Twin-Agroforest: The case of cocoa

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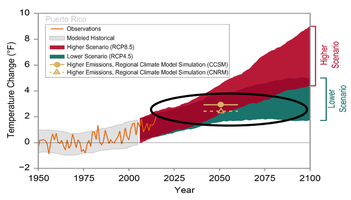
Background

Agroforestry, the combination of forest trees and crops, is widely seen as a climate-smart nature-inclusive strategy as it combines agricultural production with forest services. But the generally long-lived nature of these systems makes that a decision made today may have implications for decades, and makes experimentation very expensive. Using digital tools is thus essential but the temporal and spatial dimensions of agroforests makes them hard to analyze with conventional models. This leaves major knowledge gaps about the functioning of agroforests, which in turn hampers their development as a successful production strategy. We therefore develop a agroforest digital twin (DT) that combines novel 3D functional-structural plant modelling with detailed data monitoring at tree and stand level.

Perennial systems without digital tools

Long-lived organism changing uncertain future?



Experiments difficult and expensive?

People limited resources to deal with wrong decision?

Optimal pruning practices?

Optimization of shade tree density and species in cocoa production

Objectives

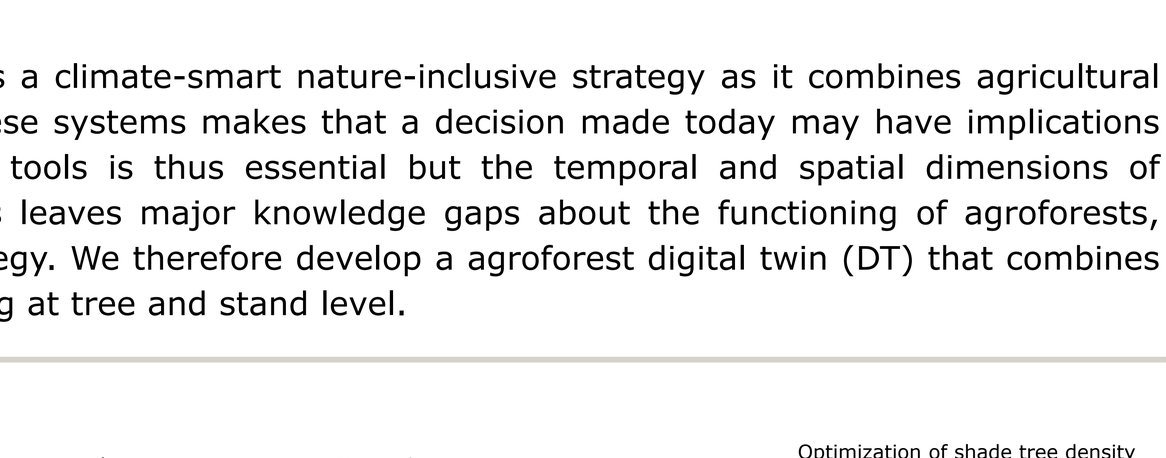
1. Develop novel methods for the rapid generation of digital models of cocoa trees and cocoa farms in relation to a surrounding tropical forest for the benefit of local farmers and society;

2. Operationalize this twin as a biological research tool and as a stakeholder co-learning tool;

3. Explore opportunities for scaling this twin for a broader assessment of the impacts of cocoa agroforestry systems in West Africa;

4. Promote trust in and adoption of the digital twin among local farmers, other public and private cocoa stakeholders, forest professionals, and policy makers

Digital twin as an alternative

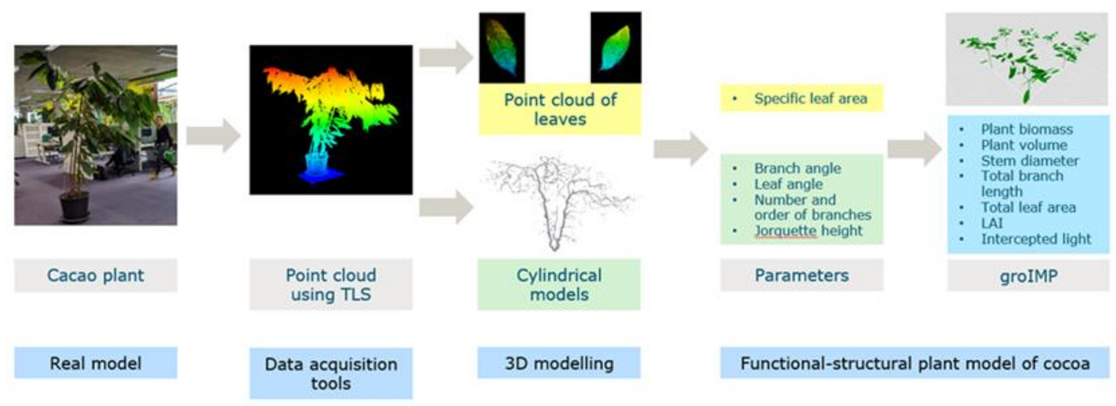


Results

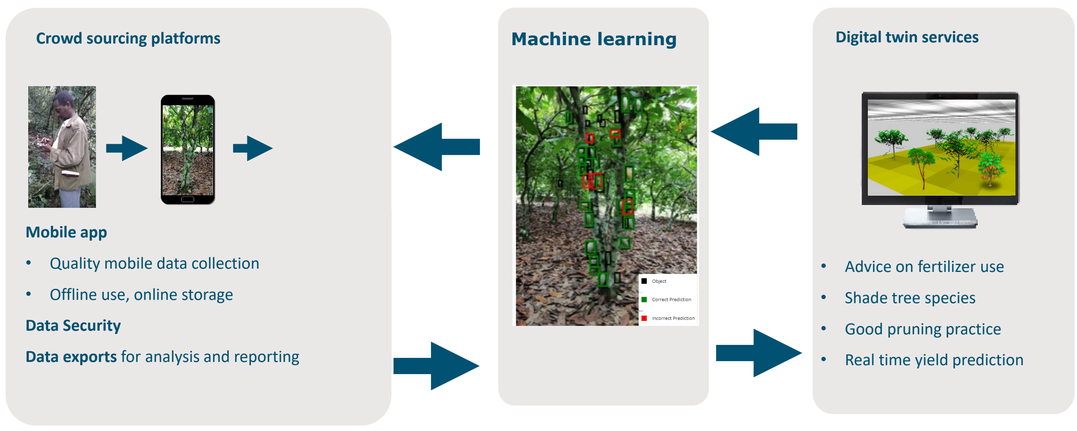
1) Data to develop cocoa Twin – Agroforest

Sensor	Description
Terrestrial LiDAR	Detailed 3D measurements of cocoa tree and canopy structure and surrounding to capture tree growth, effects of pruning, shade trees etc.
Sap flow	Monitoring water use at tree level using autonomous sensors
SPAD	Measure chlorophyll content at leaf level.
Microclimate sensors	Measure microclimate at crop level
Leaf physiology sensors	Leaf gas exchange, and low budget leaf fluorescence meters give indications of photosynthesis and overall abiotic stress.
Mobile App	Engaging local farmers to provide in situ data (e.g. fertilizer use, existing shade trees, pruning practices, yield prediction) and feedback to Twin – Agroforest services. Such data form the basis for using AI to extract additional information and for object recognition. This way local farmers can interactively contribute to the twin development.
Satellite data	Regular coverage of high space/time resolution satellite time series data (Sentinel 1 and 2, Planet-scope) serve as additional source of information on stand level and monitor the landscape context surrounding the sites where measurements are being done on the ground

2) High-tech research module for cocoa growth and food production



3) Two-way farmer – researcher feedback



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