Climate change perception and migration: questioning the immunity of the system. The case of Niger

Pierre Ozer
Department of Environmental Sciences and Management, University of Liège, Belgium

Florence de Longueville
CEDEM, University of Liège, Belgium

Context and objective

**Perception of climate change (rainfall)**

<table>
<thead>
<tr>
<th>Climate</th>
<th>Arid Sahel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean annual rainfall</td>
<td>300-500 mm</td>
</tr>
<tr>
<td>Perception of change</td>
<td>NC</td>
</tr>
<tr>
<td>Source / Indicator</td>
<td>Yearly total rainfall</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Study</th>
<th>Value</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Akponikpè et al. (2010)</td>
<td>91</td>
<td>2</td>
</tr>
<tr>
<td>Nielsen &amp; Reenberg (2010)</td>
<td>62</td>
<td>6</td>
</tr>
<tr>
<td>Mertz et al. (2012)</td>
<td>83</td>
<td>4</td>
</tr>
<tr>
<td>Diessner (2012)</td>
<td>90</td>
<td>6</td>
</tr>
<tr>
<td>This study (based of AMMA data)</td>
<td>81</td>
<td>3</td>
</tr>
</tbody>
</table>
Context and objective

Perception of climate change (rainfall)

<table>
<thead>
<tr>
<th>Source / Indicator</th>
<th>Yearly total rainfall</th>
<th>Mean annual rainfall</th>
<th>Perception of change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Akponikpè et al. (2010)</td>
<td>91</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Nielsen &amp; Reenberg (2010)</td>
<td>62</td>
<td>6</td>
<td>32</td>
</tr>
<tr>
<td>Mertz et al. (2012)</td>
<td>83</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>Diessner (2012)</td>
<td>90</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>This study (based of AMMA data)</td>
<td>81</td>
<td>3</td>
<td>14</td>
</tr>
</tbody>
</table>

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 retrieved 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 6 hectares by TLU (Achard & Chanono, 2006), 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 length 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

PTOT

\[ y = -1.46x + 479.38 \]

\[ p = 0.007 \]

Results

Px1J

\[ y = 0.0353x + 51.111 \]
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

- Desert: 64% [81.9 x 10^6 ha]
- Forest area: 1% [1.2 x 10^6 ha]
- Arable land and Permanent crops: 13% [16 x 10^6 ha]
- Permanent meadows and pastures: 22% [28.8 x 10^6 ha]

Current needs in land resources in Niger

- Desert: 25%
- Forest area: 1%
- Arable land and Permanent crops: 12%
- Permanent meadows and pastures: 62%
Evolution of some indices in Niger (1961-2013)

What’s next?

Past & future population in Niger
Conclusion

• The critical threshold for some “tipping element” have passed in recent years: livestock area in the 1990s & 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...
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).