Climate change perception and migration. Introducing the concept of « social tipping point ».

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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

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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'.

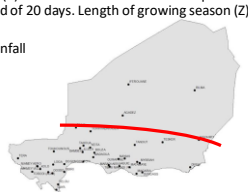
Methodology

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):

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

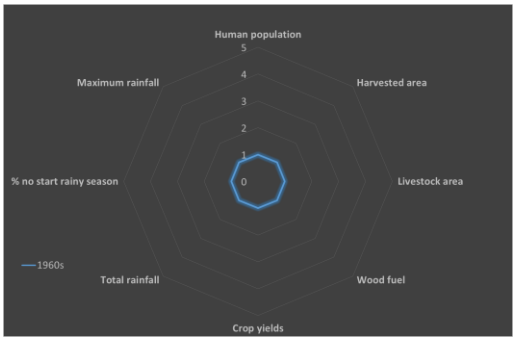


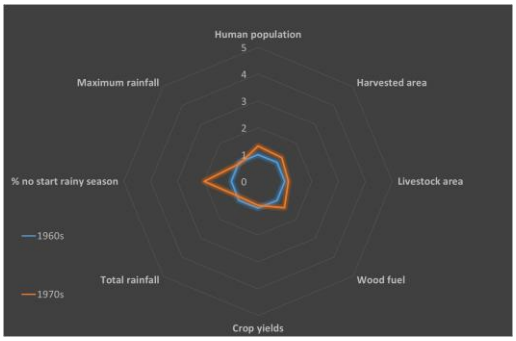
Methodology

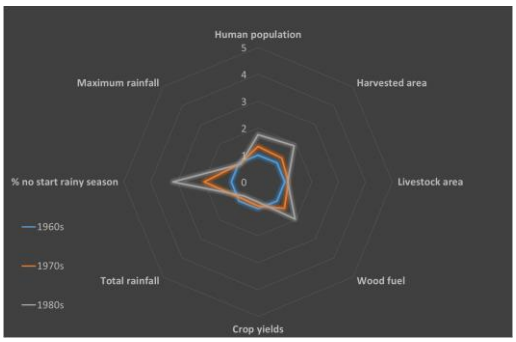
All indices were calculated per decade.

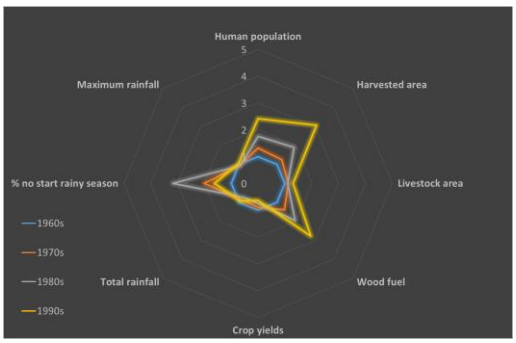
They were analyzed individually in order to find any critical threshold or trend.

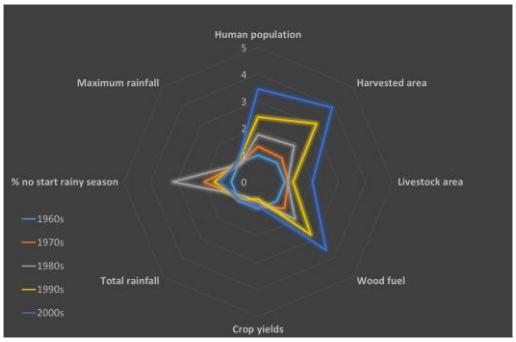
The first decade is 1961-1970(1960s). All indices are equal to 1 in the 1960s and were plotted as a 'radar'. This allows a relative comparison with other decades.

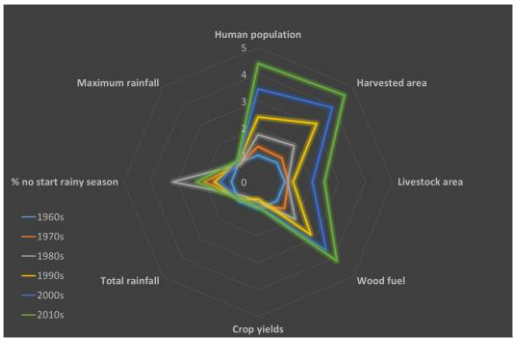




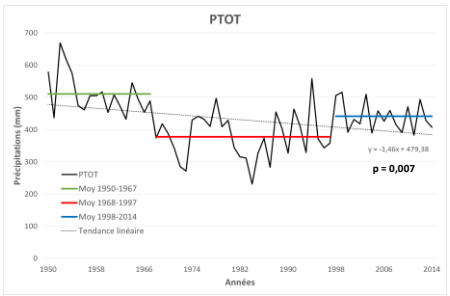








Results



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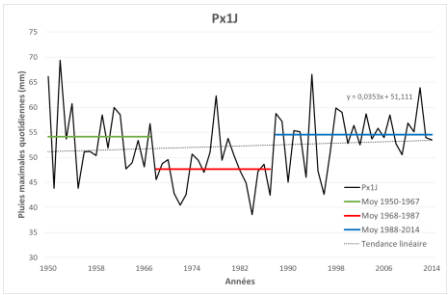

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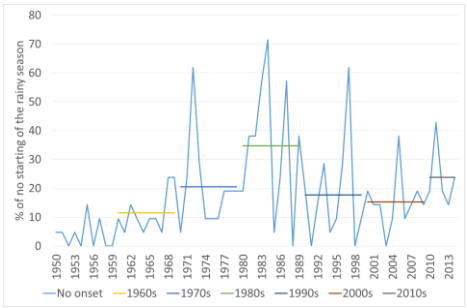
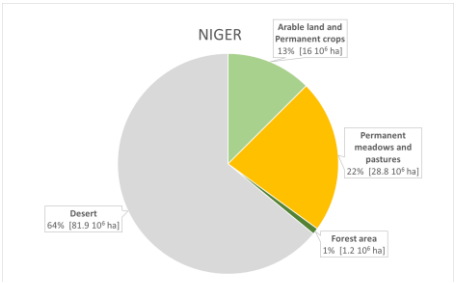
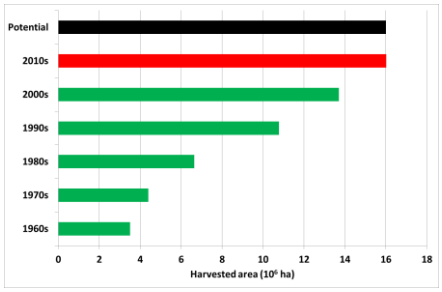


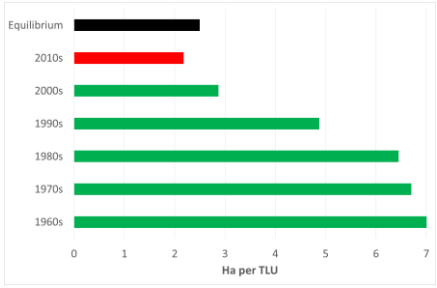
Potential land resources in Niger (FAO, 2015)



Harvested area Vs Arable land and permanent crops potential



Livestock area Vs Permanent meadows and pastures potential



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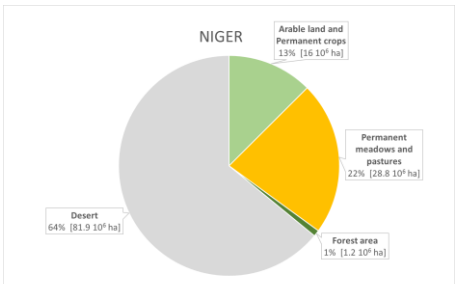
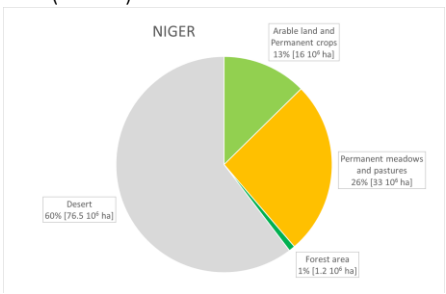
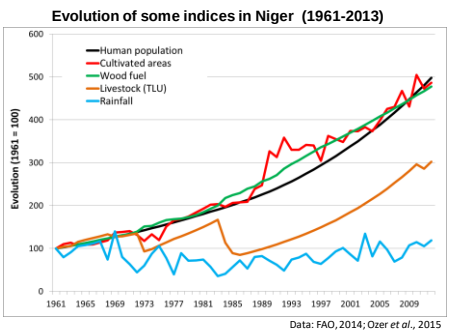
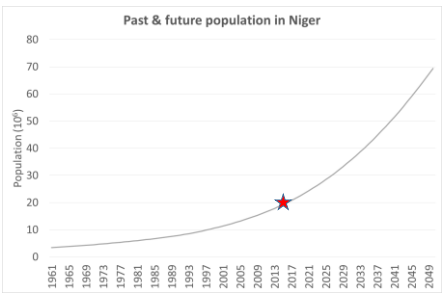


Current (2010s) needs in land resources in Niger





What's next ?



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…

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Agricultural area

Agricultural area is the sum of areas under

- (a) **arable land - land under temporary agricultural crops** (multiple-cropped areas are counted only once), **temporary meadows for mowing or pasture**, land under market and kitchen gardens and land temporarily fallow;
- (b) **permanent crops** - land cultivated with long-term crops which do not have to be replanted for several years
- (c) **permanent meadows and pastures** - land used permanently (five years or more) to grow herbaceous forage crops, either cultivated or growing wild (wild prairie or grazing land).