Unveiling the factors associated with cocoa agroforestry adoption intensity and ecological and socio-economic outcomes in West Africa

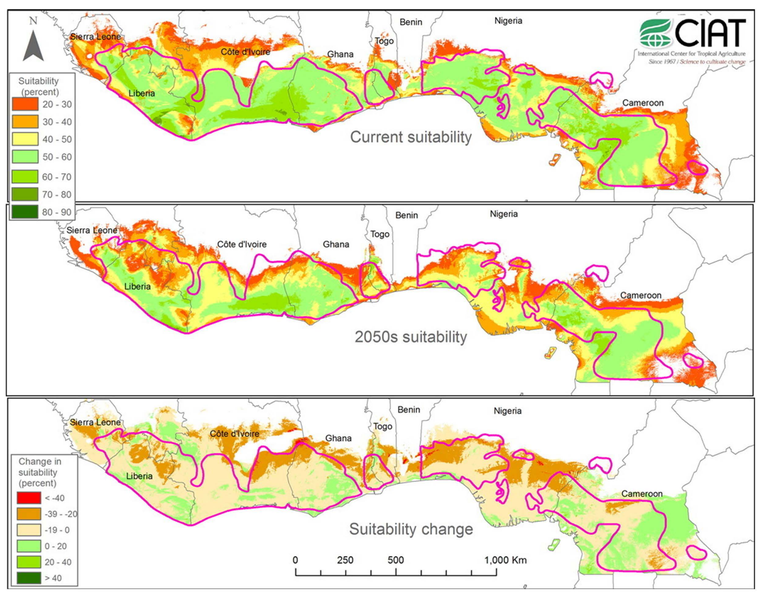
Keessy Maria-Prisca Kouakou[1,2], William Thompson[3], Rachael Garrett[1,2]

[1]*Conservation and Development Lab, Department of Geography, University of Cambridge, Cambridge, UK,*
[2]*Cambridge Conservation Research Institute, University of Cambridge, Cambridge, UK,*
[3]*Nature-Based Solutions Initiative, Department of Biology, University of Oxford, Oxford, UK.*

Overview

- Global agrifood supply chains face multiple challenges, including climate change, tropical forest loss[1] and social inequities[2].
- In the West African cocoa sector, ~90% of cocoa production areas are expected to become unsuitable by 2050, affecting the livelihoods of ~2.5M smallholder farmers[3] (Fig. 1).
- Efforts to promote cocoa agroforestry, the intercropping of shade/multipurpose trees with cocoa on farms, have been promoted alongside zero-deforestation commitments to support climate adaptation, reduce forest loss and improve smallholder farmers' livelihoods[4].
- However, the adoption of agroforestry in West African cocoa-growing landscapes remain low[5].
- This study investigates the factors associated with agroforestry adoption and their outcomes.

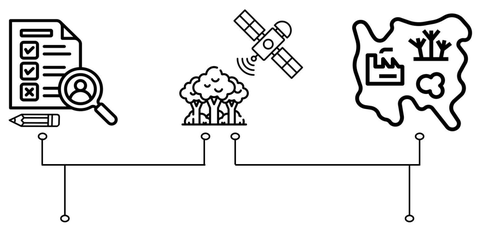
Figure 1. Cocoa suitability map[3]



Background

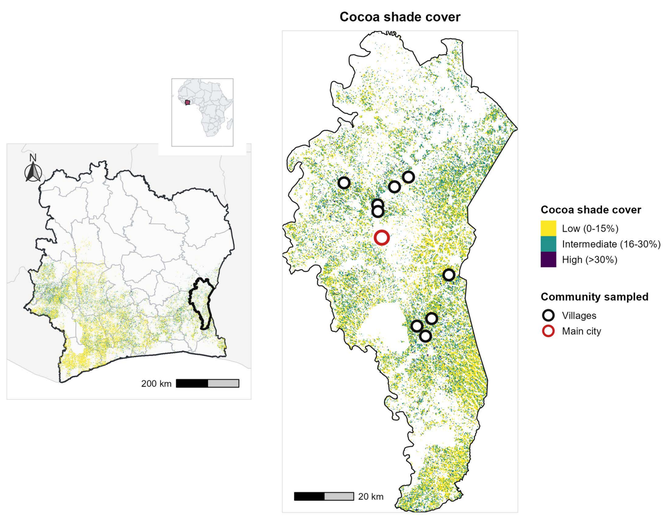
- Studies investigating the factors associated with cocoa agroforestry adoption often conceptualise smallholder farmers' decision-making as a binary process (i.e., to adopt or not) [6].
- However, from a theoretical perspective, the adoption of new technologies is a continuous process that may occur gradually and can be characterised by the rate, degree, and intensity of adoption[7].
- For example, studies on other commodities, such as cattle, show that factors such as social capital and participation in sustainability projects are associated with initial adoption of sustainable farming practices, while resource endowments and farming experience are associated with adoption intensity[8].
- If certain that factors associated with a new technology's initial adoption differ from those associated with its adoption intensity, differences in these factors may be observed in the West African cocoa context.
- Furthermore, socio-economic and ecological trade-off analyses of cocoa agroforestry remain focused on cocoa yield and income [9], while other socio-economic outcomes, such as the potential contribution of agroforestry products (e.g., fruits, timber or other tree products) to household income, remain underexplored.

Methods



- 305 smallholder cocoa households and 122 biomass plots were surveyed,
- Using the double-hurdle model (DHM), we investigated whether the factors associated with low shade agroforestry adoption are similar to the factors associated with higher shade agroforestry adoption,
- Using, respectively, polynomial regressions and GLMMs, we assessed the socio-economic and ecological outcomes associated with these adoption decisions within existing agroforestry systems in South-east Côte d'Ivoire (Fig.2).

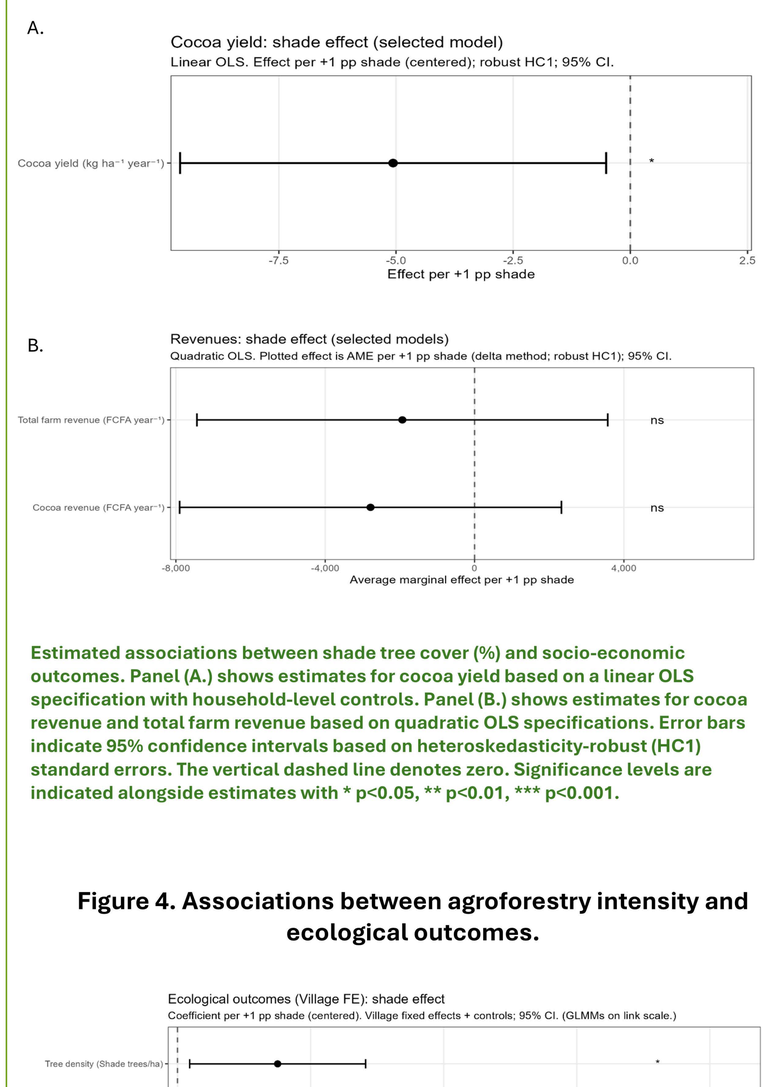
Figure 2. Study area map



Results

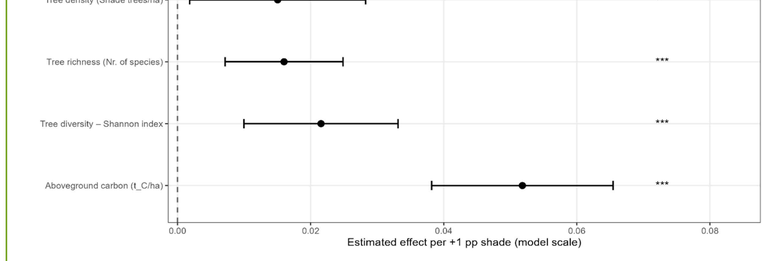
- The findings showed that distinct factors are associated with low-shade agroforestry adoption and higher shade agroforestry adoption (λ = 932.431, p<0.01).
- Labour availability (ME = 0.313, p<0.05) and perceived agroforestry knowledge (ME = 0.065, p<0.05) are associated with low-shade agroforestry adoption.
- However, household access to extension services, including agroforestry training (ME = 2.160, p<0.10), is associated with higher shade agroforestry adoption. Surprisingly, male-headed households are negatively associated with higher shade agroforestry adoption (ME = 5.993, p<0.01).
- The analysis also demonstrates that adoption of higher shade cover produces both synergies and trade-offs (Fig. 3,4):
  - Higher shade cover is associated with reduced cocoa yield (-5.062 kg ha^{-1} year^{-1}, p<0.05) and revenues (-4.25 € ha^{-1} year^{-1}), suggesting the economic constraints farmers face when pursuing ecologically beneficial outcomes.
  - Higher shade cover is associated with reduced total farm income (-2.95 € ha^{-1} year^{-1}), but we found limited evidence that this relationship is statistically significant.
  - Higher shade cover is simultaneously associated with higher ABG carbon (β = 1.05, p<0.001) and shade tree diversity Shannon index (β = 0.02, p<0.001) benefits.

Figure 3. Associations between agroforestry intensity and socio-economic outcomes.



Estimated associations between shade tree cover (%) and socio-economic outcomes. Panel (A.) shows estimates for cocoa yield based on a linear OLS specification with household-level controls. Panel (B.) shows estimates for cocoa revenue and total farm revenue based on quadratic OLS specifications. Error bars indicate 95% confidence intervals based on heteroskedasticity-robust (HC1) standard errors. The vertical dashed line denotes zero. Significance levels are indicated alongside estimates with * p<0.05, ** p<0.01, *** p<0.001.

Figure 4. Associations between agroforestry intensity and ecological outcomes.



Estimated associations between shade cover and ecological outcomes at the household level. Points indicate coefficient estimates, and horizontal bars denote 95% confidence intervals. Models are estimated using generalised linear mixed models (GLMMs) on the link scale. The vertical dashed line denotes zero. Significance levels are indicated alongside estimates with * p<0.05 , ** p<0.01 , *** p<0.001.

Conclusions

- Low shade adoption was associated with labour availability and perceived agroforestry knowledge, whereas higher shade adoption was associated with access to extension services, consistent with the literature on agroforestry and sustainable land use adoption[6,10].
- Contrary to previous studies[6,10], female-headed households were positively correlated with higher shade adoption, regardless of resource access disadvantages they typically face[11]. The mechanisms underlying these associations between inter-/intra-household dynamics and agroforestry adoption are expected to be investigated within my postdoctoral project.
- Additionally, despite ecological benefits associated with higher shade adoption, the contribution of shade-tree product sales to household incomes remains marginal.

Acknowledgements

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Prisca Kouakou
kmpk2@cam.ac.uk