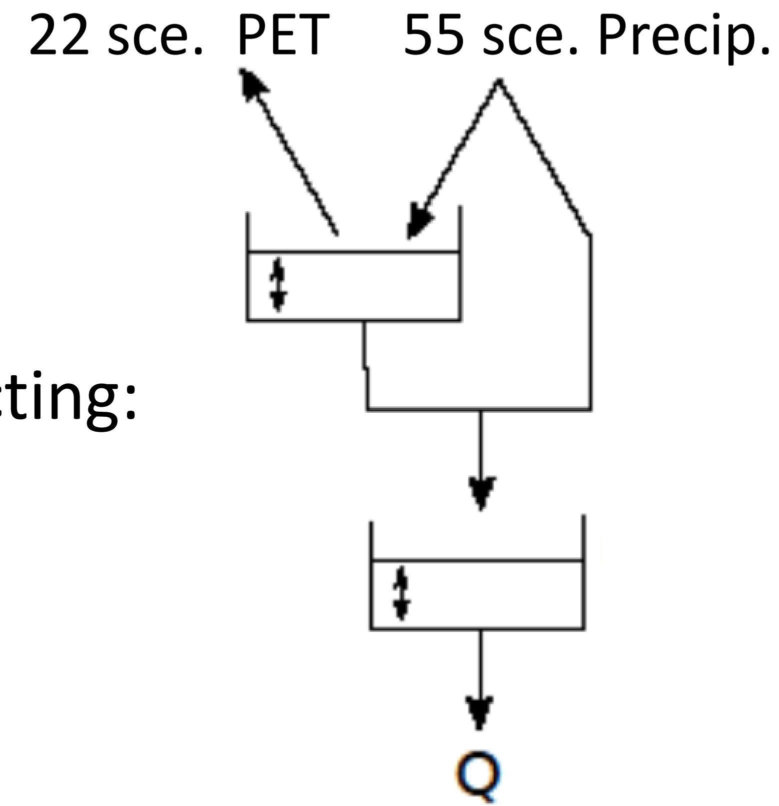
Background

Climate scenarios

Hydro. projections

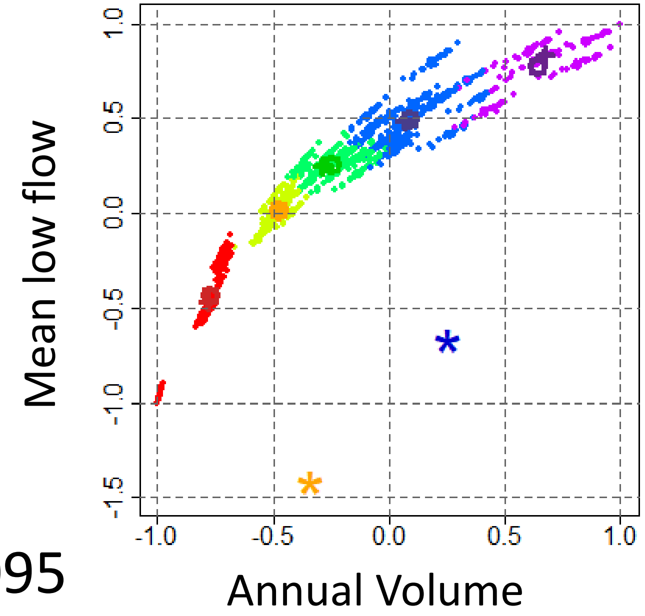
What hydro-eco future ?

Combination of the 22 PET scenarios with the 55 precipitations scenarios



Selection of the five most representative :
K-means clustering + 8 hydrological attributes reflecting:

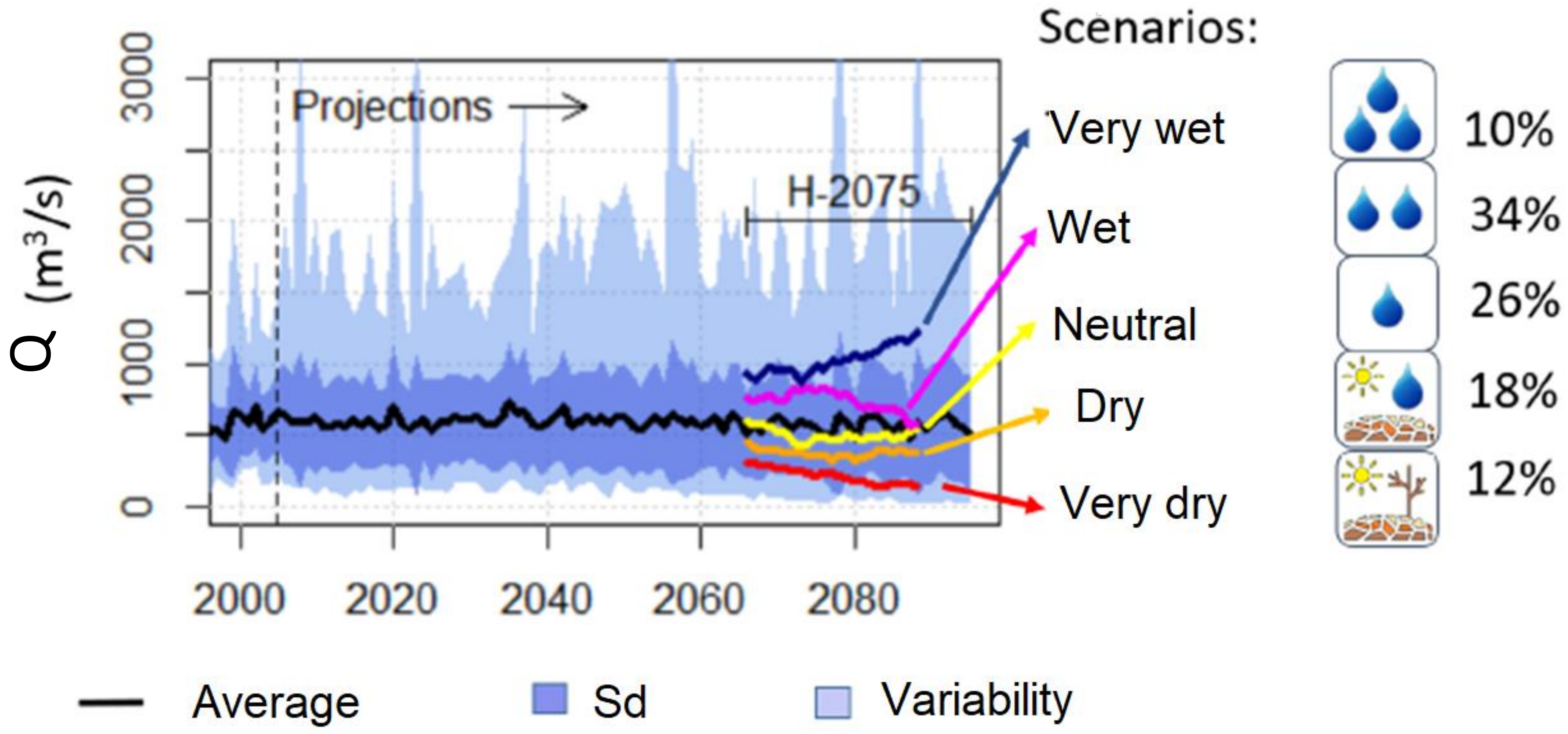
- The annual flood and its variations
- The low-flow season and its variability.



2066-2095

1210 hydrological projections

Hydrological projections in the Senegal River Basin



Background

Climate scenarios

Hydro. projections

What hydro-eco future ?

Background

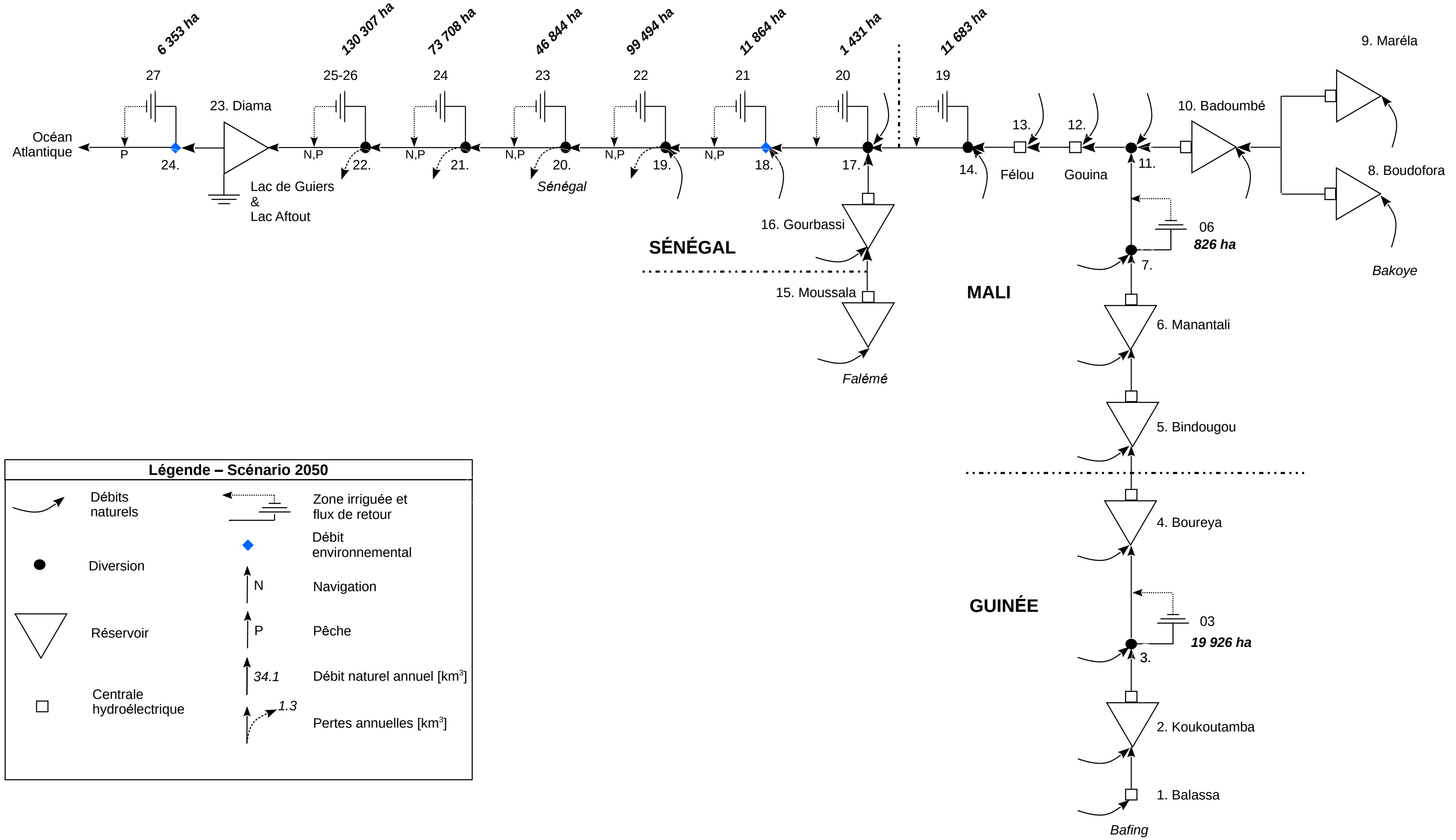
Climate scenarios

Hydrological projections

What hydro-eco future ?

SDDP Hydro-economic model of the basin

- Arcs and nodes
- Five main water uses



Climate scenario

Management scenarios

Analysis tools

Developpement scenarios

Hydrological scenarios

Tilmant et al, 2020

Development and management scenarios

- Two development scenarios:

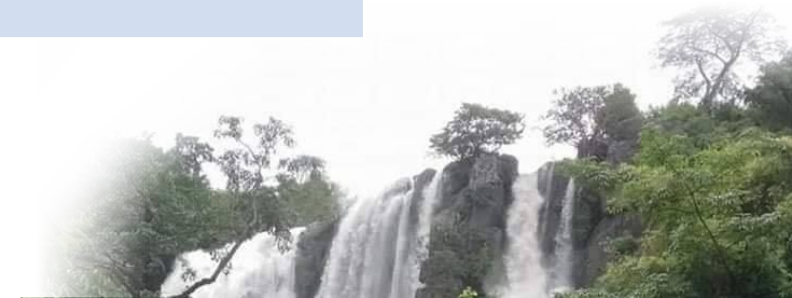
Development Level	Intermediate	Full
Irrigation (area)	255 kha	402 Kha
Hydropower generation (capacity)	866 MW	1214 MW

- Two management scenarios:

Polocy	« Food security »	« Energy security »
Artificial flood	Mandatory	Optional

- Five hydroclimatic scenarios

➔ 15 combinations explored



Performance indicators

The optimization of allocation policies followed by their simulation makes it possible to assess the performance of the sectors:

IMPACTS AND VULNERABILITIES

<u>Navigation</u>
Number of navigable months

<u>Energy</u>
Average or guaranteed annual hydroelectric production

<u>Flood recession agriculture</u>
Flooded superficy

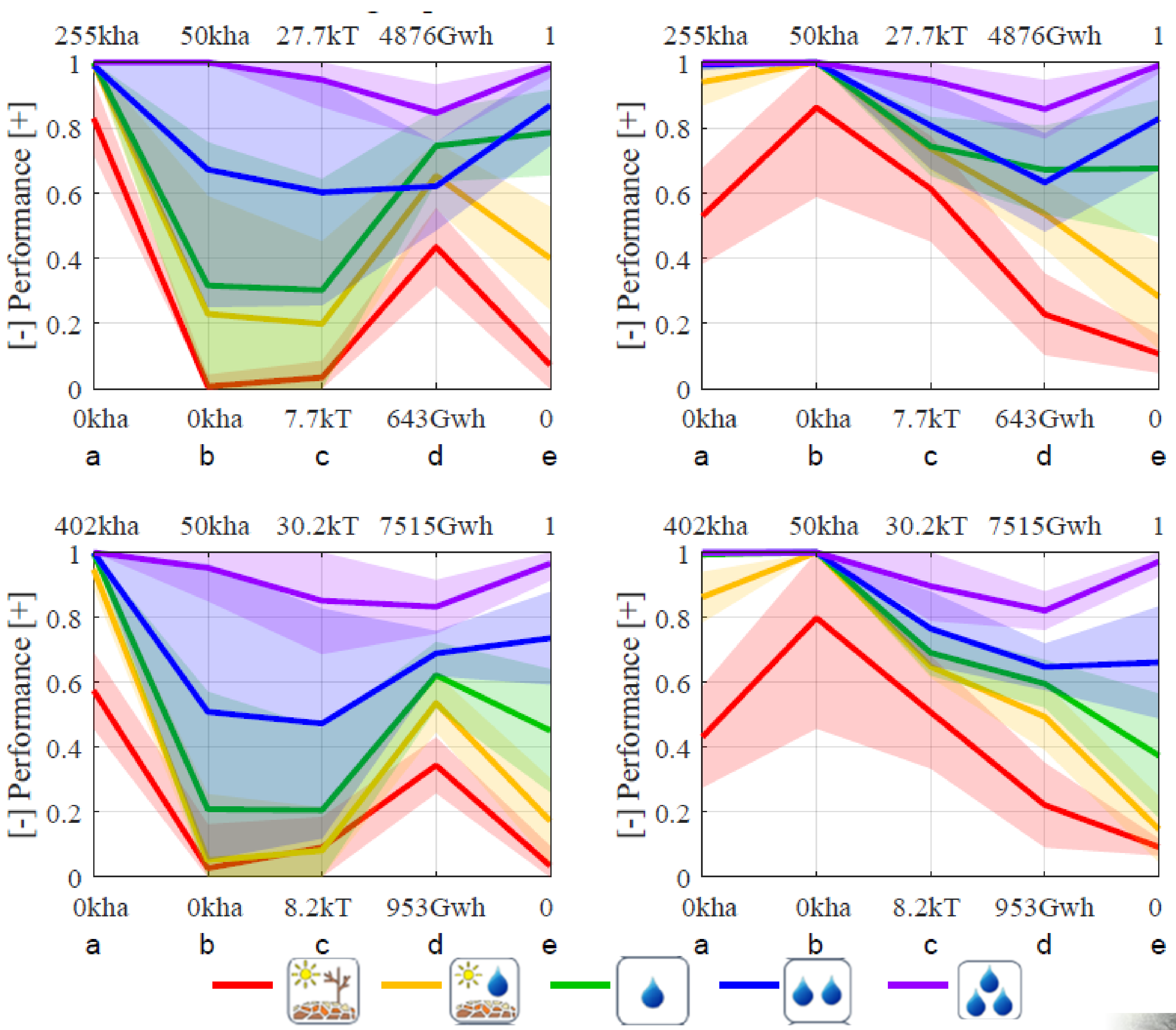
<u>Irrigated agriculture</u>
Area actually irrigated

<u>Fishing</u>
Annual catches in the valley and reservoirs

Performance of the water system under climate change

Irrigated agriculture	165	252	255	249	255	87	203	253	240	255
	167	341	399	402	402	106	283	391	400	402
Energy	1643	2689	3006	2417	3593	880	2050	2831	2250	3617
	2420	3458	4049	4719	5537	1358	2688	3950	4474	5722
Navigation	0	1.9	6.0	7.9	10.9	1	1	3.9	6	11
	0	0	1.9	5.6	10	1	1	1	5.0	10.9
Flood recession agriculture	0	0	0	0	50	12.0	50	50	50	50
	0	0	0	0	36.3	1.2	50	50	50	50
Fishing	7.8	7.8	8.0	7.9	22.2	12.8	21.5	21.5	21.4	22.8
	8.9	8.3	8.8	9.4	20.5	11.6	21.4	22.1	22.4	24.1

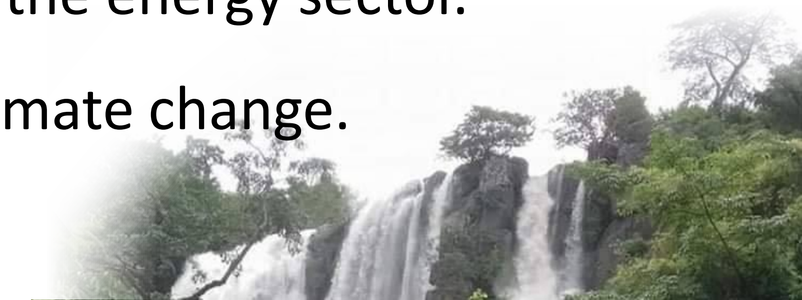
Performance of the water system under climate change



a. Irrigation
b. Flood recession agr.
c. Fishing
d. Energy
e. Navigation

Conclusions

- Modern uses (energy, irrigation, river transport) are vulnerable to climate change.
- Traditional uses (recession agriculture, fishing) are affected in priority by the decision to maintain or not an artificial flood rather than by climate change.
- The results indicate that in 2020 the basin is at a crossroads:
  - ➢ Either the basin is transformed into an energy-agriculture-transportation hub.
  - ➢ Or a balance is found between modern uses and traditional uses.
- The development of hydroelectric potential should be done in priority on the Bafing upstream of Manantali in a way to:
  - ➢ Reduce the opportunity cost of artificial flooding for the energy sector.
  - ➢ Maintain traditional uses that are less sensitive to climate change.



Background

Climate scenarios

Hydrological projections

What hydro-eco future ?

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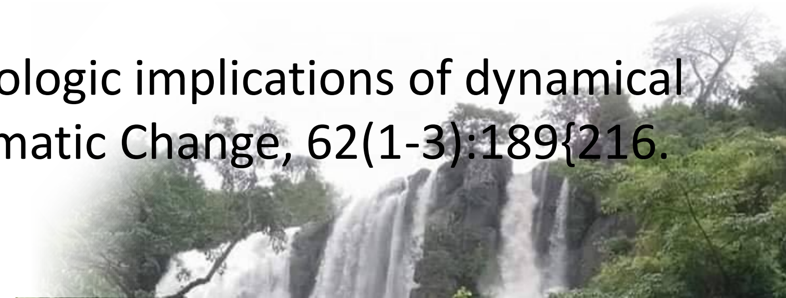

Thank you for your attention

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<u>Data and reports</u>