Risques et catastrophes climatiques en Afrique de l'Ouest
Gérer l'inéluctable

Ecole Normale Supérieure, Université Abdou Moumouni de Niamey, Niger
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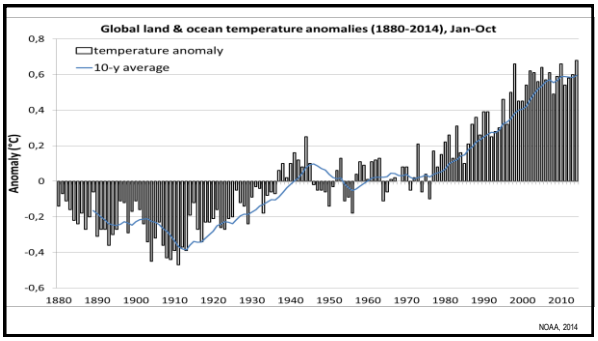
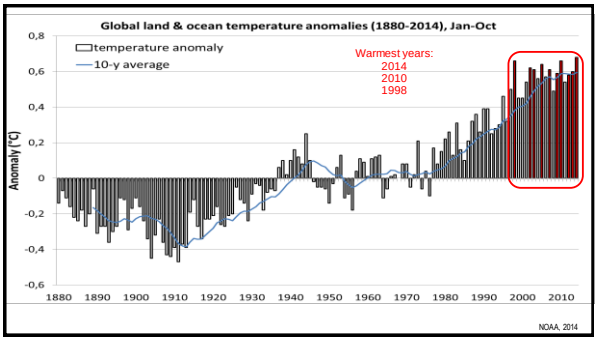
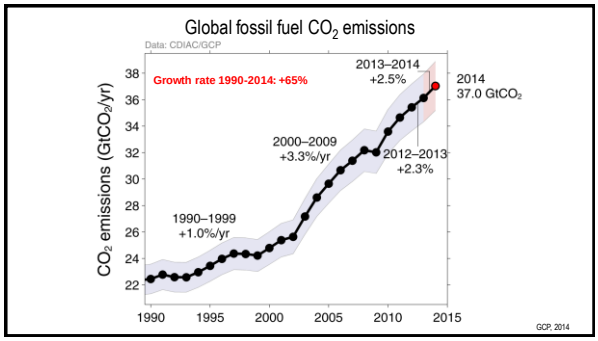
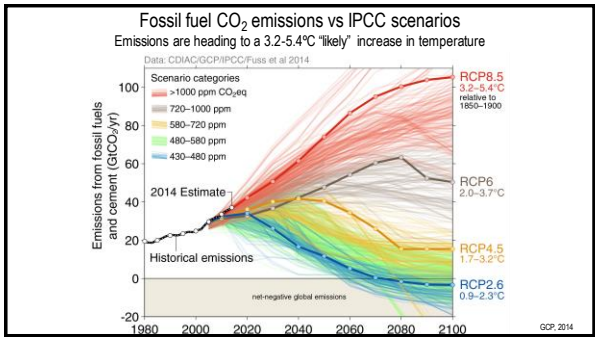
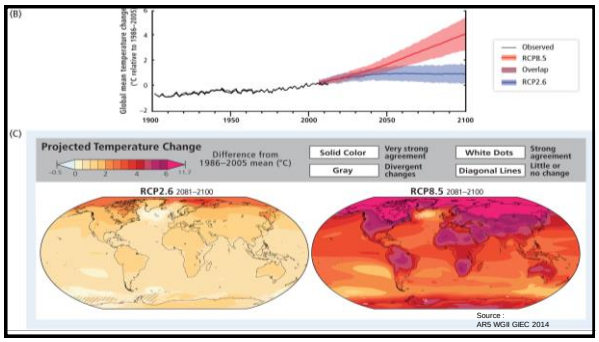


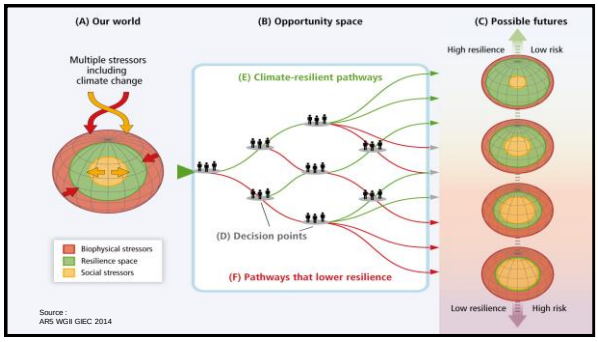



Global fossil fuel CO_2 emissions
Data: CDIAC/GCP
Growth rate 1990-2014: +65%
2013–2014
+2.5%
2014
37.0 $GtCO_2$
2000–2009
+3.3%/yr
2012–2013
+2.3%
1990–1999
+1.0%/yr
CO_2 emissions ($GtCO_2$/yr)
GCP, 2014

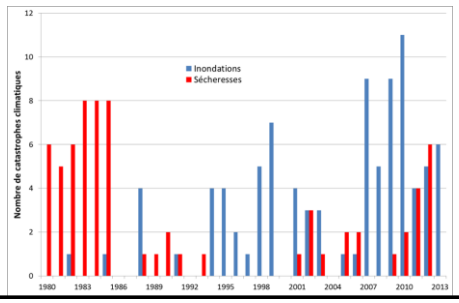

Fossil fuel CO_2 emissions vs IPCC scenarios
Emissions are heading to a 3.2-5.4°C "likely" increase in temperature
Data: CDIAC/GCP/IPCC/Fuss et al 2014
Scenario categories
>1000 ppm CO_2eq
720–1000 ppm
580–720 ppm
480–580 ppm
430–480 ppm
2014 Estimate
Historical emissions
net-negative global emissions
RCP8.5
3.2–5.4°C
relative to 1850–1900
RCP6
2.0–3.7°C
RCP4.5
1.7–3.2°C
RCP2.6
0.9–2.3°C
Emissions from fossil fuels and cement ($GtCO_2$/yr)
GCP, 2014


(B)
Observed
RCP8.5
Overlap
RCP2.6
(C)
Projected Temperature Change
Difference from 1986–2005 mean (°C)
Solid Color
Very strong agreement
Gray
Divergent changes
White Dots
Strong agreement
Diagonal Lines
little or no change
RCP2.6 2081–2100
RCP8.5 2081–2100
Source :
AR5 WGII GIEC 2014

Many consequences



Nombre de catastrophes climatiques majeures en Afrique de l'Ouest de 1980 à 2013

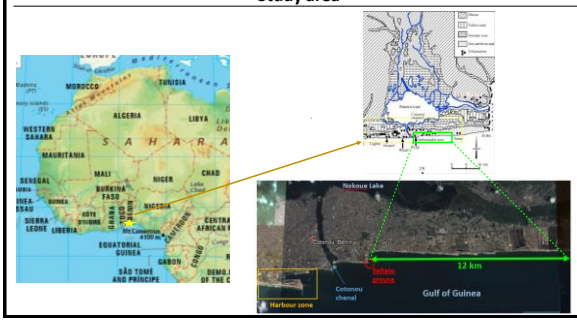


Case study 1

Shoreline erosion and displacement
Case of Cotonou, Benin

(Ozer *et al.*, submitted)

Study area



Objectives

Understand the dynamic of population in the coastal area of Cotonou exposed to a rapid erosion and put it in the context of the climate change:

- Assess the **extent** of the processes (coastal erosion and habitat's destruction)
- Determine the **vulnerable populations**
- Identify the **adaptation strategies** by populations
- Know the **responses** to this process by authorities
- Underline the **needs** in the context of climate change

Data and methods

Literature (scientific articles, reports, regional studies, press…)

Recent very **high resolution satellite images** from Google Earth
→ multi-temporal analyses (2002, 2011 and 2013)

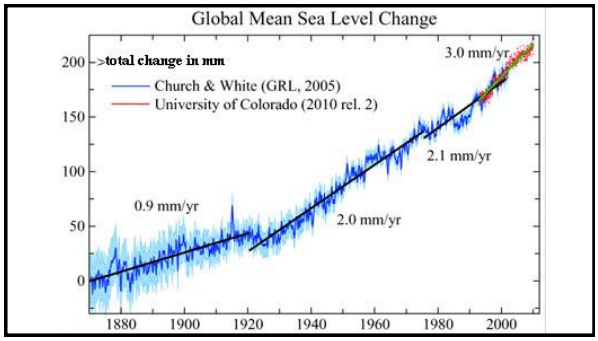
Field missions in 2012, 2013 and 2014
→ Pictures
→ Discussions with institutional actors, local authorities and researchers
→ Interviews of resident populations (20 individuals)

Main causes of the coastal erosion in Cotonou

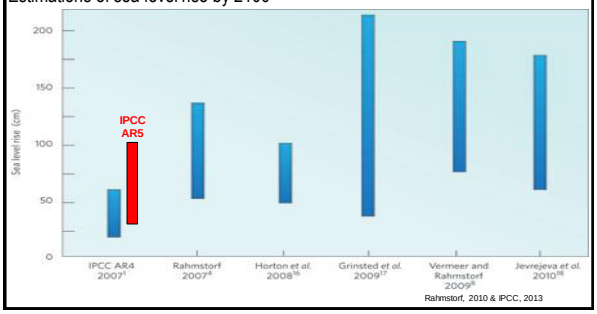
The obstruction of the littoral transit by the harbor structures (built in 1962) and recently extended by Bolloré S.A. without any environmental impact assessment

The decrease in sedimentary inputs from the West due to dams on rivers and diverse coastal protection constructions

The sand quarries carried out on the beach



Estimations of sea level rise by 2100



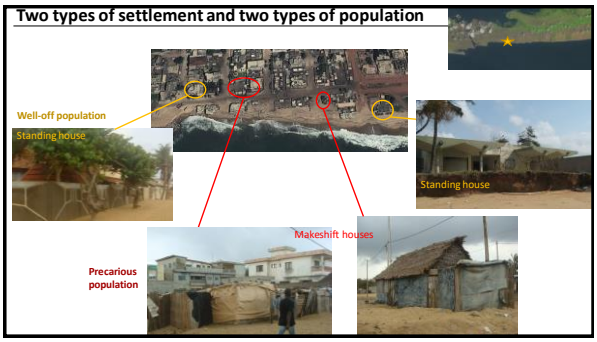
Rahmstorf, 2010 & IPCC, 2013

Significant change in the coast line

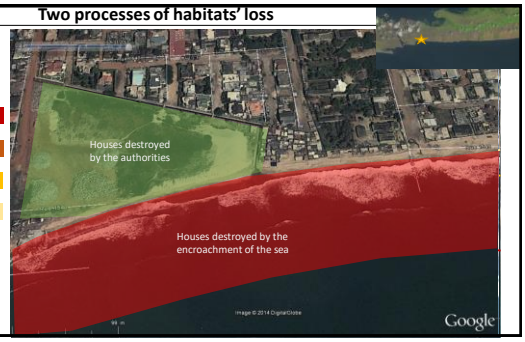
According to Codjia (1997), between 1963 and 1997, the shoreline retreated by 400 meters in the area east of the harbour of Cotonou, with a maximum speed of 16 meters per year, that is to say a loss of around 112 hectares of land.

Between 2002 and 2011,we have calculated a retreat of the shoreline by 100 meters in the same zone. Coastal erosion is observed until Nigeria, which is 27 km East of Cotonou, with an erosion of 30 meters in 10 years recorded at the border. This is a novelty because beyond the 6th km east of the groyne of Safiato, the coast was recording sand accretion between 1963 and 2000 (Kaki et al. 2011)

Two types of settlement and two types of population



Two processes of habitats' loss



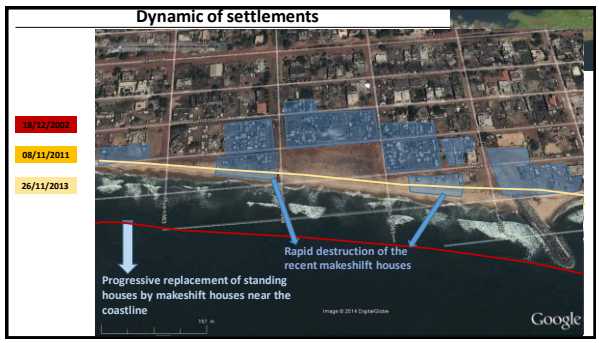
Progressive destruction of standing houses

The well-off people generally leave the coastal area and go to live inland

Fast destruction of makeshift houses

Makeshift houses destroyed by the sea in 24h (30-31 May 2014)

Dynamic of settlements



Who are the people trapped in the risk zone?

Fishermen → Precarious population

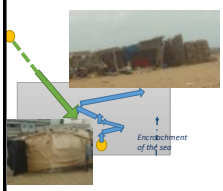
Characteristics and dynamics of the trapped populations

In July 2014, the most of the respondents were living for less than 5 years in their current habitat, nobody has a property title

Precarious population

- Native of the area or coming from other districts of Cotonou
- Originally, often house with permanent structure (brick walls)
- Successive displacements in the zone because of the encroachment of the sea
- Currently settlement in makeshift house

- Coming in the zone because no money to go elsewhere
- Money for settlement but not rent
- Successive displacements in the zone if not recently arrived
- Life in very precarious makeshift house

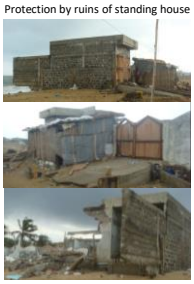


- Want to leave the area but no financial means and no relatives to help/welcome them

In July 2014, all respondents feared being ousted by the sea and did not know where they would go

'Measures' taken by the population

Protection by ruins of standing house



Protection by bricks of destroyed house

Very short displacements

All these 'measures' are temporary and allow at the best to gain a few months

Measures taken by the authorities

Local authorities

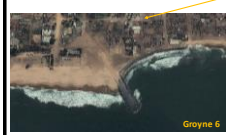
- According to district chiefs, the Government does nothing
- The wish of the town council of Cotonou is to solve the erosion problem
- Awareness campaign of fishermen. In some cases, local authorities try to persuade fishermen to go away from the sea

National authority

- In March 2009, under the pressure of NGOs, all marine sand quarries are closed (Decree No. 2008-615 of 22 October 2008)
- Since May 2014, 7 groynes are built at the East in the most exposed zone (45.4 milliards FCFA, financed by la Banque islamique de développement (Bid), la Banque Arabe pour le développement économique en Afrique (Badea), le Fonds de l'Opep pour le développement international (Ofid), le Fonds Saoudien de développement (Fsd), le Fonds Koweitien pour le développement économique arabe (FKDEA) and l'Etat béninois).

Protection by groynes

Until now, population observes no positive effect



At the scale of a groyne, positive effect to the West but negative effect to the East

A the scale of the protected zone, the problem is transferred at the East of the zone with 7 groynes

What are the real issues in this risk zone?

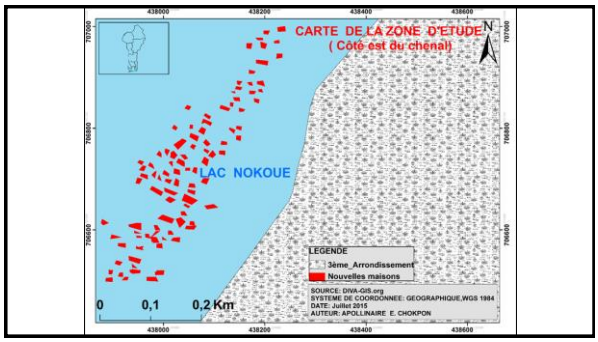
- The coast of Cotonou is under the sea level
- A rise in sea level of 30 to 100 cm is expected by 2100
- There is a disproportionate population growth in the city of Cotonou (rural exodus) as in other coastal zones of West Africa
- Authorities have few means to prohibit new habitats near the sea seen that the land belongs to individuals
- There is no legal recognition of people displaced by natural phenomena

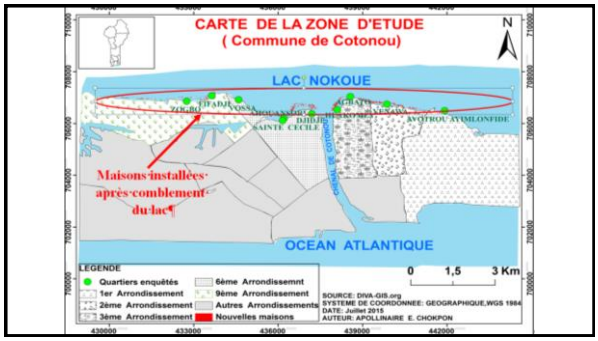
Et quelques kilomètres au nord (Lac Nokoué)?

(Sokpon & Ozer, 2016)


POINT 2
POINT 3
POINT 4
POINT 5
129,46 m
107,65 m
Google earth


POINT 4
Habitations installées dans le lac
Google earth

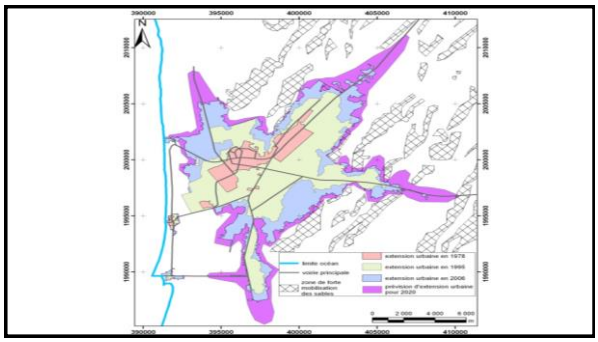

CARTE DE LA ZONE D'ETUDE
(Côté est du chénal)
N
LAC NOKOUE
LEGENDE
3ème_Arrondissement
Nouvelles maisons
SOURCE: DIVA-GIS.org
SYSTEME DE COORDONNEE: GEOGRAPHIQUE,WGS 1984
DATE: Juillet 2015
AUTEUR: APOLLINAIRE E. CHOKPON
0
0,1
0,2 Km

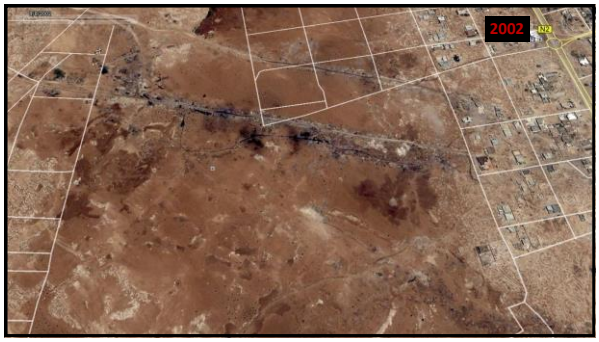


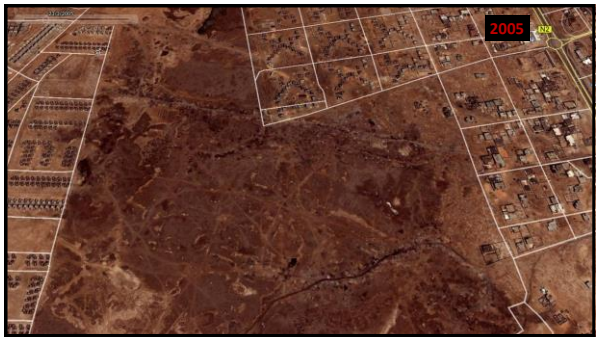
Case study 2

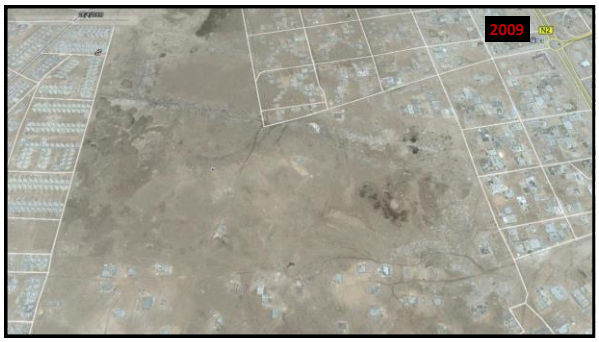
Urban sprawl increases risks
Nouakchott, Mauritania

(Ozer *et al.*, 2015)




2002

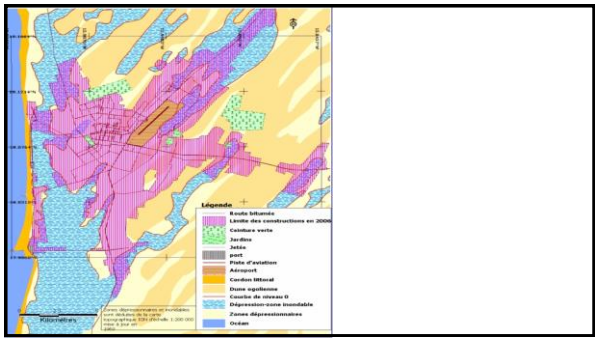

2005

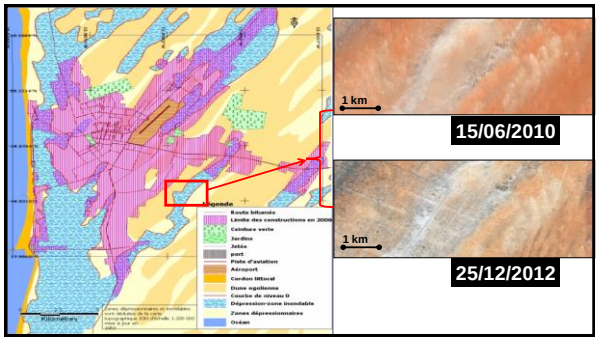

2009


2011


2012


2013


Légende
Route bitumée
Limite des constructions en 2006
Ceinture verte
Jardins
Jetée
port
Piste d'aviation
Aéroport
Cordon littoral
Dune ogilienne
Courbe de niveau 0
Dépression-zone inondable
Zones dépressionnaires
Océan
Kilometers


1 km
15/06/2010
1 km
25/12/2012
Légende
Route bitumée
Limite des constructions en 2006
Ceinture verte
Jardins
Jetée
port
Piste d'aviation
Aéroport
Cordon littoral
Dune ogilienne
Courbe de niveau 0
Dépression-zone inondable
Zones dépressionnaires
Océan
Kilometers

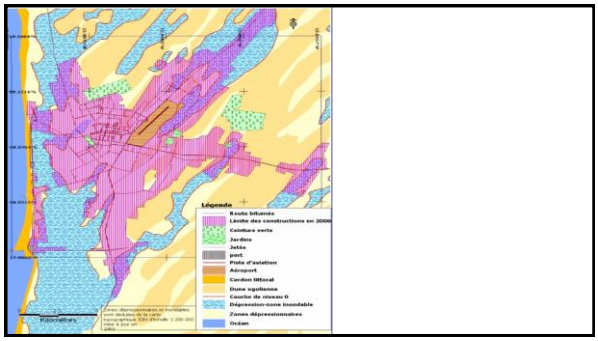
Sur la célérité du processus…

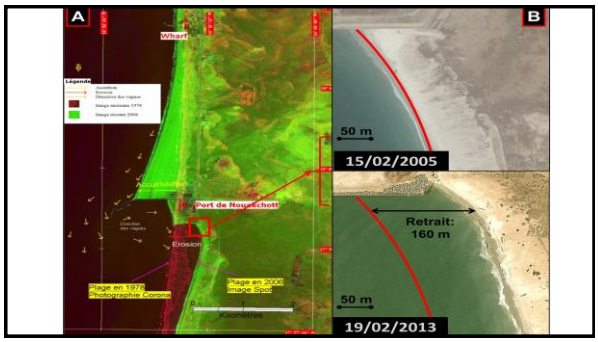

22-07-2014


10-08-2014


14-09-2014


03-10-2014


Légende
Route bitumée
Limite des constructions en 2006
Ceinture verte
Jardins
Jetée
port
Piste d'aviation
Aéroport
Cordon littoral
Dune ogrifoisne
Courbe de niveau 0
Dépression-zone inondable
Zones dépressionnaires
Océan
Kilomètres


A
B
Wharf
Légende
Accumulation
Port de Nouakchott
Erosion
Plage en 1978
Photographie Corona
Plage en 2006
Image Spot
Kilomètres
50 m
15/02/2005
Retrait:
160 m
50 m
19/02/2013

Case study 3

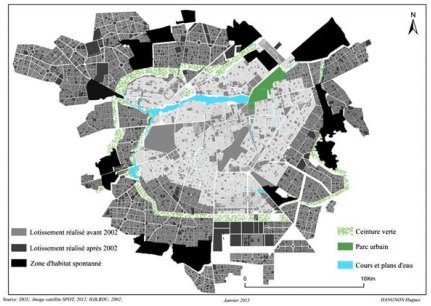
Ouagadougou under water

(Hangnon *et al.*, 2015, 2016 ; de Longueville *et al.*, 2016)

Ouagadougou: Périodes de retour des pluies

- Normale: <62 mm
- Anormale: 62 – 80,1 mm
- Très anormale: 80,1 – 107,6 mm
- Exceptionnelle: >107,6 mm
- Très exceptionnelle: >137 mm

20-05-91	105,2
25-08-02	58,3
10-07-05	75,7
26-08-07	127,7
19-07-08	43,6
01-09-09	261,3
28-07-10	70,4
18-07-11	43,8
24-07-12	67,8
24-06-15	67
21-07-16	51,4



Case study 4

Forced displacements: THE solution?
Abidjan, Côte d'Ivoire

(Comoe & Ozer, 2016)

Déguerpissement de Port-Bouet

- 125 ha en moins d'une semaine
- Sans sommation préalable
- Ordre de déguerpir tenu 'secret'
- Période difficile (début septembre 2015)
- Pas de compensations pour les ménages déguerpis
- Non respect de la Convention de Kampala (Convention de l'Union Africaine sur la protection et l'assistance aux personnes déplacées en Afrique)

Case study 5

Questioning the immunity of the system.
The case of Niger

(Ozer & de Longueville, 2015)

Context and objective

Perception of climate change (rainfall)

Climate	Arid Sahel		
Mean annual rainfall	300-500 mm		
Perception of change	-	NC	+
Source / Indicator	Yearly total rainfall		
Akponikpè et al. (2010)	91	2	2
Nielsen & Reenberg (2010)	62	6	32
Mertz et al. (2012)	83	4	13
Diessner (2012)	90	6	3
This study (based of AMMA data)	**81**	**3**	**14**

Context and objective

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Adaptation to climate change (rainfall)

Temporal migration in response to a drier climate: 4.4% (1.2%)
Permanent migration in response to a drier climate: 29.8% (12.5%)
Temporal migration in response to a drought: 35.9% (31.8%)
Migration in the 'top 3' adaptation strategies to climate change: 54%

Context and objective

- The term "**tipping point**" commonly refers to a **critical threshold** at which a **tiny perturbation** can qualitatively alter the state or development of a system (Lenton *et al.*, 2008).
- Here we use the term "**tipping element**" to describe components of the analysed system that may have passed a tipping point.
- We try to explain, focusing on Niger, why Sahelian rural population **perception of climate change** is critically negative while rainfall patterns are more favorable lately.

Data

We have selected 8 indices that do represent potential pressures on the system on the 1961-2014 period:

1. Human population (units)
2. Harvested area (ha)
3. Livestock (heads of cattle, goats, sheeps and camels)
4. Wood fuel (m^3)
5. Crop yields (kg/ha)
6. Total annual rainfall (mm)
7. % of no starting of the rainy season (%)
8. Annual maximum daily rainfall (mm)

Indices 1-5 were retreived from FAOSTAT (2015)

Indices 6-8 were derived from long-term (1950-2014) daily rainfall datasets of 34 stations of southern Niger

Methodology

Livestock (heads of cattle, goats, sheeps and camels) were converted into Tropical Livestock Units (TLU) as such (JGRC, 2001):

Cattle = 0.8 TLU

Goat = 0.15 TLU

Sheep = 0.15 TLU

Camel = 1 TLU

Since the average load on the pasture is of around 2,5 hectares by TLU, the livestock (heads) was converted into hectares needed to be in sustainable balance with pastoral resources. It is named "livestock area".

Areas obtained were compared to the 'potential' resources available in Niger: 'Arable land and Permanent crops', 'Permanent meadows and pastures', 'Forest area' & 'Desert'.

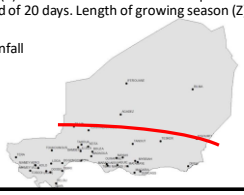
Methodology

From daily rainfall datasets (1950-2014) of 34 stations in southern Niger, we derived total annual rainfall, extracted the maximum annual daily rainfall and calculated the lenght of the rainy season using the Sivakumar (1988) method:

The date of onset of rains (*X*) is defined as that date after 1 May when rainfall accumulated over 3 consecutive days is at least 20 mm and when no dry spell within the next 30 days exceeds 7 days. The date of ending of rains (*Y*) is taken as that date after 1 September following which no rain occurs over a period of 20 days. Length of growing season (Z) is taken as the difference *(Y-X)*.

National rainfall analysis is based on the rainfall anomaly index (Lamb, 1982):

$$X_j = \frac{1}{N_j} \sum_{i=1}^{N_i} \frac{r_{ij} - \bar{r}_i}{\sigma_i}$$

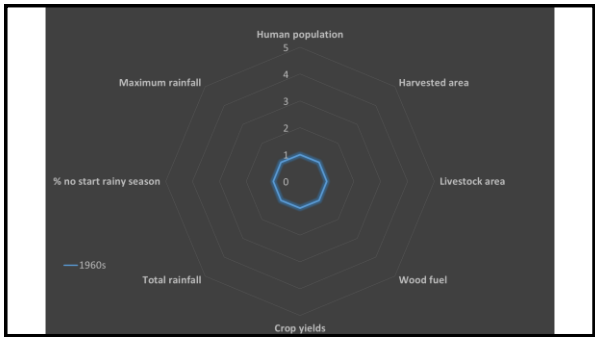


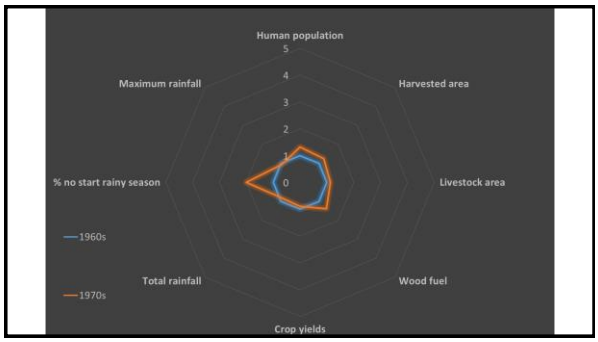
Methodology

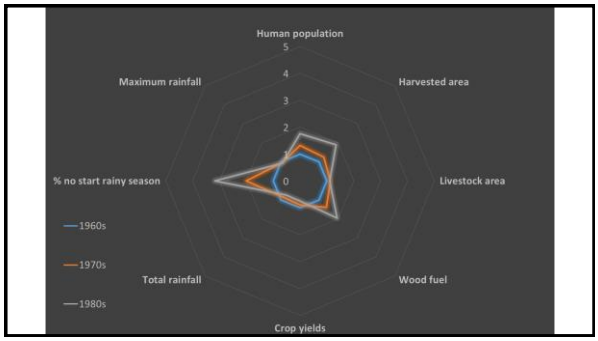
All indices were calculated per decade.

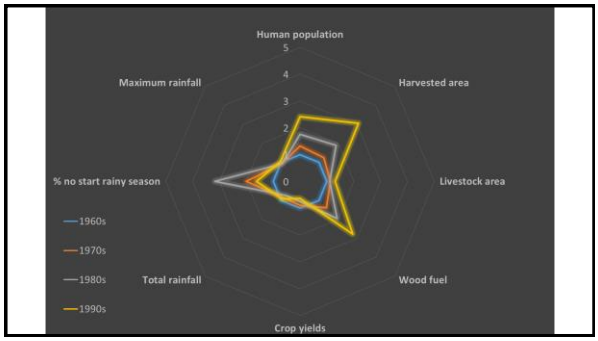
They were analyzed individually in order to find any critical threshold or trend.

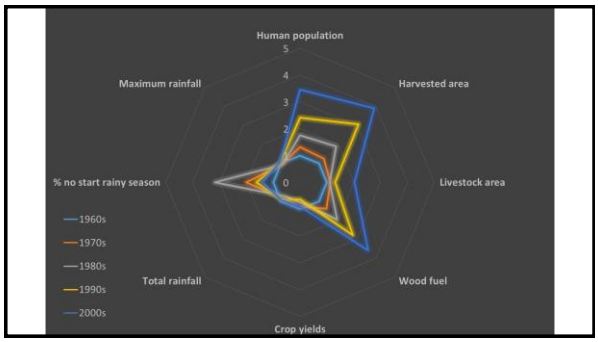
The first decade is 1961-1970 (1960s). All indices are equal to 1 in the 1960s and were plotted as a 'radar'. This allows a relative comparison with other decades.






Human population
5
4
3
2
1
0
Harvested area
Livestock area
Wood fuel
Crop yields
Total rainfall
% no start rainy season
Maximum rainfall
1960s
1970s
1980s


Human population
5
4
3
2
0
Harvested area
Livestock area
Wood fuel
Crop yields
Total rainfall
% no start rainy season
Maximum rainfall
1960s
1970s
1980s
1990s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1970s
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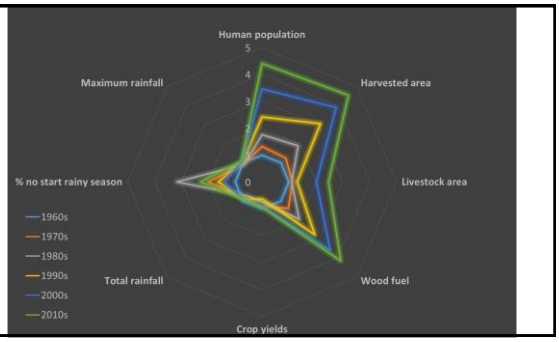
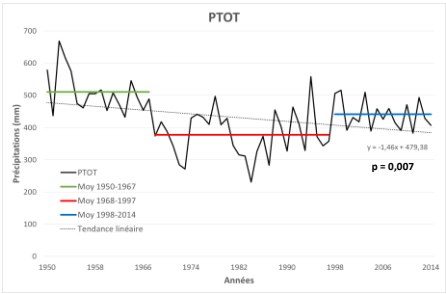
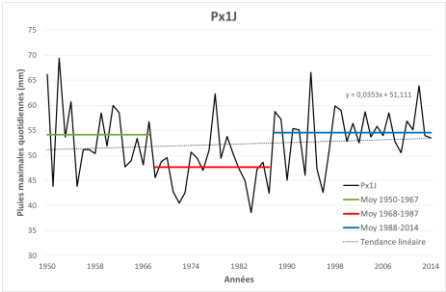
2000s



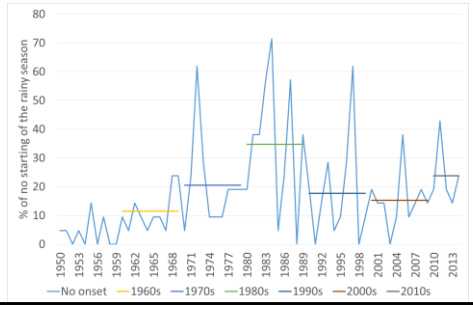
Results



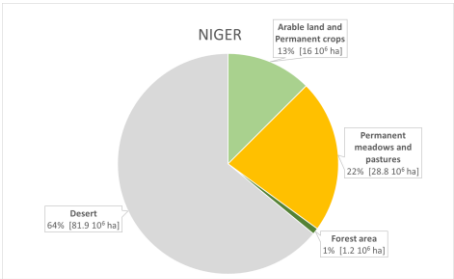
Results



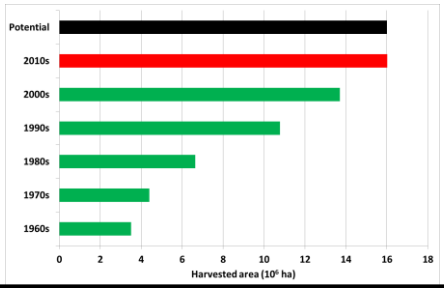
Results



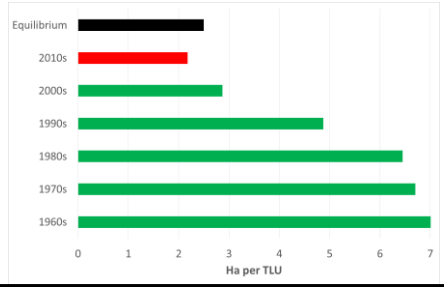
Potential land resources in Niger (FAO, 2015)



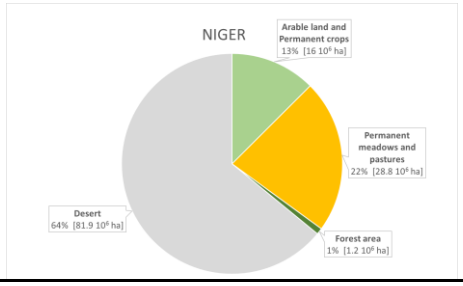
Harvested area Vs Arable land and permanent crops potential



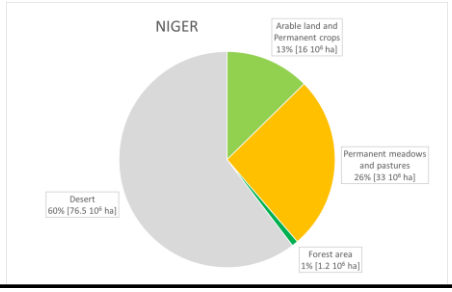
Livestock area Vs Permanent meadows and pastures potential

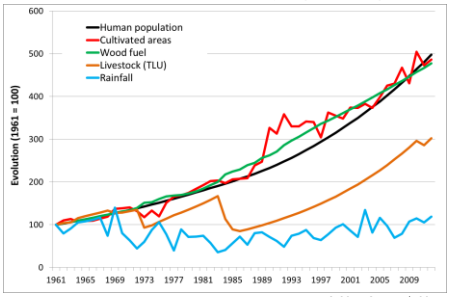


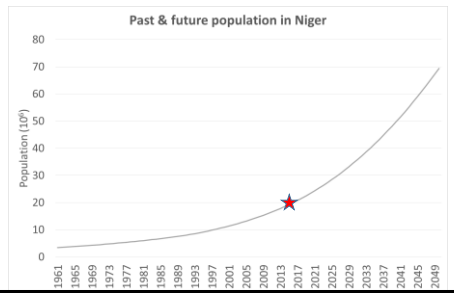
Potential land resources in Niger



Current (2010s) needs in land resources in Niger







Conclusion

- The **critical threshold** for some "**tipping element**" have passed in recent years: **livestock area** in the late 2000s & **agricultural crop area** in the 2010s.
- The negative **perception of climate change** of rural population of Niger is very likely explained by the reduction of available resources.
- We conclude showing that without 'global warming' impacts, the Sahelian system is more and more fragile to any tiny 'accident'. And that things are not likely to improve in future decades…