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Mature, diverse shade tree communities are needed to reap broad biodiversity benefits in cocoa agroforestry systems

Calum Maney[1], Samantha Hill[1], Ken Giller[2], Marieke Sassen[2]

[1] *UNEP-WCMC, United Kingdom*
[2] *Wageningen University & Research, Plant Production Systems, The Netherlands*

Abstract

Efforts to improve the sustainability of cocoa production seek to maximise benefits to farmer livelihoods and minimise impacts on biodiversity. We surveyed 168 cocoa farms in four West and Central African countries, and assessed the diversity of shade tree community composition, structure, and functioning. We then modelled the relationship between shade trees communities and ecosystem services, including cocoa yield, and identified the most important traits of trees and shade tree communities from the perspective of cocoa farmers. We found that tree-level traits can be used to predict benefits and disbenefits as perceived by farmers. Taller trees were considered more useful for construction, and fruiting trees for food. Traits such as evergreen leaf habit were linked to trade-offs between food provision and competition with cocoa. Farms with more trees, and larger trees, were more likely to provide provisioning ecosystem services like timber for construction or sale, as well as cultural services like recreation. Farms with more fruiting trees were most useful in providing food both for farmers and for the market. When shade tree diversity was low, maximum yields were predicted at low shade tree density, in line with current recommendations of 20 trees ha^{-1}. When shade tree communities were more diverse, maximum yields could be achieved at higher tree densities of up to 100 trees ha^{-1}, though yields were lower overall. Typical agroforestry recommendations such as 30–40 % shade cover can be achieved in a variety of ways, using tree communities that promote different values to famers. But this standard alone does not always accommodate benefits to yield and ecosystem service provision. Within these boundaries, compositional, structural, and functional traits of shade communities could be optimised to maximise yield and a number of ecosystem services simultaneously. However, most yield and highly-valued ecosystem service benefits are dependent on large, mature trees, which can take longer than the productive lifespan of cocoa trees to grow. Guidance should move beyond shade cover alone to accommodate farmer preferences and the role of structure and function in supporting ecosystem services, including a steady supply of the most important types of trees to ensure sustainable production.

Keywords: Ecosystem services, farmer preferences, shade tree biodiversity

Contact Address: Marieke Sassen, Wageningen University & Research, Plant Production Systems Group, Wageningen, The Netherlands, e-mail: marieke.sassen@wur.nl