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Prospects for agroforestry in REDD+ landscapes in Africa

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Agroforests and agroforestry can be direct targets of Reduced Emissions from Deforestation and Forest Degradation (REDD+) programs, or indirect parts of the necessary conditions for success. Whether or not it becomes a core element of REDD+ depends on the country's forest definition. We review these dimensions of agroforestry in REDD+, with supporting examples, mostly from Africa, and highlight the implications and challenges for enhancing the contributions of agroforestry to REDD+ and corresponding sustainable benefits. Where carbon stocks in agroforestry cannot be directly targeted in REDD+, agroforestry still can be included in REDD+ strategies, as ways to (1) shift demand for land (land sparing) and (2) provide alternative sources of products otherwise derived from forest over-exploitation or conversion, thereby avoiding leakage from forest protection efforts.

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Introduction

In the past five years, the hope that Reducing Emissions from Deforestation and Forest Degradation (REDD+) programs could become a major game-changer for tropical forests has been challenged by slow progress in operationalization of the concepts [1]. REDD+ suggests a mechanism through which countries are rewarded for keeping forests and reducing emission from forests against an agreed baseline, with details still under discussion within the United Nations Framework Convention for Climate Change (UNFCCC). It can combine 'reducing emissions from deforestation', 'reducing emissions from (forest) degradation', 'conservation of forest carbon stocks', 'sustainable management of forests' and 'enhancement of forest carbon stocks'. It hinges on the concept of forest as the defining element of its scope. In principle, REDD+ should be voluntary, performance-based (measureable and verifiable), fair and equitable and it is expected to generate additional sustainable benefits such as biodiversity conservation.

While several land uses have had a specific place within the UNFCCC such as forests (REDD+), agriculture (sectoral approaches), afforestation and reforestation (Clean Development Mechanism), agroforestry has not had a prominent place of its own despite its proven climate change mitigation and adaptation benefits in the literature [2•,3,4,5,6]. Agroforestry is the deliberate integration and management of trees on farms and in landscapes. Being an intermediary land use (belonging to both forestry and agriculture, if the definitions allow double membership), it has often been variedly linked to either forestry or agriculture, as the dominant forest definition and data collection by FAO presumed incompatibility. Related to the absence of agroforestry is the challenge for the UNFCCC constructs to deal with swidden-fallow systems, which can be described as forest management, deforestation or forest degradation, depending on perspective [7]. The lack of a clear home for agroforestry within the UNFCCC could be an advantage (allowing flexibility to benefit from multiple mechanisms) as well as a disadvantage (e.g. the risk that it does not receive sufficient attention in any of the mechanisms). The later seems to have prevailed so far, as not enough attention has been given to agroforestry within each of the UNFCCC mechanisms. This is also the case with REDD+ despite tremendous potentials.

Considerations for agroforestry within REDD+ remain embryonic at national and sub-national level. We reviewed documents like REDD+ Readiness planning documents (particularly the Readiness Preparation Plan-RPP - the main strategic planning documents for tropical and subtropical developing countries) to show how agroforestry is being considered within the REDD+ actions at national level and in some cases at sub-national/project levels. In total, eleven REDD Readiness Preparation Plans (R-PP) belonging to Burkina Faso, Cameroon, Central African Republic, Republic of Congo, Democratic Republic of Congo, Ethiopia, Ghana, Kenya, Liberia, Tanzania and Uganda were reviewed. RPPs were downloaded from the FCPF website (See Table S1

Table 1

Linkages between agroforestry and REDD+ options

Agroforestry position vis-a-vis forest definition	REDD option	Pathway
Agroforestry as part of REDD+	Sustainable management of agroforests; Enhancement of Carbon stocks; and Conservation of agroforests carbon stocks	REDD+ directly targets and compensates for carbon in agroforests
Agroforestry as a strategic option to address drivers		
Agroforestry for addressing drivers of deforestation	Reducing emissions from deforestation	Sustainable intensification and diversification
Agroforestry for addressing drivers of degradation	Reducing emissions from forest degradation	On-farm timber and fuel wood development

Supplementary Online Information for more details and Forest carbon Partnership Facility Database; URL: http://www.forestcarbonpartnership.org/). In almost all the countries reviewed, agroforestry has been mentioned as part of the strategy designed to address agriculture as driver of deforestation. Around 40% of the countries have at least two agroforestry based REDD+ strategic options. Countries like Kenya, Ghana and Cameroon have three direct agroforestry based REDD+ strategic options/activities to address the influence of agricultural expansion on deforestation and forest degradation. While more than 90% of countries mentioned growing household demand for wood fuel and construction as a key driver, two-third of the countries mentioned a potential role of trees on farms or outside forests as a strategic option for addressing this driver. Despite the very positive figures, we found very few cases of actual deployment of agroforestry in REDD implementation.

This paper aims to redress the deficiency, by exploring the prospects for agroforestry in an evolving REDD+ mechanism. Here, we examine circumstances under which agroforestry is firmly part of REDD+ and when agroforestry is a complementary strategy for achieving REDD+ objectives and the implications thereof, for managing agroforestry and shaping policy actions that can help enhance the contributions of agroforestry either way.

When is Agroforestry part of REDD+?

Many agroforestry systems can be part of REDD+ given the current definition of forests within the UNFCCC. The UNFCCC as part of the Kyoto protocol states '*forest is a minimum area of land of 0.05-1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10-30 per cent with trees with the potential to reach a minimum height of 2-5 metres at maturity in situ*' [8]. Agroforestry systems may meet the forest canopy cover threshold chosen by the country (10–30%) and thus become part of REDD+, as the explicit disqualifier of agriculture of the FAO forest definition was not followed by the UNFCCC [9••]. For instance, Bisseleau et al. [10] showed that at least some cocoa agroforestry systems in South Cameroon have a canopy cover of 88%, clearly above the threshold. This implies for UNFCCC forest definition that all cocoa agroforestry systems in Cameroon have the potential to be forest, and should be included in REDD+. Once a canopy threshold is set, it has to be adhered to consistently. Most tree crop production and agroforestry systems meet the minimum requirements of tree cover and potential tree height–unpruned coffee, for example, can easily reach a height of five metres [9••]. Table 1 summarizes the potential linkages between agroforestry and REDD+ options.

When agroforestry is considered part of REDD+, then sustainable management of agro- 'forests', enhancement of carbon stocks within these forests and/or indeed avoiding degradation of these systems into more profitable mono-tree systems with less carbon can become eligible actions within REDD+.

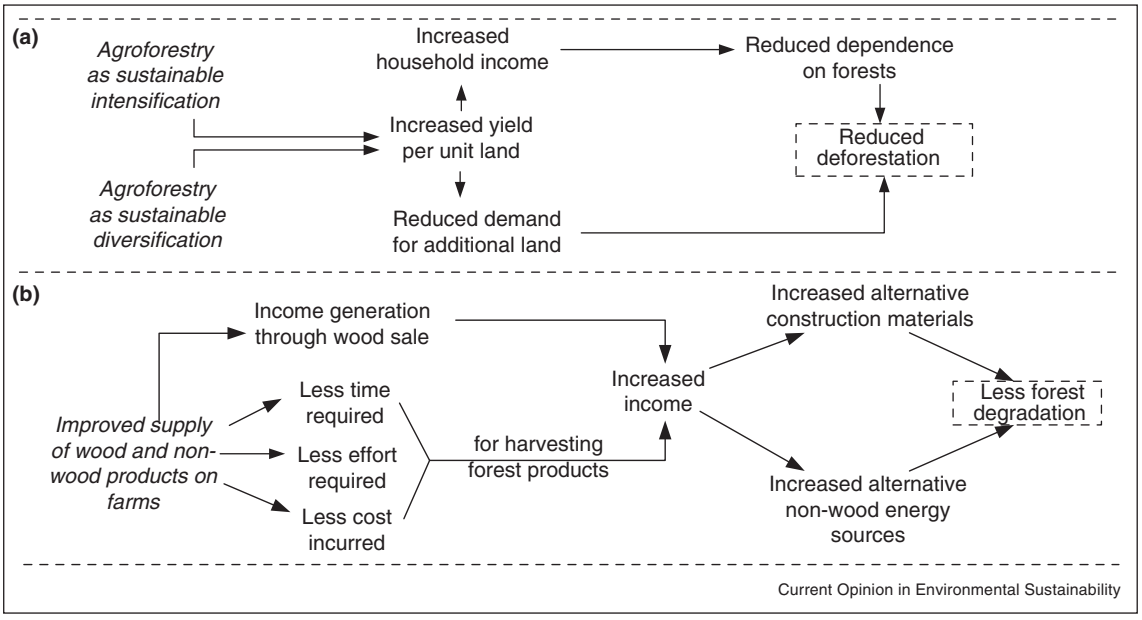
When agroforestry is not 'forest' but complements REDD+ strategies

When agroforestry systems do not qualify as forest because they do not meet the threshold of forest cover and tree height required by the country definition, then agroforestry can still remain a strategy or an approach for addressing drivers of deforestation in either of the following ways summarized in Figure 1: firstly, by potentially avoiding deforestation through sustainable intensification (land sparing) and diversification, secondly, by reducing emissions from forest degradation through increased production of on farm timber and fuel wood especially in instances of restricted access to forests or limited supply in 'open access' forests.

Agroforestry as a strategy for avoided deforestation

The land sparing or intensification hypothesis suggests the following process. First, investments are made in agriculture that result in increased productivity per unit area, through increased inputs and better technology. Once these interventions enable adequate supply of food, fuel and fiber, less forest land would be cleared for agriculture, thereby sparing more forest lands from being cut or for conservation [11]. Agroforestry has been shown

Figure 1



A simplified sketch of two pathways through which agroforestry contributes to the REDD+ mechanism: **(a)** as sustainable intensification and diversification pathway and **(b)** as a source of wood and non-timber forest products.

to be one of the main sustainable intensification activities in many parts of Africa with great impact on soil fertility and increased productivity through nitrogen fixing trees [12•,13,14] as well as with great benefits for biodiversity. This makes agroforestry a great candidate for achieving land sparing. In addition, sustainable intensification provides opportunities for profitable labour absorption that would otherwise engage in deforestation.

Gockowski and Sonwa [15••] showed that intensification of cacao (*Theobroma cacao* L.) agroforestry systems through seed-fertilizer technologies and the integration of timber species in the Guinean rainforest of West and Central Africa (Cote D'Ivoire, Ghana, Nigeria and Cameroon) could have spared 21 000 km^2 of forests and reduced emissions of nearly 1.4 billion t CO_2 if it had been adopted in the late 1960s. This is against a baseline of extensive expansion of cacao, cassava and oil palm into forest areas by about 68 000 km^2 over the same period. Sustainable intensification and diversification approaches can be effective where extensive small farm holdings are the main drivers of deforestation such as in Africa [16].

Agroforestry as a strategy for avoided degradation

Fuelwood, charcoal and timber have been documented as frontline drivers of forest degradation in several countries and to some extent a driver of deforestation in especially dry forest countries in Africa (e.g. in Burkina Faso). Therefore, increasing on-farm timber and fuelwood production is likely to relieve forests of pressures from an increasing demand for timber and fuelwood. On-farm timber is increasingly becoming mainstream timber sources in a number of tropical countries across the world [17].

Kimaro *et al.* [18] demonstrate the significant contributions of rotational woodlot systems to reduce forest degradation and offset CO_2 emissions through on-farm wood supply in semi-arid Morogoro in Eastern Tanzania. Using native vegetation fallows forests as a reference, they show that after a 5-year rotation, wood yield (23–51 Mg C ha^{-1}) was sufficient to meet household demand for fuelwood. They also provide evidence that highly productive acacia fallows (*Acacia crassicarpa* A. Cunn. Ex Benth., *Acacia leptocarpa* A. Cunn. Ex Benth., and *Acacia mangium* Wild) would take four to nine years to recover carbon lost through clearance of Miombo forest for agricultural expansion compared to 2 decades required for re-growing Miombo Woodlands.

Additionally, on-farm timber and fuelwood production can avoid leakage (displacement of activities such as logging and charcoal extraction and labour from project areas) from forest protection efforts. The analysis of Meyfroidt and Lambin [19] showed that at country scale a net increase in forest area is associated with an increased dependence on external agricultural footprint (roughly 50% of the forest area gained) is indicative of the effects that can be expected at subnational scale as well.

Implications for REDD+ implementation, policies and research in Africa

One additional reason for adopting agroforestry as part of REDD+ strategies is its relative potential for generating non-carbon and sustainable development benefits. Some of these benefits might also include the simultaneous enhancement of adaptation and mitigation in multiple ways. Evidence of the multiple benefits from agroforestry is growing [20]. In practice, at sub-national level, agroforestry has been deployed in the last 20 years as a strategy or approach for addressing deforestation with integrated conservation and development projects [21,22,23•] and in emerging REDD+ sub-national projects [1] with some degree of success. However, technical, policy and economic challenges remain, which if overcome would further enhance the potential contribution of agroforestry to REDD+. Technical challenges include, getting good quality planting material for desired species, limited agronomical understanding of optimal shade management in sustainably intensive and diversified agroforestry systems and processing of products [12•,24]. Economic and policy challenges include unclear rights to land, trees and carbon, poor market infrastructure, long waiting periods for recovery of investments (sometimes up to three years) and labour shortages [21,25].

Though agroforestry features as a prominent dimension of sustainable intensification in Africa, complementary policy actions and research might be needed to enable the achievement of its full potential at national and sub-national levels [26,27]. To enhance its contributions to REDD+ at landscape level, it is crucial to understand the demand dimensions and employ better planning approaches in which land is shared between agroforestry, protected forests and other land uses with clear and agreed rules for management [28]. Research on the context, demand dynamics for agroforestry products, wood, and other tree products is therefore needed in many places in Africa and along tropical forest margins. So far evidence of how far agroforestry intensification and diversification has avoided deforestation and degradation has been largely anecdotal cases studies. Further quantitative evidence and understanding of the processes and institutional and policy arrangements that enable agroforestry contribution to REDD+ are needed.

Conclusions

This paper set out to explore the potentials of agroforestry to contribute to REDD+ with a focus on Africa. We find that close to half of the REDD+ strategies in African countries identify agroforestry as a strategic option for effective, efficient and equitable REDD+ delivery. But most of the countries do not specify how and most are yet to deploy agroforestry in the context of REDD+. We show that agroforests and agroforestry can be direct targets of Reduced Emissions from Deforestation and Forest Degradation (REDD+) programs, or indirect parts of the necessary conditions for success. Whether or not it becomes a core element of REDD+ depends on the country's forest definition. Where carbon stocks in agroforestry cannot be directly targeted in REDD+, agroforestry still can be included in REDD+ strategies, as ways to (1) shift demand for land (land sparing) and (2) provide alternative sources of products otherwise derived from forest over-exploitation or conversion, thereby avoiding leakage from forest protection efforts.

However, enabling and eliciting the multiple benefits for REDD+ through agroforestry at national level may require considerable policy, technology and institutional innovations. Sub-national level experiences so far demonstrate the need for tenure reforms, as well as tremendous agricultural, physical and market infrastructure investments. Planning reforms might also be needed to allow for landscape multi-functionality at meso and macro levels. Further research that helps quantify the REDD+ and multiple benefits of agroforestry beyond the micro scale may also help reinforce policy actions that are supportive of agroforestry in REDD+ and climate change in general at both national and global levels.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at http://dx.doi.org/10.1016/j.cosust.2013.10.015.

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