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French German cooperation in Africa
in the field of Climate Change, food security and Water Resources

Water resources assessment and impacts of climate change in Benin: case of Ouémé basin

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OUTLINE

Introduction

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❖ Introduction

Located in the West African region, Benin is watered by a dense river system with Ouémé River as the main (510 Km).

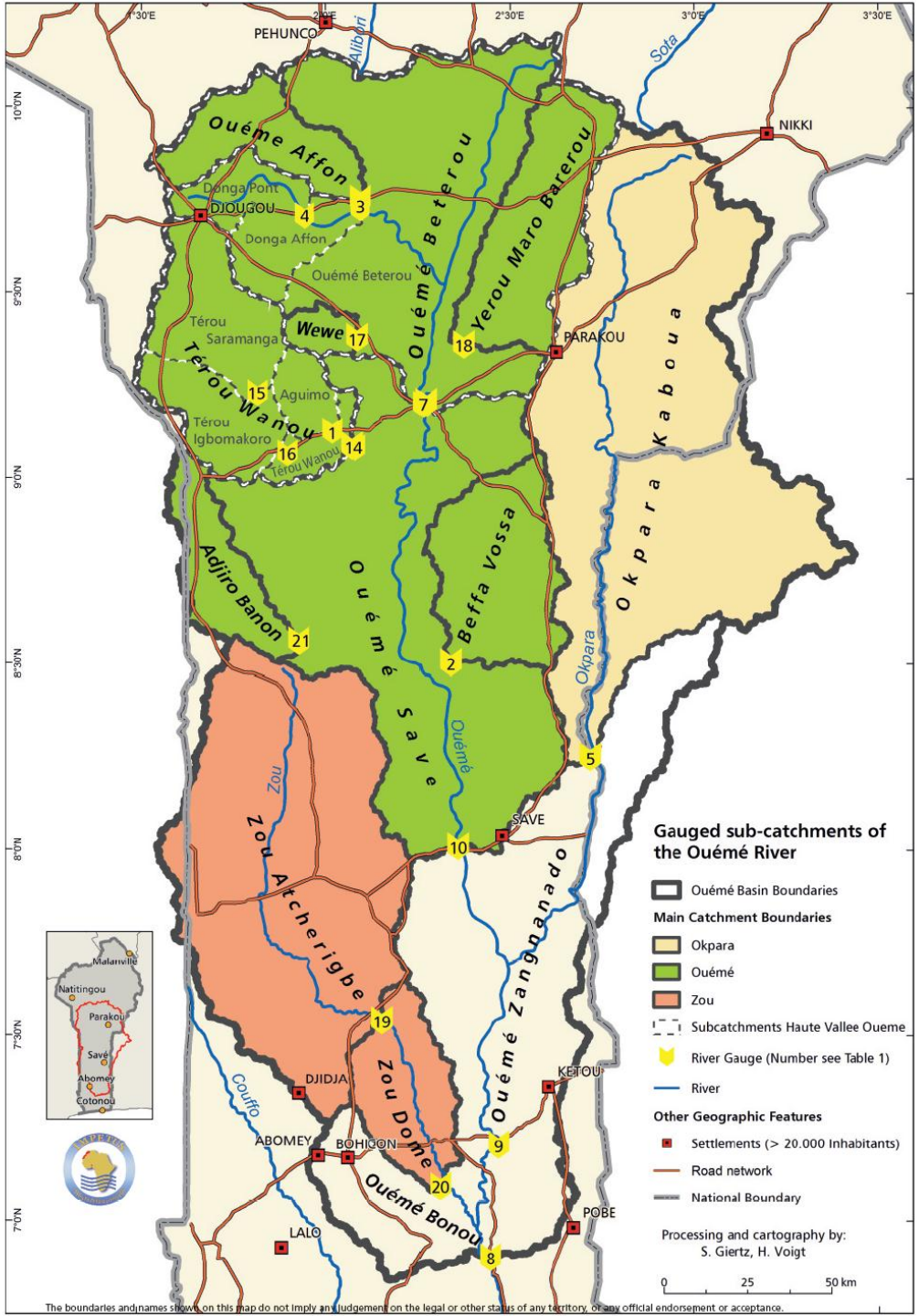
Its basin was the subject of various modeling studies to estimate current and future water resources.

Water resources drained by major rivers of the country are estimated at 13.2 billion cubic meters of water per year and the total annual recharge of various aquifers is estimated at about 2 billion cubic meters of water.

❖ Introduction

these generally abundant resources are under threat from various forms of pollution and various results of hydrological modeling works include a significant reduction in rainfall with a corresponding reduction in water production for the next decade.

There is an urgent need to contribute to the sustainable management of water resources in our basins, particularly in the largest one of Benin which is Oueme basin (Fig.1) by formulating strategies for protection, conservation and increased productivity of hydro basin systems.



- **Oueme Basin with its sub- basins**

- **Superficie: 54,000 km²**

- **Soudano Guinean climate in South with two reany seasons (1200 mm) alterning with two dry and soudanian climate with one reany season in north (1100 mm)**

❖Objectives

This presentation summarizes the modeling results on various sub-basin of Ouémé in a context of climate change and degradation of plant cover.

Theses studies have as objectives:

i) To caracterise climate change issue in Benin;

ii) to estimate the impacts of Climate Change and land use / land cover dynamics on water Resources in 2025 in order to formulate strategies for protection, conservation and increased productivity of hydro basin systems;

❖Methodology

For the future water yield in the basin, the SWAT 2005 model was used to perform various simulations based on the results of the calibration of the model, the climate change scenarios developed by IMPETUS research program and scenarios of land use developed by the CENATEL under RIVERTWIN project.

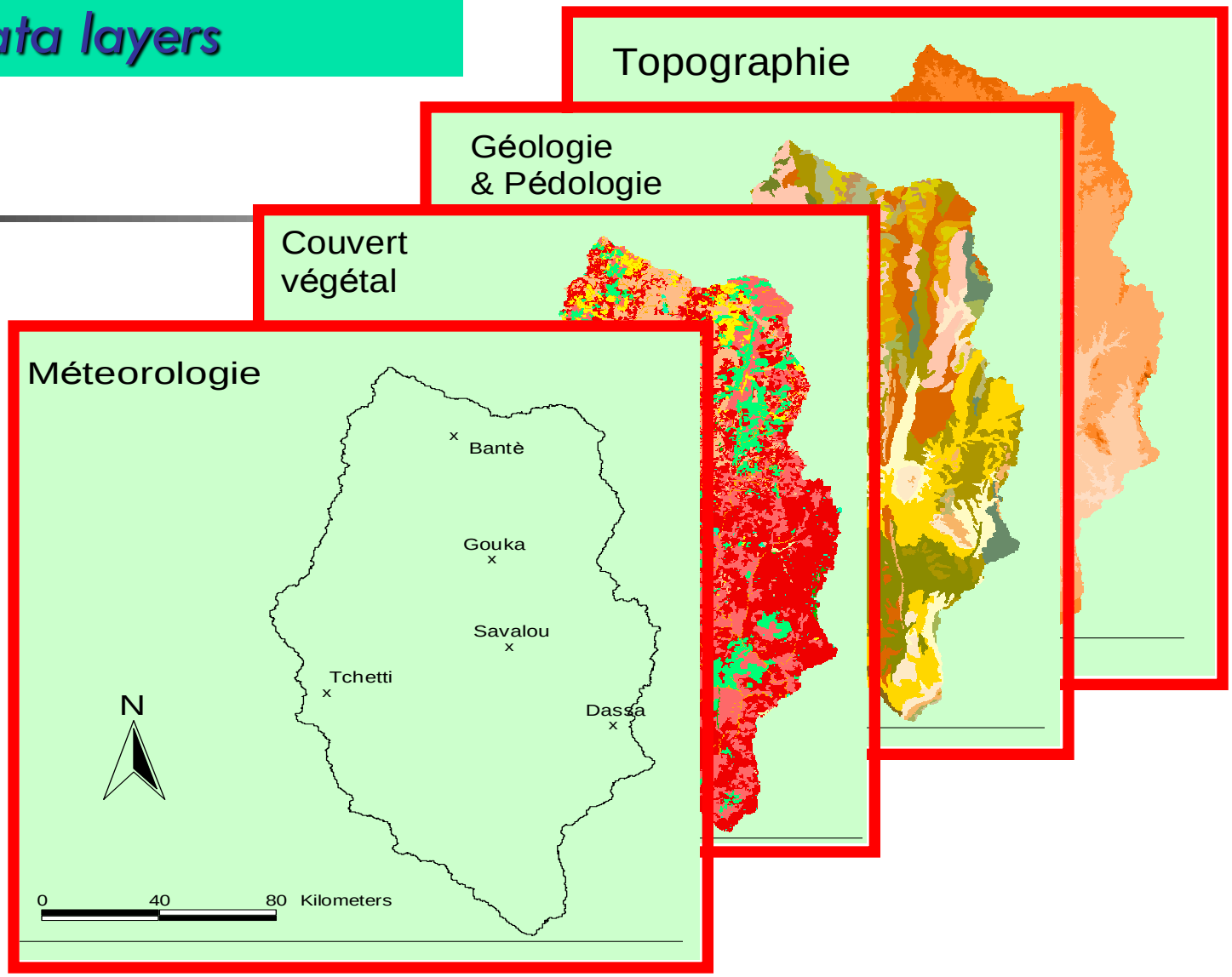
Materials and methods

Materials

- *DEM of 90m and 30m resolution performed by the SRTM (Shuttle Radar Topography Mission) of NASA*
- *Topographic map and lands occupation of IGN-2000 at 1/200000 scale.*
- *GPS (Global Positioning System)*
- *Sediments traps*
- *Metallic cylinders*

Data Configuration

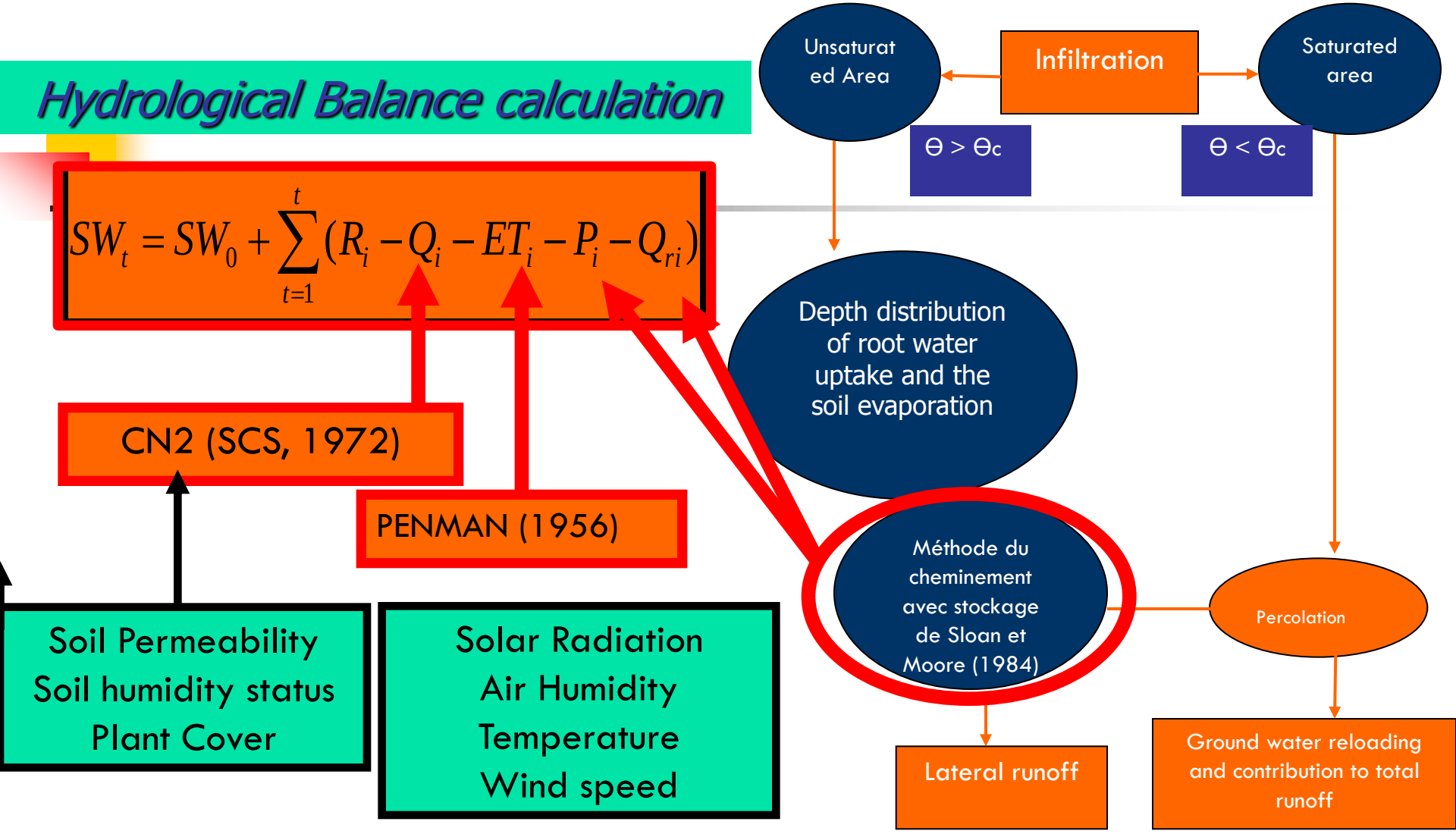
Data layers



Materials and methods (continue)

Hydrological Balance calculation

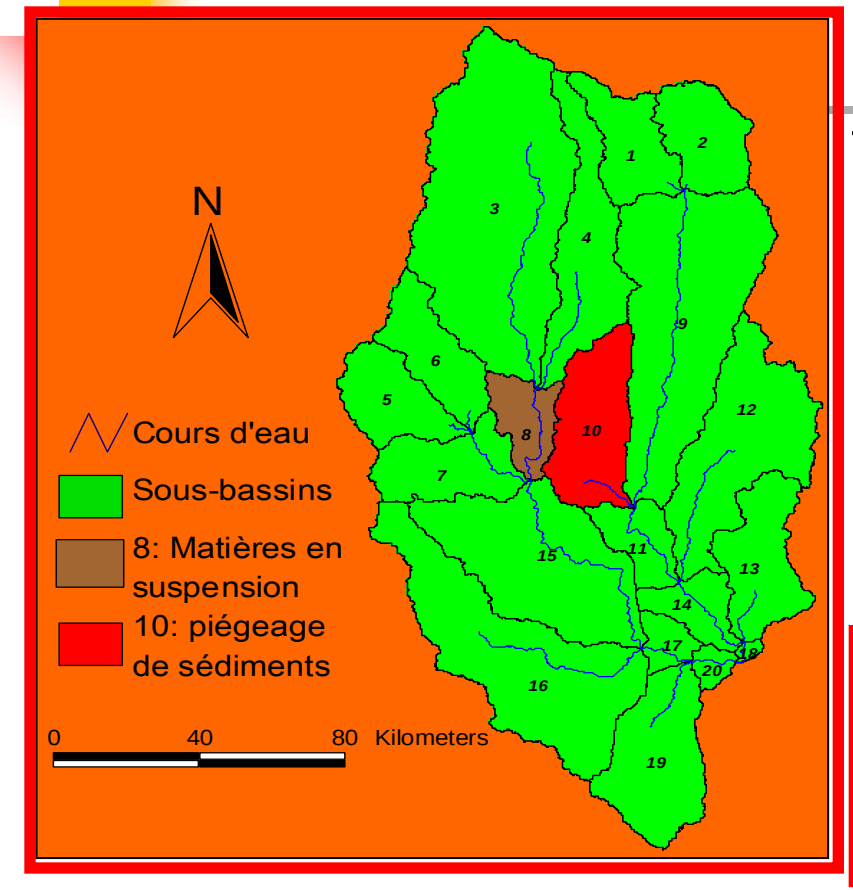
$$SW_t = SW_0 + \sum_{t=1}^{t} (R_i - Q_i - ET_i - P_i - Q_{ri})$$



The spatial unit for the calculation is the HRU ***(Hydrologic Response Unit)*** which is the result of a combination of one soil type and one plant cover in the watershed.

Material and methods (continue)

Measurement and simulation of land losses



Niveau de toposéquence	Site 1 : billons isohypses	Site2 : labour à plat	Site 3 : billons parallèles à la plus grande pente
Amont	P111 P112 P113	P211 P212 P213	P311 P312 P313
Versant	P121 P122 P123	P221 P222 P223	P321 P322 P323
Aval	P131 P132 P133	P231 P232 P233	P331 P332 P333

$$sed = 11.8 \cdot \left(Q_{surf} \cdot q_{peak} \cdot area_{hru}\right)^{0.56} \cdot K_{USLE} \cdot C_{USLE} \cdot P_{USLE} \cdot LS_{USLE} \cdot CFRG$$

(Wischmeier et *al*, 1965)

(Williams, 1975)

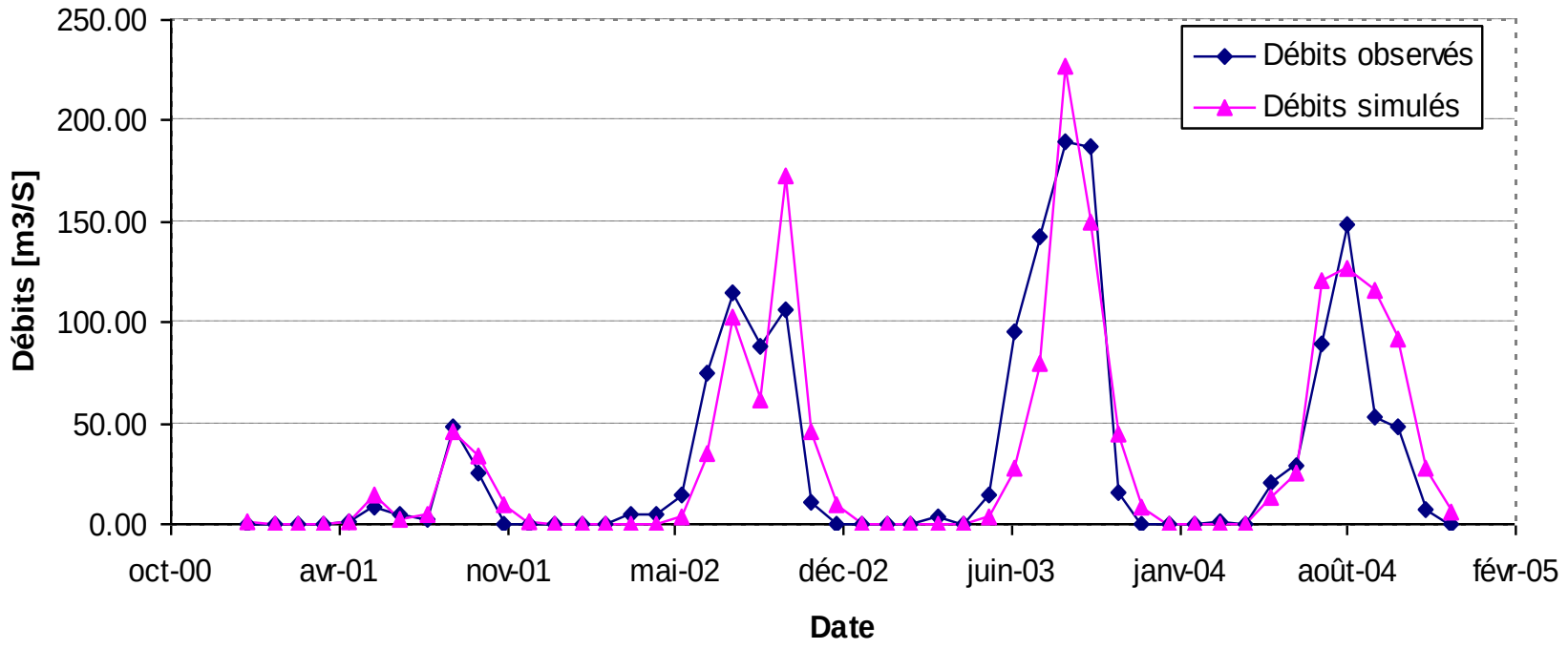
Data configuration (continue)

Data Tables

Station	Longitude (°décimal)	Latitude (°décimal)	Elévation (en m)	Période des paramètres de pluie	Période : vent, soleil, humidité et température
Savalou	1,98	7,93	174	1995-2006	_
Gouka	1,95	8,13	242	1995-2006	_
Bantè	1,88	8,41	264	1995-2006	_
Savè	2,46	8,03	199	1974-2006	1974-2006
Tchetti	1,66	7,63	353	1995-2006	_
Dassa	2,16	7,74	155	1995-2006	_

Results and discussion

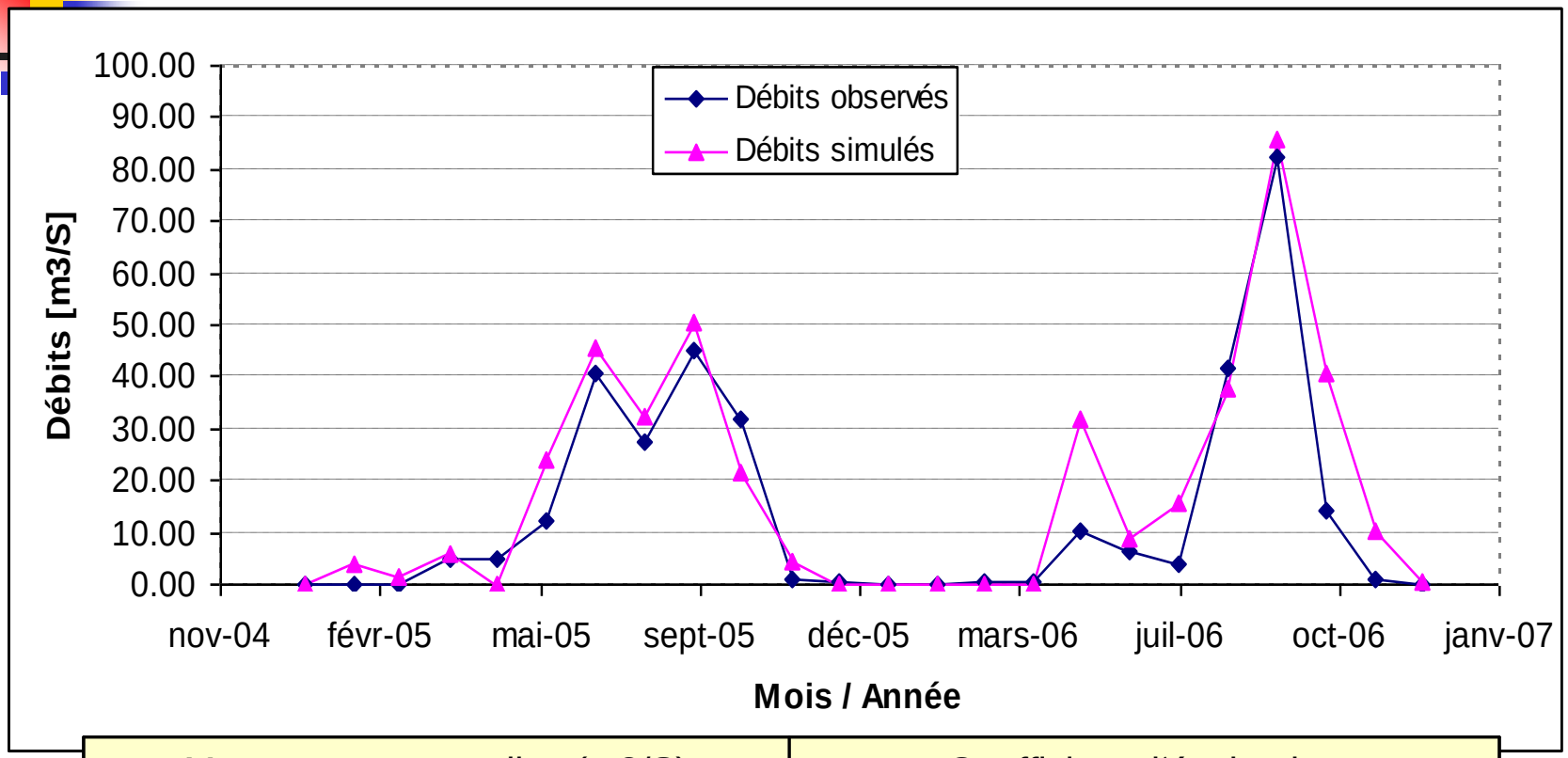
Correlation between simulated and observed flows on Zou sub - basin at monthly time step: calibration (1999-2004)



Moyennes mensuelles (m3/S)		Coefficients d'évaluation		
Débit observé	Débit simulé	R^2	ME	IA
32.46	33.7	0.79	0.79	0.94

Results and discussions

Correlation between simulated and observed flows on Zou sub - basin at monthly time step: validation(2005-2006)

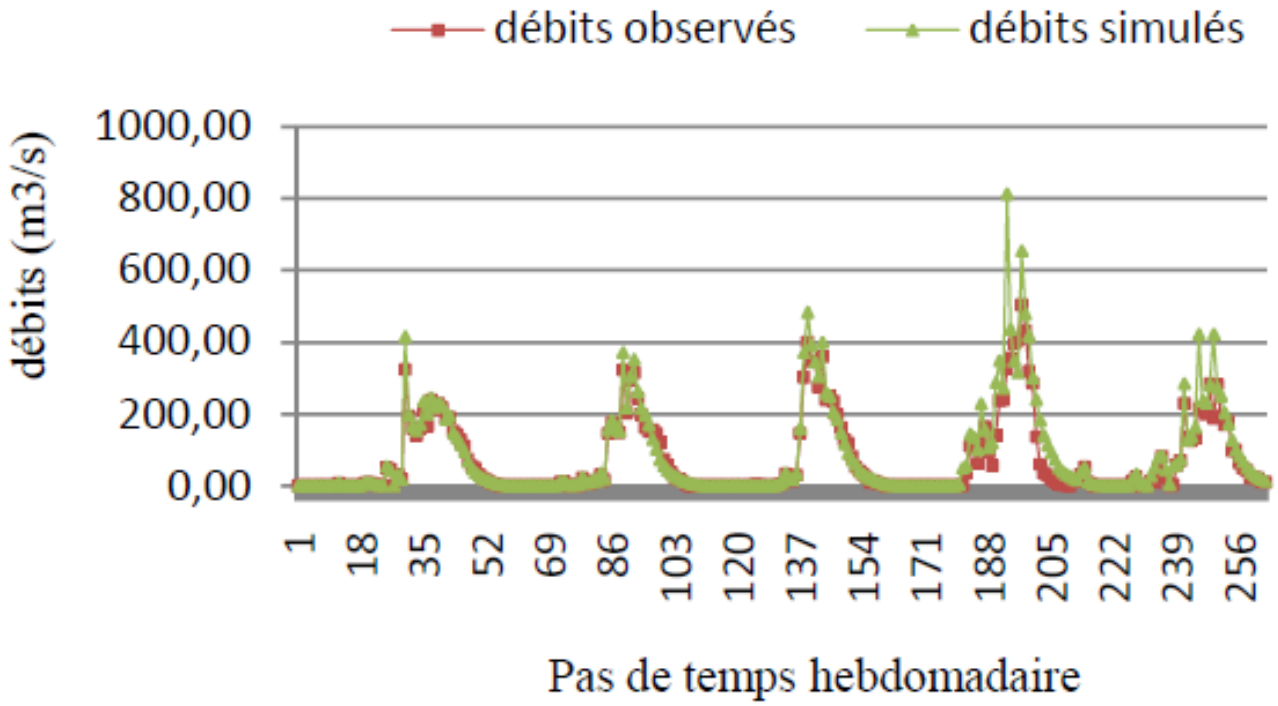


Moyennes mensuelles (m3/S)		Coefficient d'évaluation		
Débit observé	Débit simulé	R^2	ME	IA
13.76	17.54	0.87	0.82	0.95

Results and discussion

Correlation between simulated and observed flows on the Okpara sub-basin at weekly time step: ***calibration (2000-2004)***

- Figures below show the degree of agreement of simulated and observed flows at the outlet of Kaboua for the timing period from 1 January 2000 to 31 December 2004.

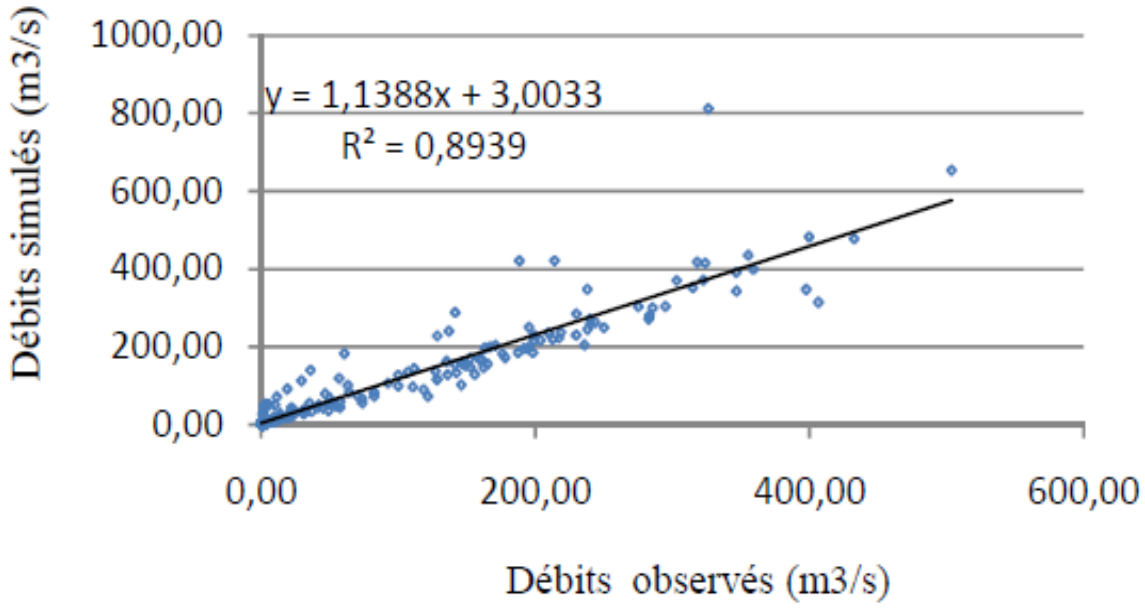


Model goodness

R^2	ME	IA
0,89	0,81	0,91

The calibration of the model at weekly step time to take account of intra seasonal variations, reveals significant evaluation factors

Results and discussion



Moyennes hebdomadaires (m^3/s)		Coefficients d'évaluation		
Débit observé	Débit simulé	R^2	ME	IA
72,38	85,44	0,89	0,81	0,96

Result and discussion

Table : Annual Water Balance Components at Opkara sub - basin (2000-2004)

Composantes du bilan hydrologique	Quantités (mm)
Précipitations totales	1113,7
Ecoulement de surface	130,17
Ecoulement latéral	3,22
Ecoulement souterrain	165,20
Recharge de l'aquifère profond	50,60
Recharge de l'aquifère peu profond	37,22
Perte par transmission	2,82
Evapotranspiration réelle	741,5
Evapotranspiration potentielle	2007,6
Variation du stock d'eau du sol	-17,03
Production d'eau	298,12
Production de sédiments	7 t/ ha

Source : Dossou-Yovo (2009)

Results and discussion

Annual Hydrological Balance of Zou : Timing period (2001-2004)

Composantes du bilan hydrique	Quantités	
Précipitations totales	1023 mm	
Ruissellement de surface	75 mm	7,3%
Ecoulement latéral	8 mm	0,8%
Contribution de l'eau souterraine au débit du cours d'eau	71 mm	
Recharge de l'aquifère profond	17 mm	
Recharge totale des aquifères (profond et peu profond)	187 mm	18,3%
Lame totale écoulée	152 mm	
Perte par transmission	2 mm	
Evapotranspiration réelle	741 mm	72,4%
Variation du stock d'eau du sol	12 mm	1,2%

Disponibilité en eau du bassin: 1,8 milliards de m^3 par an

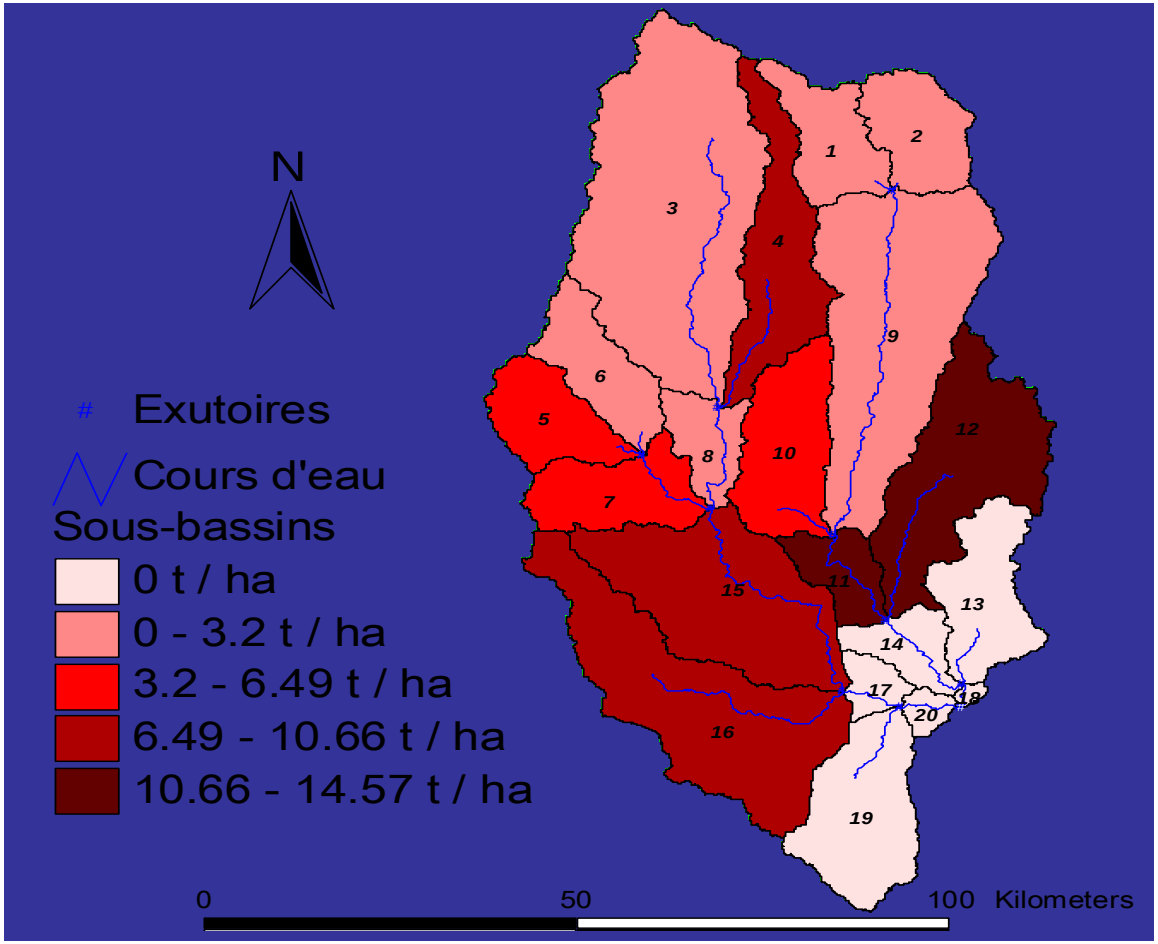
Niveau de maîtrise: 800 000 m^3 par an

Besoin minimal: 3 000 000 m^3 par an

Results and discussion

Soil loss on Zou basin: calibration period (2001-2004)

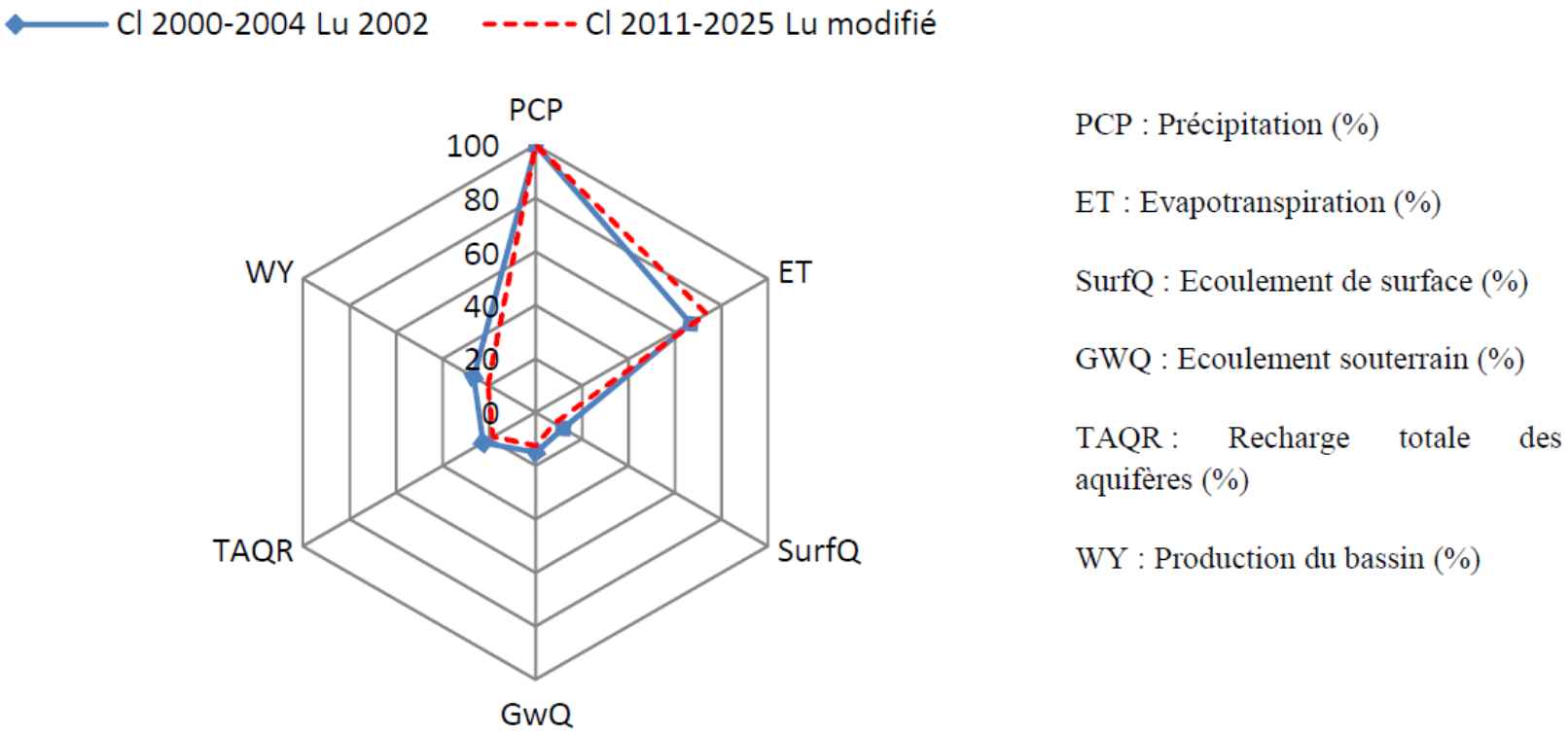
Disparity per sub -bassin



Results and discussion

Effects of combined scenarios of changes in climate and land use on the water balance

Climate change and future changes in vegetation cover will affect the components of the water balance as shown in Figure below



PCP : Précipitation (%)

ET : Evapotranspiration (%)

SurfQ : Ecoulement de surface (%)

GWQ : Ecoulement souterrain (%)

TAQR : Recharge totale des aquifères (%)

WY : Production du bassin (%)

Results and discussion

Effects of combined scenarios of changes in climate and land use on the water balance

Analysis of the Figure shows that the amount of moisture contributing to evapotranspiration increased from 66.58 to 73.59% under the combined effects of scenarios.

The other water balance components (surface runoff, groundwater flow, aquifer recharge and total water production) experienced a decrease of proportion compared to the reference period (2000-2004).

Indeed, surface flow decreased from 11.7 to 8.12%; groundwater flow from 14.83% to 12.57%; overall recharge and basin water yield decreased from 22.72 to 18.24% and from 26.77 to 20.42% respectively.

Results and discussion

Effects of combined scenarios of changes in climate and land use on the water balance

From studies on other Oueme sub-basins, due to reduced precipitation and increased evapotranspiration, climate scenarios combined with the various land uses lead to a reduction of the surface flow of the order of 34.73%;

Reduction of the groundwater flow in the order of 20.39%.

The total groundwater recharge and basin water production also decreased of 18.74% and 28.34% over the timing period

climate change issue in Benin

- Several research studies have shown the vulnerability of Benin's economy already weakened by poverty and affected by poor governance.

- Concerted vulnerability assessment conducted with the populations in the frame of a National Action Program for Adaptation to Climate Change of Benin (PANA Benin) confirms this state of affairs.

climate change issue in Benin

- In Benin, the effects of climate change will increase the variability of the climate system based on the results of interdisciplinary research projects (IMPETUS, RIVERTWIN ...).
- The assessment of the PANA project revealed three major climate risks: drought, late and heavy rains and floods;
- Two very worrying climate risks in places: the strong winds and high temperatures; and localized risks such as the advance of the sea and coastal erosion.

climate change issue in Benin

- The expected trends in the northwest of Benin are:

- decrease in rainfall compared to the annual average (15% to 2025)
- greater variation in rainfall
- increase in extreme weather elements like heavy rain and thunderstorms
- Monsoon shorter, ticking with irregular rainfall
- long-term increase in the average temperature (1-2 until the 21th century).

Superficies côtières vulnérables et valeur actuelle des biens dans les zones menacées*

	Superficies submergées (km²)	Superficies perdues par érosion (km²)	Valeur des biens affectés (millions de dollars)
Sénégal	1 650	28 – 44	345 – 464
Gambie	46	-	-
Côte d'Ivoire	471	-	4 710
Bénin	17,5	22,5	
Nigeria	8 864	78 – 145	9 003

Source : UICN (2004) *Réduire la vulnérabilité de l'Afrique de l'Ouest aux impacts du climat sur les ressources en eau, les zones humides et la désertification.*
* Conséquence d'une élévation du niveau marin (0,5 mètre d'ici 2100)

Phenomenon of flooding in Cotonou

Phenomenon of flooding in Cotonou


Thanks for your attention