Sensitivity analysis of the water balance simulated by WaNulCAS model: a case study of complex cocoa agroforestry systems in Cameroon

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INTRODUCTION

Climate change is predicted to induce modifications of rainfall regimes. In Central Cameroon, cocoa trees are already cultivated in sub-optimal pedoclimatic areas. Yet, local systems include many complex agroforestry systems (**cAFS**) which response to drought is currently debated (Abdulaï et al, 2018). Models like **WaNuLCAS** (van Noordwijk et al, 1999) are powerful tools to explore a wide set of agroecosystems functioning scenarios.

HYPOTHESES: WaNuLCAS is able to (i) correctly model water functioning in cocoa cAFS; (ii) represent changes in water fluxes induced by modifications of AFS structure, soil properties and rainfall.

OBJECTIVES: Produce a sensitivity analysis to evaluate WaNuLCAS functioning and its ability to represent changes in water fluxes in cocoa cAFS.

MATERIAL AND METHODS

Water, **Nu**trient and **L**ight **C**apture in **A**groforestry **S**ystem (v4.3) has proven to be efficient at modelling a wide variety of agroforestry systems (AFS) but **HAS NOT YET BEEN USED IN TREE-TREE INTERACTION**.

The model has been parameterized using several data sets:

- **Weather data** : 30 years of daily data from 5 site in sub-Saharian Africa (Fig 2; Africa Rice project)
- **Characterization** of cAFS in Central Cameroon as in Nijmeijer (2017)
- **Tree positions** among cAFS in Bokito as shown in Jagoret et al (2017) and typical cAFS in Cameroon :

→ Highly **heterogeneous**
→ High **species richness**

ESFM: Ecosystem Services Functional Motifs (ESFM; Rafflegeau et al., 2019; Fig 2 A) as basic bricks of the AFS for modelling

SENSITIVITY ANALYSIS FRAMEWORK

Three variable categories (inputs) are selected for their impact on cAFS water balance :

1. **Soil characteristics** (depth and composition) → soil water availability by changing the soil volume and water soil conductivity.
2. **Weather** (Fig 1) → rainfall quantity and distribution (unimodal vs bimodal). Six replicates of five years → climatic variability within site
3. **AFS structure** → trees' combinations based on 10 ESFM (Fig 2A). representing most of the situations encountered in cocoa-crop in Sub-Saharian Africa.

Categories of observed outputs of the model :

- **Soil water** availability (water stock in soil)
- Trees **water uptake** and transpiration vs evaporation
- Cocoa **production** and other product (wood, fruits…)

CONCLUSION & PERSPECTIVES

First results of the sensitivity analysis is able to provide *in silico* data to assess the ability of WaNuLCAS to model cocoa complex agroforestry systems. We identified needed technical adaptations of the modelling chains which shall be carried with its design team at ICRAF (Bogor, Indonesia). Predictions using the model will require fieldwork to ensure an optimal calibration/validation --> work planned in 2020 in Cameroon for analyzing the functioning of cocoa AFS.

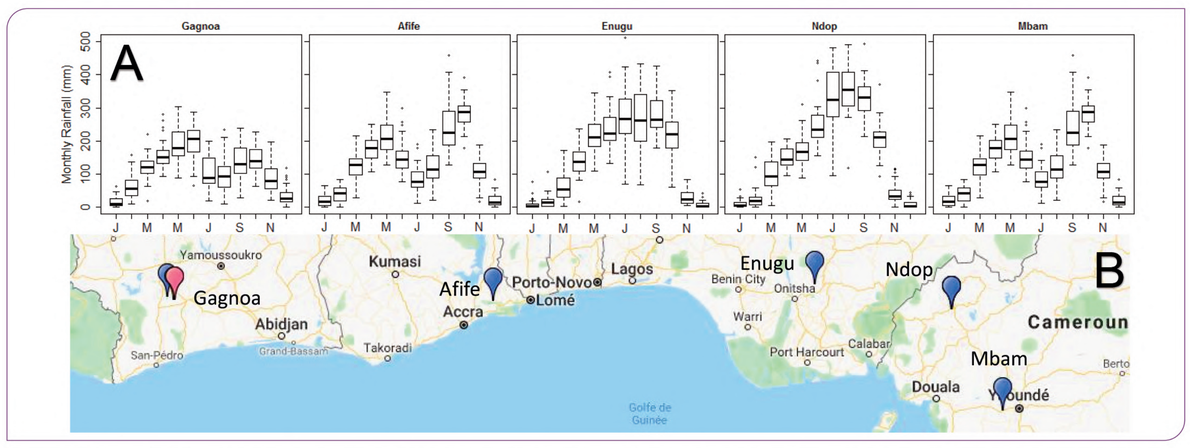

Fig. 1: A : Monthly rainfall (mm) in the five studied regions over 30 years. B: Positions of the stations

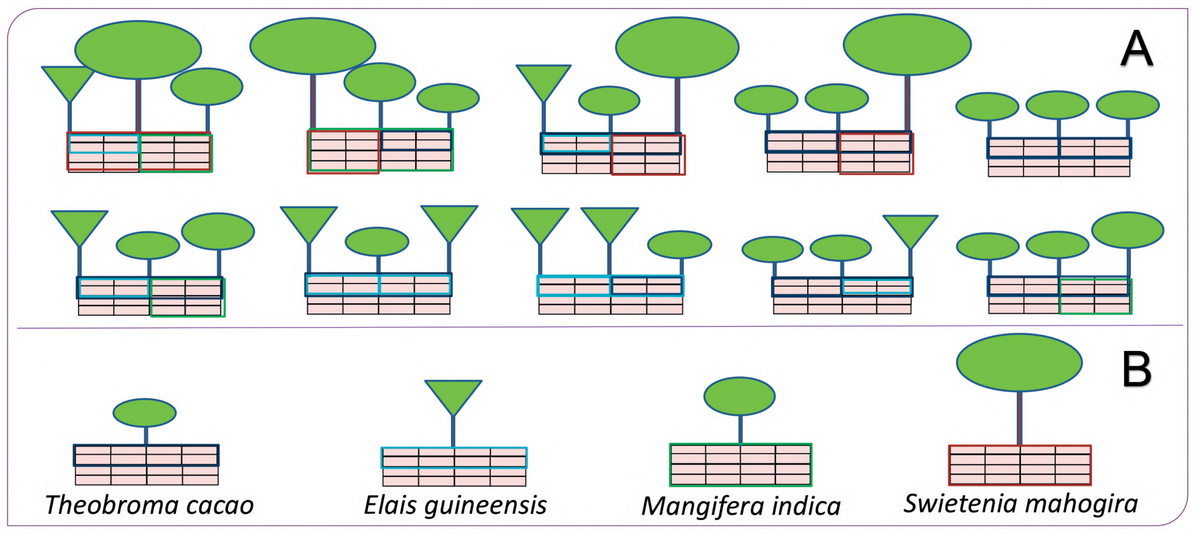

Fig. 2: A: Ten Ecosystem Services Functional Motifs from cocoa monoculture to complex cocoa agroforestry systems. B : Species used and their roots distribution.

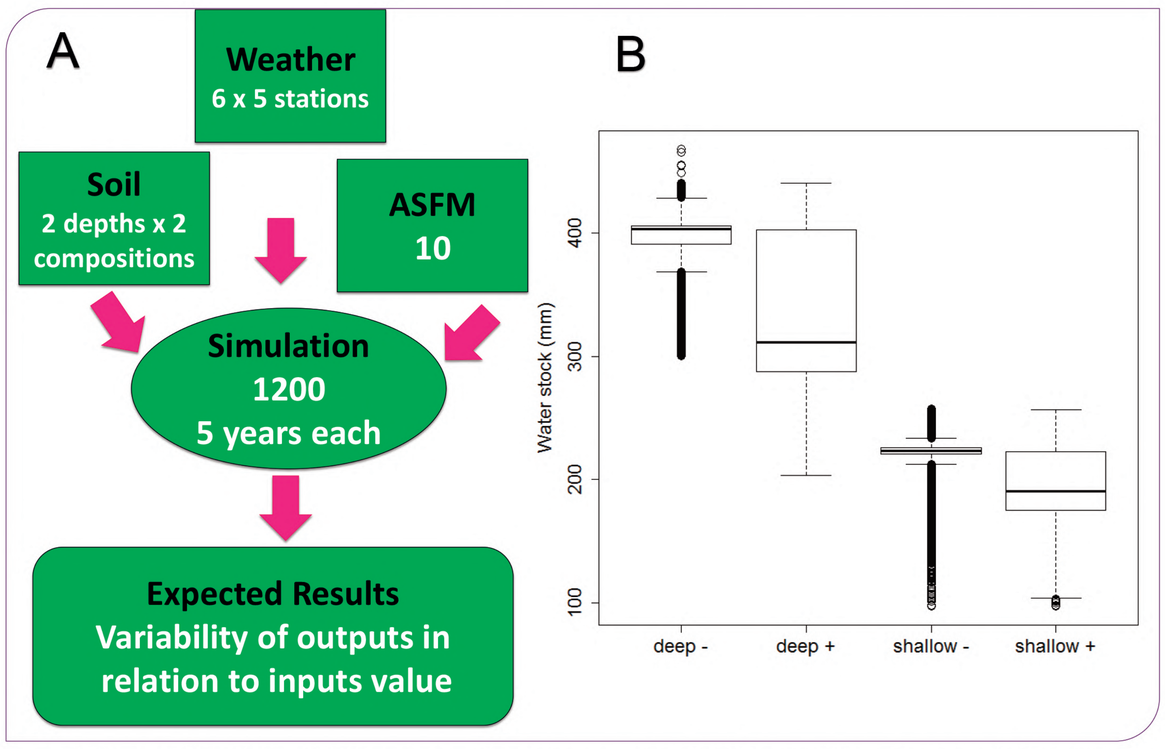

Fig. 3: A : Sensitivity analysis framework; B : Example of expected results : Variability of water stock in soil in relation to the soil depths (deep vs shallow) and composition (high clay "+" vs high sand "-" content

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