5e Congrès mondial d'agroforesterie
En transition vers un monde viable

Québec, 17 - 20 July 2022

Remote sensing techniques for calculating the above-ground biomass stored in agroforestry systems open the way for monitoring restoration policies

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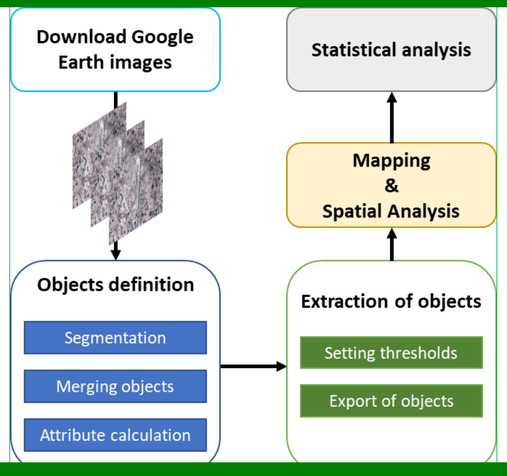
Introduction

While many companies are seeking to offset their carbon emissions, following the resolutions of COP 26 in Glasgow, **very few are financing carbon sequestration through enrichment of the above-ground biomass of traditional agroforestry parklands in Africa**. One reason is the difficulty of monitoring the effects of incentive policies on a large number of small-scale farmers in areas that are sometimes difficult to access.

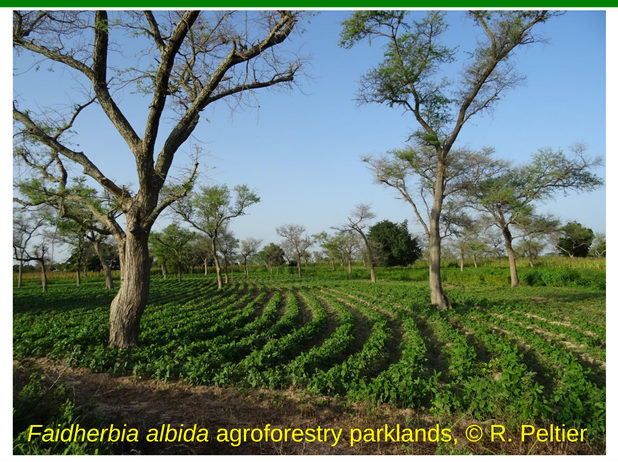
In the Sahelian Far North region of Cameroon, several projects encouraged the restoration of *Faidherbia albida* agroforestry parklands by subsidising their FMNR (Farmer Managed Natural Regeneration) from 1997 to 2008 [1]. **An inventory of these parks in 2012 showed that about 1 million trees had been conserved**[2].

However, the security crisis of 2015 and restrictions related to Covid-19 made it difficult for scientists to access these areas[3]. Thus, it would be useful to develop approaches that would enable the remote assessment of tree cover and woody resources in these parklands. The aim of this study is to assess the evolution of tree cover in Gane and Sirlawe parklands in the Far North region of Cameroon using Google-Earth images, and how reliable this would be.

Methods



- **Tree cover mapping**: Remote sensing by semi-automatic photo-interpretation based on an object-oriented analysis of Google-Earth images from 2009, 2013, and 2018.
- **Comparison between 2012 survey and 2013 remote sensing mapping**


Faidherbia albida agroforestry parklands, © R. Peltier

Results

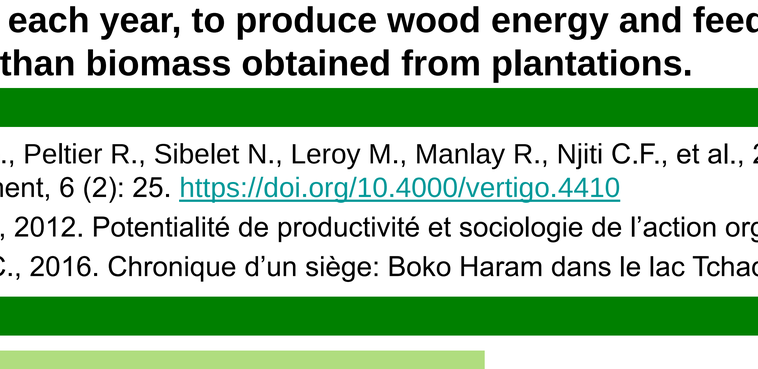


Figure 1: Structure of tree crown areas between survey and mapping

- The structure of the crown areas mapped (2013) is closed to that of the field measurements (2012). However, these structures are significantly different at the 0.05 threshold (Gane site: X-squared = 7.6164, df = 4, p-value = 0.1067; Sirlawe site : X-squared = 3.1758, df = 4, p-value = 0.5289).

- The average tree cover more than doubled between 2009 and 2018, increasing from 246 to 587 m^2*ha^{-1} (2.5% to 5.9%) and from 245 to 575 m^2*ha^{-1} (2.5% to 5.8%) for Sirlawe and Gane, respectively

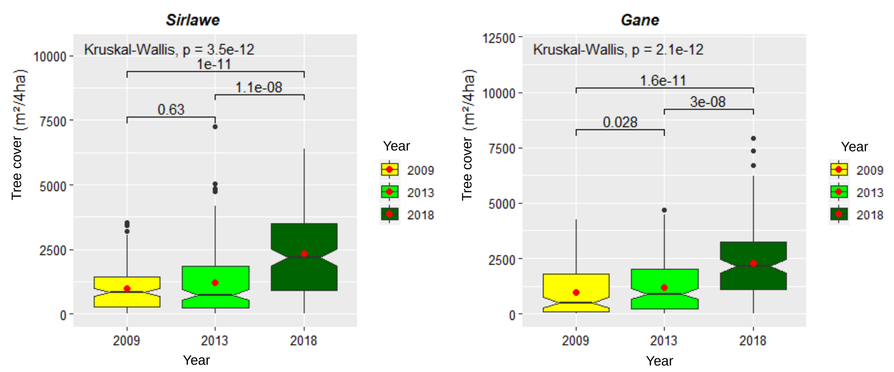


Figure2 : Tree cover change over time as estimated by mapping

Discussion

- The remote sensing monitoring of parklands by our approach is quite accurate and still needs to be improved.
- The allometric equations for estimating the above-ground biomass of trees, as a function of crown area, remain too imprecise to make an acceptable estimation of the carbon stored during this period.
- **However, it is very likely that the amount of biomass pruned, removed and stored each year, to produce wood energy and feed livestock cost much less than biomass obtained from plantations.**

Conclusion

On both sites, the tree cover has become denser, most likely due to the impacts of projects from the 1990s onwards and particularly the dissemination of the FMNR technique supported by a grant from 1997 to 2008.

Further work needs to be carried out by a European project (INNOVACC) from 2022 onwards, to refine the remote sensing methods and the reliability of the allometric equations **which would pave the way for monitoring the quantities of carbon stored and saved by this type of FMNR subsidy.**

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