RAINFALL VARIABILITY AND ANTHROPOGENIC ACTIVITIES INFLUENCING LAND USE IN KORHOGO (NORTHERN CÔTE D’IVOIRE) FROM 1986 TO 2015

Fulgence Kouamé Kouamé

Centre Universitaire de Recherche et d’Application en Télédétection (CURAT), Université Félix Houphouët-Boigny (UFHB)
INTRODUCTION

I- STUDY AREA

II- MATERIAL AND METHODS

III- RESULTS AND DISCUSSION

CONCLUSION
INTRODUCTION
Studies on climate change and variability are of interest to the global community (Sircoulon, 1976; Cantat, 1995, Kouassi et al., 2012).

Côte d’Ivoire is experiencing problems of environmental change as a result of lower rainfall and rising temperatures (Goula et al, 2006, Brou, 2010).

Accelerated population growth and increased food needs in various agricultural products and energy (firewood and charcoal) leading to increasing pressure on its northern zone.

Northern Côte d’Ivoire remains largely dependent on climatic conditions and more particularly on rainfall variability.

Correlatively to this climatic variability, we observe a change in the dynamics of the vegetation cover.
This study aims to analyze rainfall variability and the anthropogenic disturbances impacts on spatial and temporal dynamics of land use in the sub-prefecture of Korhogo in Northern Côte d'Ivoire from 1986 to 2015
STUDY AREA
o Region of Poro,
o longitudes 5°29’10” and 5°52’30” N
o latitudes 9°21’40” and 9°45’O;
o Senoufo: 61%, Malinké 24%, (peulh, haoussa, maliens, etc.) 15% (INS, 2014);
o 453,006 hbts (INS, 1998), 536,851 hbts (INS, 2014);
o Annual average growth rate is 3.18% (INS, 2014);
o Dry tropical climate (26° C to 35° C), annual rainfall average of 1000 to 1200 mm / year;
o Rainy season: from May to the end of October with a peak of rainfall in September.
MATERIAL AND METHODS
Monthly rain data provided from the Aeronautical Development and Exploitation, Airport and Meteorological Company (SODEXAM) to calculate rainfall index, Korhogo weather station from 1983 to 2014
<table>
<thead>
<tr>
<th>SYSTEMES</th>
<th>SCENES</th>
<th>DATE</th>
<th>Bandes SPECTRALES</th>
<th>Spatial RESOLUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM</td>
<td>197-53</td>
<td>16/11/1986</td>
<td>Bleu, Green, Red, NIR, SWIR-1, TIR, SWIR-2</td>
<td>30, 30, 30, 30, 120, 30</td>
</tr>
<tr>
<td>ETM +</td>
<td>197-53</td>
<td>02/10/2000</td>
<td>Blue, Green, Red, NIR, SWIR-1, TIR, SWIR-2, PAN</td>
<td>30, 30, 30, 30, 60, 30, 15</td>
</tr>
<tr>
<td>OLI</td>
<td>197-53</td>
<td>31/01/2015</td>
<td>Aerosols, Blue, Green, Red, NIR, SWIR-1, SWIR-2, PAN, CIRRUS</td>
<td>30, 30, 30, 30, 60, 30, 15, 30</td>
</tr>
<tr>
<td>MATERIAL</td>
<td>GROUND INVENTORY EQUIPMENT</td>
<td>SOFTWARES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>---------------------------</td>
<td>-----------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GARMIN ETREX</td>
<td></td>
<td><strong>IMAGES PROCESSING</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAMERA</td>
<td></td>
<td><code>- ENVI 5.1</code></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOTE PAD</td>
<td></td>
<td><strong>CARTOGRAPHY</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><code>- ArcGis 10.2.1</code></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>PAINT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><code>- Finalise maps</code></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>MICROSOFT EXCEL</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><code>- Storage and processing of data</code></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Nicholson Index allows highlighting excess and deficit periods within a time series (highlights the degree of humidity or drought in the environment)

\[ Ip = \frac{(P_i - P_{moy})}{\sigma} \]

With \( Ip \): Rainfall index; \( P_i \): value of the annual rain of the year \( i \) (mm);
\( P_{moy} \): inter-annual average value of rain on the studied period (mm);
\( \sigma \): standard deviation of inter-annual rain value over the studied period.

- \( Ip > 2 \), extreme humidity; \( -1 < Ip < 2 \), high humidity;
- \( -1 < I < 0 \), moderate drought; \( -2 < I < -1 \), high drought;
- if \( SPI < -2 \), drought is described as extreme
**LAND USE MAPPING**

**SATELLITE DATA ACQUISITION**

**PRE-PROCESSING**
- Radiometric correction
- Atmospheric correction
- Extraction of study area

**PROCESSING**
- Colourful composition NIR-SWIR 1 et 2 (discrimination of the types of vegetation)
- Choice of the training sites
- Field work (data collection)
- Supervised classification

**LAND USE MAPS 1986/2000/2015**
- Validation of the classification (visit post classification and confusion matrix)

Figure 2: Synthesis of the methodology used to study the land use
Interviews and focus groups organized to get people's perceptions about the impacts of rainfall variability on the environment and crops.
RESULTS ET DISCUSSION
Two periods with contrasting tendencies emerge:

- 1: Positive indexes (0 and 2), wet period (from 1984 to 1986 and from 2008 to 2014). It is characterized by moderate to high humidity. And there is a resumption of rain from 2009.


**Figure 3:** Annual rain index at Korhogo weather station
Figure 4: Land use of 1986

Table 1: Confusion Matrix (1986)

<table>
<thead>
<tr>
<th>Classes</th>
<th>Forest</th>
<th>Plantation/Tree savanna</th>
<th>Culture/Fallow</th>
<th>Settlement/Naked soil</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>100</td>
<td>1,11</td>
<td>0,00</td>
<td>0,00</td>
<td>0,23</td>
</tr>
<tr>
<td>Plantation/Tree savanna</td>
<td>0,00</td>
<td>69,93</td>
<td>0,00</td>
<td>0,00</td>
<td>8,75</td>
</tr>
<tr>
<td>Culture/Fallow</td>
<td>0,00</td>
<td>23,99</td>
<td>98,38</td>
<td>0,87</td>
<td>1,17</td>
</tr>
<tr>
<td>Settlement/Naked soil</td>
<td>0,00</td>
<td>4,98</td>
<td>1,62</td>
<td>99,13</td>
<td>1,87</td>
</tr>
<tr>
<td>Water</td>
<td>0,00</td>
<td>0,00</td>
<td>0,00</td>
<td>0,00</td>
<td>87,98</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Overall accuracy: 84.63%  
Kappa: 0.78
Table 2: Confusion Matrix (2000)

<table>
<thead>
<tr>
<th>Classes</th>
<th>Forest</th>
<th>Plantation/Tree savanna</th>
<th>Culture/Fallow</th>
<th>Settlement/Naked soil</th>
<th>Forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>100</td>
<td>0,00</td>
<td>0,16</td>
<td>0,00</td>
<td>0,00</td>
</tr>
<tr>
<td>Plantation/Tree savanna</td>
<td>0,00</td>
<td>44,65</td>
<td>5,78</td>
<td>0,32</td>
<td>0,00</td>
</tr>
<tr>
<td>Culture/Fallow</td>
<td>0,00</td>
<td>16,05</td>
<td>86,23</td>
<td>0,32</td>
<td>0,47</td>
</tr>
<tr>
<td>Settlement/Naked soil</td>
<td>0,00</td>
<td>39,30</td>
<td>7,84</td>
<td>99,36</td>
<td>0,00</td>
</tr>
<tr>
<td>Water</td>
<td>0,00</td>
<td>0,00</td>
<td>0,00</td>
<td>0,00</td>
<td>98,53</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

**Overall accuracy:** 87.04%

**Kappa:** 0.75

<table>
<thead>
<tr>
<th>Classes</th>
<th>Forest</th>
<th>Plantation/Tree savanna</th>
<th>Culture/Fallow</th>
<th>Settlement/Naked soil</th>
<th>Forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>99.77</td>
<td>0.00</td>
<td>0.03</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Plantation/Tree savanna</td>
<td>0.00</td>
<td>99.26</td>
<td>0.11</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Culture/Fallow</td>
<td>0.00</td>
<td>0.55</td>
<td>98.05</td>
<td>1.63</td>
<td>1.17</td>
</tr>
<tr>
<td>Settlement/Naked soil</td>
<td>0.23</td>
<td>0.18</td>
<td>1.81</td>
<td>98.37</td>
<td>0.00</td>
</tr>
<tr>
<td>Water</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>98.83</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Overall accuracy: 98.08%
Kappa: 0.96

Figure 6: land use of 2015
Changes operated in different landscapes.

- Decrease of the areas of:
  - Forest: from 153.5 to 43.2 km²
  - Growing areas or fallow land: from 1005.3 to 702 km²

- Significant increase in areas of:
  - Plantation area or tree savanna: from 141 to 392.3 km²
  - Settlement/necked ground: from 196.7 to 359.9 km²

Figure 7: Areas of change observed between 1986 and 2015
Increase in the area occupied by the city of Korhogo following a strong demographic growth.

Increased vegetation, mainly related to the development of teak plantations (reforestation policy and also cultivated by some farmers), the cultivation of cashew (Côte d'Ivoire, first in production), that of mango and the creation of sacred forests (figure 6).

Introduction of these new crops (cashew nuts).

Favorable conditions for the development of these crops. This plant stand is visible on the 2015 land cover map.
REGRESSIVE EVOLUTION OF RAINFALL

Rainfall recession generally observed in West Africa and particularly in Côte d'Ivoire (Ardoin et al., 1990; Ardoin, 2004; Brou, 2010).

SATELLITE IMAGES CLASSIFICATION ACCURACY

Global accuracy: 84.63% (1986); 87.04% (2000); 98.03% (2015)

GIRARD et GIRARD (1999) GA=80% .

The results of an image analysis with a Kappa value greater than 0.50 are good and usable (Pontius, 2000)

Confusion errors are acceptable to the extent that none of these errors is above 70% which is the limit value (Mama et Oloukoi, 2003)

CHANGE OF LAND COVER BETWEEN 1986 AND 2015

Increase in the City of Korhogo in 2015

A return of vegetation around the city of Korhogo and inhabited areas in 2015 reflecting the development of perennial crops
CONCLUSION
Rainfall indices from Korhogo station over the period 1984-2014, reveal a wet period (from 1984 to 1986 and from 2008 to 2014) and dry period (1987 to 2007).

Thematic maps produced highlight a dynamic vegetation cover that reflects a transformation of the landscape.

Anthropic pressures (rural and urban exodus) and rainfall droughts led, during the period 1986-2015, to a change in vegetation cover in the Korhogo Sub-Prefecture.
THANK YOU FOR YOUR ATTENTION!