AGROFORESTRY – TEEBAGFOOD

[EXECUTIVE SUMMARY]

Agroforestry: an attractive REDD+ policy option?

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Agroforestry is a practice involving the deliberate integration of trees or shrubs in farming landscapes involving crops or livestock in order to obtain benefits from the interactions between trees and/or shrubs the tree and crop or livestock component. The most up-to-date study of tree cover in agricultural landscape by Zomer et al. (2014), estimates the global extent of agroforestry, considering agricultural landscapes with at least 10% tree cover, as over 1 billion hectares of land (more that 43% of all agricultural land area), supporting more than 900 million people, mostly in the tropical and sub-tropical regions inhabited by poorer populations.

The same study shows an overall increase in the extent of agroforestry (>10% tree cover) between 2000 and 2010 by about 1.85% of all agricultural land in sub-Saharan Africa, 12.6% in South America, 2.7% south east Asia and by 1.6% in central America. Over the same period, there is a large increase in the number of people living in landscapes with greater than 10% tree cover, from 746 million to over 837 million.

Agroforestry is important in rural livelihoods as it provides a range of ecosystem services with additional benefits such as keeping farmers more food secure through more diversified food and cash crop outputs (fruit tree products, other non-timber forest products, food crops) and resilient to environmental or socio-economic shocks by on-farm livelihood diversification and enhancement of regulating ecosystem services for yield stability. As the growing population demands for food and other agricultural products, there is a tendency to replace agroforestry with monoculture intensified systems, which leads to increased yield of a few provisioning services and tradeoffs of ecosystem services, of critical value at local, national and global levels.

However, if ecosystem values in agroforestry are better understood and integrated into formal decision-making processes, potential exists for making agroforestry an economically attractive option for farmers, land owners and governments. Within reducing emissions from deforestation and forest degradation in developing countries and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks (**REDD+**) under the **United Nations Framework Convention on Climate Change** (UNFCCC), the recognition of the role of trees in contributing to global climate mitigation provides scope for agroforestry to contribute to carbon sequestration.

This study aims to shed light on the value of ecosystem services agroforestry systems provide and the attractiveness of agroforestry in terms of the ability to remove carbon emissions compared to monoculture cropping. The study is part of a broader project of the **TEEB for Agriculture and Food** (**TEEBAgFood**) study. At the same time the study is relevant for UN-REDD partner countries as they identify what policies and measures (PAMs) to undertake as part of REDD+ implementation. The report uses cases studies from Ethiopia (coffee), Tanzania (Ngitili) and Ghana (cocoa).

Based on the literature reviewed, total carbon stocks are over 300% higher coffee agroforestry than monoculture maize systems, approximately 33-100% higher in cocoa agroforestry, depending on shade density, than full sun cocoa systems, and over 200% higher in Ngitli (grazing exclosures) than maize-grazing rotation system.

Ongoing trends in **Ghana** and **Ethiopia** involve forest conversion to smallholder agriculture and the adoption (sometimes with the Governments' active promotion) of intensive and less diversified land use systems such as monoculture maize and smallholder coffee plantations in Ethiopia (especially in the southwest - Hylander et al. 2013; Tadesse 2014a), full sun cocoa and oil palm systems in Ghana (especially in the Western region - Gockowski et al. 2011a; Asase 2014). This deforestation and conversion to more simplified systems at the expense of coffee and cocoa agroforestry systems entails loss of the tree-based ecosystem services critical to rural livelihoods as will be elaborated.

Objectives

The study seeks to provide insight in the possibility for agroforestry to be an interesting REDD+ policy or measure (PAM) as countries move towards REDD+ implementation. As part of that objective this study presents a consolidated overview of the carbon and non-carbon ecosystem services values in agroforestry systems in Tanzania, Ethiopia and Ghana under different scenarios at smallholder farm and national level. Second, recommendations are given for potential policy interventions to promote agroforestry in productive or lived-in landscapes that contribute to achieving REDD+. The specific objectives of this analysis are to:

1. Understand carbon and non-carbon values in various agroforestry systems. Demonstrate the potential of agroforestry in delivering provisioning and regulating ecosystem services, in addition to carbon storage and other ecosystem benefits arising from sustainable land use management that are relevant in the context of REDD+
2. Economic valuation using scenario analysis. Quantify and value the changes in ecosystem services including impact and trade-offs for three different agroforestry systems using scenario analysis
3. Policy recommendations. Suggest policy recommendations and incentives needed to promote agro forestry in productive or lived-in landscapes that contribute to achieving REDD+.

Selection of case studies

The study is based on three case study agroforestry systems**: 1) cocoa agroforestry in Ghana**; **2) coffee agroforestry in Ethiopia**; and **3) Ngitili system in Tanzania**. These were selected based on various criteria summarised in Table 1 below. The three case study countries are UN-REDD partner countries where these agroforestry systems make significant contribution to national economies reflected in the gross domestic product (GDP). These systems are threatened by challenges such as the volatility of commodity prices, unclear land and tree ownership, climate change and the current drive for more intensified full sun systems that are believed to be more productive.

The case of Ngitili (restored woodlands) agroforestry is an example of agro-pastoralism, where a mosaic of forest patches is conserved in crop-production to enable sustainable grazing. This system is currently being threatened by the growing demand for food and fuelwood due to a rapidly growing population.

Table 1: Selected Agroforestry Systems

Selection criteria	Cocoa agroforestry Ghana	Coffee agroforestry Ethiopia	Ngitili system Tanzania
Trend of agroforestry system	Increased by about twice the area in the 1990s to about 1.6 million ha (FAOSTAT 2013)	Increased by 100% since the 1990s to about 520,000 ha (FAOSTAT 2013)	Increased from 600 ha in 1986 to >350000 ha in 2003 (Mlenge 2004)
Number of people benefiting from the system	Between 1.9 million (Coulombe & Wondon 2007) to 6 million people (Anthonio and Aikins, 2009) - 700,000 smallholder farmers (Kolavalli & Vigneri 2011).	7 million to 15 million people (Petit 2007); 95% of the coffee produced by smallholder farmers About 4.5 million smallholder farmers (Central Statistical Agency 2013)	No data available, but stimated about 1500 households employed in Shinyanga's formal and informal forestry sector, in which ngitili products play a major role
Contribution to national economy	18.9% of the agricultural GDP; 8.2% of the Ghana's GDP and 30% of total export earnings (GAIN, 2012)	36% of national export income in 2006/07 (Ejigie 2005) *Approximately* 10% of national GDP (Economic Report on Africa 2013)	No data available but estimated to contribute approximately 0.43% of Shinyanga region's GDP

Approaches and Methods

The study primarily used extensive review of documented sources ranging from journal articles to grey literature to quantify and value biophysical and economic values of ecosystem services delivered by agroforestry. The **analysis of ecosystem services** (ES) included provisioning services (cash crops, food crops, tree products, medicines, wild food and all other non-timber forest products, timber and poles, wood fuel/charcoal and fresh water provisioning), regulating and supporting services (carbon, soil erosion control, soil fertility (nitrogen, phosphorus and potassium, runoff, water quality, biological pest control, pollination and biodiversity).

In addition, the analysis recognised the qualitative ecosystem services from agroforestry for which quantification values were not available. Information was obtained directly for the case study locations, but where data was missing, literature from comparative locations was used. The WaterWorld model was also used to combine existing primary documented information with spatial data to infer how ecosystem services change under different scenarios.

Valuation of ecosystem services

Economic valuation of ecosystem services adopted a total economic value (TEV) framework, which differentiates between direct and indirect use values, option and quasi-option values, along with existence values (Perman et al. 2003; TEEB 2010). The ecosystem service values were standardized into per hectare units, and adjusted to 2013 US dollar values using the Purchasing Power Parity (PPP) index for private consumptions and for inflation (as measured by the World Bank's GDP deflator). Total economic value of the agroforestry systems was estimated by combining provisioning with regulating service values as briefly outlined below.

The total asset value of each system was estimated as its net present value at maturity (i.e. full yield capacity) at a 10% real[1] discount rate over a twenty-year time horizon. A 10% rate was chosen as the principal rate for cost-benefit analysis because it accords with previous cost-benefit analyses studies for agroforestry systems in the country case studies (e.g. Monela et al. 2005; Obiri et al. et al. 2007; Reichuber et al. 2012; Asare et al. 2014), and it also is in line with the opportunity cost of loanable funds from multilateral development banks such as the Wold Bank. In the sensitivity analysis, a lower-bound rate of 2.5% and an upper-bound rate of 20% were used.

Valuation of provisioning services was done using recent price data in relation to the physical units (e.g. $/headload of fuel wood). No price premiums were used. Where gaps existed, datasets from comparable situations were considered using the benefit transfer method, which increases uncertainty. Provisioning services were valued through their estimated gross margin (value of output less variable cost).

Valuation of regulating services was done using various methods depending on the ecosystem service. *Carbon stocks* (above and belowground biomass and soil carbon pools, excluding litter and dead wood), were valued by considering both private financial benefits to farmers through possible payments from carbon markets for agroforestry/sustainable agricultural land management at US$6.50/ton (Forest Trends, 2013)[2], and as a global public good, using the social cost of carbon as estimated by the United States Environmental Protection Agency (2013)[3] at $40.3/ton. The US EPA social cost of carbon estimate was used in order to remain conservative in estimating the social cost, and to better approximate the likely upper bound of developed countries' willingness to pay for emissions offsets in developing countries (eg. Beltran et al. 2013). The resulting estimations provided the lower and upper bounds of the carbon stock value in a sensitivity analysis for the cost-benefit analysis. However, only the lower bound estimates were used for the scenarios analyses and calculations of GDP of the poor.

Regulating services, such as ***soil erosion control*** *and* ***maintenance of soil fertility***, ***biological control of pests*** and ***pollination*** can be understood as intermediate ecosystem services which contribute to the final benefit of crop production. As such, they were not valued additively (i.e. in addition to the value of the crop provisioning services), but in terms of their incremental contribution to the final provisioning service as separate set of environmental service "flow" accounts.

***Pollination* and *biological pest control* services**, were valued as their percent contribution to the the gross margin of the final crop, supplemented by replacement cost and avoided cost estimates where relevant.

Soil fertility and ***erosion control*** values were estimated using the replacement costs approach, valuing the differences in nitrogen (and, where available, phosphorous and potassium) stocks by multiplying the additional soil nutrients by the cost of urea and/or NPK fertilizer.

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[1] i.e, inflation-adjusted.

[2] Forest Trends (2014) gives $4.2/tonne CO2eq for REDD+ credits, $16.1/tonne CO2eq for agroforestry/sustainable agricultural land management credits, and an average value (across all credit types) of $5.2/tonne CO2eq. The 2013 values for agroforestry credits were used since they are more conservative.

[3] The cost of one ton of emissions for the year 2015, expressed in 2011 dollars under a 3% discount rate was estimated at USD 39/tonne of CO2 equivalent emissions. Adjusting for two years of inflation gives a value of USD 40.3/tonne.

SCENARIOS ANALYSIS

The future gains and tradeoffs in agroforestry ecosystem services likely to occur due to different land use scenarios were analysed for the three case studies, under an array of possible future situations that may arise when the course set by current and emerging trends is altered due to uncertain external factors. These scenarios were therefore inspired by emerging trends and policy contexts in each study country, and chosen to be consistent with existing scenarios developed for West and East Africa by the CGIAR programme on Climate Change, Agriculture and Food Security (CCAFS). Scenario analysis was done on the following sample area extent: 206,000 ha for cocoa agroforestry, 202,432 ha for Coffee agroforestry and 1.3 million ha for Ngitili.

Coffee agroforestry in Ethiopia

Globally coffee covers an area of 10.2 million ha, supporting 15-20 million households. Of this area, 40% is produced with no shade, 35% with light-moderate shade and 25% with traditional diverse shade. Coffee was responsible for 10-12 million ha of deforestation over the past 1-1.5 century (Vaast et al. 2015). In Ethiopia, the rate of deforestation is estimated at 1-1.5% per year (Teferi et al. 2013), mostly driven by smallholder coffee expansion (Davis et al. 2012).

Coffee profitability is very low in smallholder agroforestry systems in Ethiopia, mostly due to volatility in global market prices. In the 1990s-2000s, loss in income was about $200 per household (Charveriat 2001) and between 1998 and 2003 (Petit 2007) the Ethiopia government estimated a loss of about $814 million in revenue. Climatic predictions show that areas bioclimatically suitable for coffee production may reduce by 65% under the most optimistic projections (Davis et al. 2012). The following scenarios were considered.

1) **Conversion to an alternative agricultural crop**. Conversion of all areas identified as under coffee agroforestry to a maize mono cropping system. This could be caused by ongoing trends of low profitability of coffee due to occasionally low global prices, climate change, which might render many areas bioecologically unsuitable for coffee growing (Davis et al. 2012) or the allocation of land to agricultural investors for biofuel generation.

2) **Conversion existing agroforestry coffee to heavy shade grown coffee**. Conversion of all areas identified as under coffee agroforestry to a heavy shade coffee agroforestry system. This is alternative scenario that could result from the ongoing Climate Resilience Green Growth Strategy, the national REDD+ program, certification programs and improvements in land tenure conditions.

3) **Conversion and further expansion of heavy shade grown coffee**. Conversion of all areas identified as under coffee agroforestry to a heavy shade agroforestry system and expansion into all areas identified as non-agroforestry land use outside urban and other priority land uses. This can be the case if the above processes in (2) turn out to be successful and profitable for farmers.

Cocoa agroforestry in Ghana

Globally cocoa covers an area of 9.9 million ha, supporting 10-15 million households. Of this area, 30% is produced with no shade, 50% with light-moderate shade and 20% with traditional diverse shade. Cocoa production was responsible for 6 million ha of deforestation over the past 50 years (Vaast et al. 2015). In Ghana, cocoa area expanded in 1984 to 2006 due to promotion of full sun varieties under Ghana Cocoa Board (COCOBOD) High Tech and CODAPEC program (HTP) targeting to increase and stabilize cocoa production to one million tonnes per year (Gockowski et al. 2013). This affected the last remnants of the West African Guinea Forest. Since shade removal can result in doubling of yields (Acheampong et al., 2014), cocoa agroforests are decreasing across West Africa (Ruf et al. 2006; Ruf 2011). Per hectare stocking of large trees >10 m tall in farms was 50 in the 1970s; 4.7 in 1989 and 3.4 in 1991 (STCP 2008).
The following scenarios were considered.

1) **Conversion to an alternative agricultural crop**. Conversion of all cocoa agroforestry systems to a full sun/lightly shaded system. This is an ongoing trend mainly driven by the promotion of full sun varieties under COCOBOD High Tech and CODAPEC program (HTP) targeting to increase and stabilize cocoa production to one million tonnes per year. Insecure land tenure and the barriers to ownership of naturally growing trees also contribute to this.

2) **Conversion existing cocoa agroforestry to heavy share cocoa system**. Conversion of all cocoa agroforestry areas to moderate to heavy shade cocoa systems. This is an alternative scenario that could be driven by the fact that the productivity of full sun hybrids declines after short cycles (10-15 years) and may not be sustainable if subsidies for agrochemical inputs are removed. The ongoing REDD+ program and cocoa certification options may also contribute to this.

3) **Agronomic improvement**. This concerns use of fertilizer, herbicide and other inputs in not just under full sun, but in cocoa agroforestry systems. This is already practiced in some systems and could be scaled up.

Ngitili in Tanzania

The rapid growth in human and livestock population is leading to increasing demand for land to grow food crops especially maize (Fisher 2005; National Bureau of Statistics and Shinyanga Regional Commissioner's Office 2007), leading to fragmentation of Ngitili. Ngitli is also becoming degraded due to overgrazing and overharvesting of fuel wood for charcoal due to growing urban demand (World Agroforestry Centre 2010). Despite the rapid expansion in Ngitili up to 2003, tree cover on agricultural land largely decreased in Tanzania between 2002 and 2010 (Zomer et al. 2014). The following scenarios were considered.

1) **Conversion to an alternative agricultural crop**. Conversion of all Ngitili areas to a maize system. This could be driven by ongoing growing demand for land for food cultivation (maize is the major crop) and pressure on existing Ngitili for charcoal and fuel wood due to the growing population.

2) **Conversion existing Ngitili to heavy shade Ngitili system**. Enhancement of shade levels in Ngitili agroforestry system.

RESULTS

Coffee agroforestry

In the baseline scenario, coffee agroforestry in Ethiopia stores carbon stocks ranging from 49 to 150 t/ha with an overall monetary value of $865 million over the current total area coverage. The system produces provisioning services including coffee yield, food, fuelwood and non-timber forest products (NTFP) worth an annual per hectare value of $1,100-2,500. This is compared to production in the alternative maize systems, which has a value of only $450/ha/y. The agroforestry system also provides regulating ecosystem services including soil fertility enhancement, pollination, biodiversity, soil erosion control, enhancement of water quality and water flows. The overall net present value (NPV) of baseline coffee agroforestry comes to $2,750-29,300/ha compared to only $900/ha-$3000/ha in maize systems.

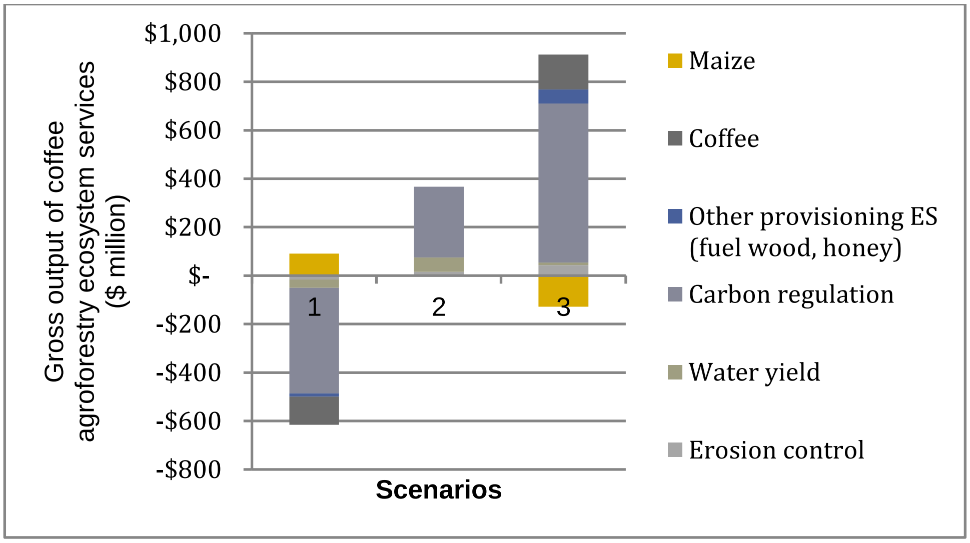
Converting coffee to maize would result in overall increase in maize, worth about $90 million a year. However, this entails loss of $116 million worth of coffee production, as well as $2.7 million and $10 million worth of wood fuel and honey production, totalling approximately $38 million of foregone provisioning services. In addition, it leads to regulating services losses (Table 2 and Figure 1) due to decreased water yield, loss in carbon stocks, increased soil erosion and runoff. Conversely, increasing canopy cover in coffee agroforestry systems would not affect provisioning services significantly compared to the baseline, yet it can potentially generate regulating service gains in terms of increased carbon stocks, increased water yield and reduces soil erosion and runoff. If such a system is expanded (scenario 3), it would increase the gains in regulating services even more while generating a net increase in provisioning services. Overall, there is substantial potential benefit in increasing tree cover in coffee agroforestry systems.

Table 2: Changes in ecosystem service values different scenarios in coffee agroforestry, Ethiopia

Ecosystem service[4]	Scenario 1 Converting to maize (million $/y)	Scenario 2: Canopy cover ≥ 30% (million $/y)	Scenario 3: Canopy cover ≥ 30% & expansion (million $/y)
Increase in system extent (ha)	202,342	0	286,852
Provisioning[5]	-$38.4	No change	73.4
Coffee	-115.9	No change	143.9
Maize	90.5	No change	-128.3
Other ES (fuel wood, honey)	-13	No change	57.9
Carbon regulation	-435	292	655
Other regulating	-19.0	74.5	54.3
Water yield	-34.9	58.6	10.7
Soil erosion	15.9	15.9	43.6

Figure 1: Changes in ecosystem service values different scenarios in coffee agroforestry, Ethiopia

[4] All ecosystem services listed are in principle compatible with the System of National Accounts, meaning that these can either be directly reflected in the value added by the agricultural sector, or are hidden in the value added of other sectors.
[5] Assuming no price effects from increased and decreased production



Cocoa agroforestry

Cocoa agroforestry in Ghana stores about 23.4 million tonnes of carbon over the current total area coverage, worth about $565 million. However, the value of provisioning services including cocoa yield, food fuelwood and NTFP from shaded cocoa systems comes to an annual per hectare value of only $2300/ha compared to the full sun option worth about $3100/ha and the high input ('high-tech') option worth $6400/ha. The overall NPV of baseline cocoa agroforestry comes to $600/ha, compared to over $4100/ha in the full sun system and $14,000/ha in the high tech system. The shade cocoa systems also provide regulating ecosystem services including soil fertility enhancement, pollination, biodiversity, enhancement of water quality and water flows. Water quality is potentially quite high in cocoa agroforestry systems due to the high tree cover, although effects from pollution from agrochemical inputs were not considered in the model used.

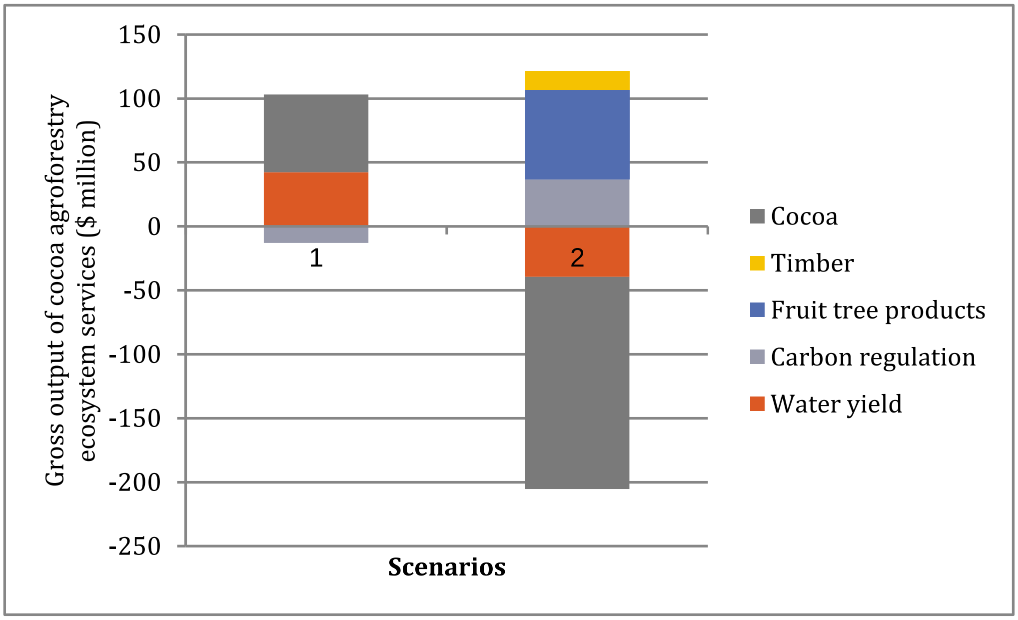
Conversion of cocoa agroforestry to full sun leads to 10,300 tonnes increase in cocoa production and gains in water yield, but causes carbon stock losses (**Table 3** and **Figure 2**). Conversely, increasing tree cover in cocoa agroforestry leads to carbon stock gains, but with losses in cocoa and water yield. Intensification of moderate and heavy shade systems using maximum recommended agro-input levels results in overall increase in value of the system, but agroforestry systems have a lower value than full sun.

Table 3: Changes in ecosystem service values different scenarios in cocoa agroforestry, Ghana

Ecosystem service[4]	Scenario 1 Converting to full sun (million $/y)	Scenario 2 Converting to moderate shade
Increase in system extent (ha)	55,482	151,154
Provisioning[5]	60.86	-81.4
Cocoa	60.86	-165.8
Timber[6]	0	14.6
Fruit tree products	0	70.2
Carbon regulation	-12.9	36.6
Other regulating	42.3	-39.4
Water yield	42.3	-39.4
Soil erosion	ND	ND

[6] Undiscounted timber yield at Year 20, divided over a twenty year period.

Figure 2: Changes in ecosystem service values different scenarios in cocoa agroforestry, Ghana



Ngitili

Ngitili systems in Tanzania deliver provisioning services including charcoal, non-timber forest products, honey, medicines, wild foods and bush meat, wood fuel, timber and poles and fodder and thatch grass worth a total of $1.6 billion over the current total area coverage, although these are mostly consumptive values, rather- than cash income values. In addition, the system stores carbon stocks of approximately 34.7 million tonnes, worth about $837 million per annum. Assuming the area was covered with maize, this would deliver 5 million tonnes of maize, worth approximately $799 million per annum.

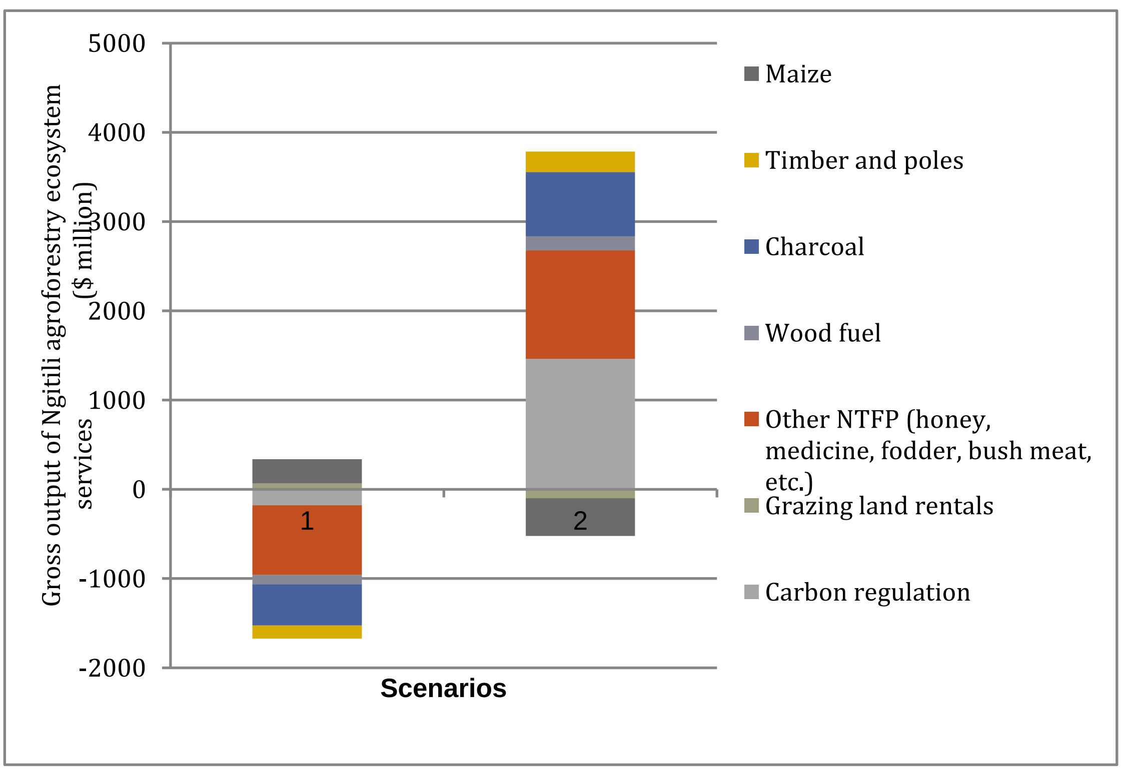
Soil nutrient value is to an extent higher than that in maize systems although given the wide variability, it could not be established whether the difference was significant. Other regulating ecosystem services from Ngitili include biodiversity, soil erosion control, enhancement of water quality and water flows. The overall NPV of baseline Ngitili agroforestry comes to $5,000 - 16,000/ha. By contrast, maize has an NPV range of $750 - 2,000/ha.

Conversion to maize systems could result in a net gain from maize production and improved water yield. However, it would lead to loss in terms of decreased carbon stocks and increased soil erosion. Conversely, increasing tree cover would cause a gain in carbon stocks, but with loss in maize production and reduced in water yield (**Table 4** and **Figure 3**).

Table 4: Changes in ecosystem service values under different scenarios in Ngitili Tanzania

Ecosystem service[4]	Scenario 1 Converting to maize (million $/y)	Scenario 2: Canopy cover ≥ 20% and conversion from maize (million $/y)
Increase in system extent (ha)	1,316,504	2,039,867
Provisioning[5]	-1,160.1	1,798.2
Maize	273.8	-424.3
Timber and poles	-148.1	229.5
Charcoal	-463.9	718.9
Wood fuel	-102.8	159.3
Other NTFP (honey, medicine, fodder, bush meat, etc.)	-782.7	1,212.7
Grazing land rentals	63.19	-97.9
Carbon regulation	-176	1,464
Carbon (REDD+)		
Other regulating	0.98	-0.94
Water yield	0.95	-0.95
Soil erosion	.031	0.009

Figure 3: Changes in ecosystem service values under different scenarios in Ngitili Tanzania



IMPLICATIONS FOR REDD+

In all the three systems analysed, there is scope to increase ecosystem service benefits to rural farmers and national economies by increasing the tree component and expanding the coverage of agroforestry systems although this requires substantial investment. However, at present most of the benefits delivered by agroforestry are externalised from formal market systems and do not translate into tangible gains at the farm or national level. Given the potential for agroforestry systems to store and sequester larger amounts carbon than conventional agriculture, there is scope to include it as a means of 'enhancement of forest carbon stocks' thereby being one of the five accepted 'REDD+ activities' under the UN Framework convention on Climate Change (UNFCCC).

Besides the carbon removal potential of agroforestry systems, these systems also provide non-carbon ecosystem service benefits that can be beneficial for the countries in question. Technically agroforests and agroforestry can be as a direct target of REDD+ programs, or be included indirectly as part of the necessary conditions for success. Whether or not it can be a core element of REDD+ depends on the country's forest definition as well the economic realities of production systems.

Serious considerations would have to be given to how REDD+ addresses the trade-offs between economically driven policies that encourage more productive low-to open coffee and cocoa systems in African countries that harbour these systems. Agroforestry sequestration capacity is quite low compared to the amount of carbon that can be stored in forests, with average aboveground biomass stock values from literature review being around 45-50% for forest coffee systems compared to Afromontane forests in Ethiopia (Tadesse 2014; Vanderhaegan et al. 2015). For Ghana, aboveground biomass C stocks compared to secondary and old-growth forests are about 23% and 18% (Sandker et al. 2009) for moderate shade cocoa, and about 34% and 42% for heavy shade cocoa. However, it should be noted that in some instances, carbon stocks from cocoa agroforestry systems have been estimated to be as high as 84% of carbon stored in secondary forests (Wade et al. 2010).

Ngitili has total biomass carbon[7] stocks equivalent to 39% of the value for degraded miombo woodlands and 22% the value for 'pristine' miombo woodlands in Tanzania (Burgess et al. 2010). As such, REDD+ payments for agroforestry are likely to offer only a small fraction of farm revenue except when aggregated across landscapes or in combination with forest-based REDD+ projects or payments for avoided deforestation. However, the situation is of course broader; while forests store more carbon, they may not provide the other economic benefits that agroforestry systems provide. When these benefits are considered, agroforestry can deliver higher value to national economies.

Hence, a government might decide to use REDD+ as a vehicle to finance the transition from monoculture to agroforestry as opposed to "setting aside land" for de-facto conservation, which can be quite expensive in terms of lost opportunity costs (unless a government already had plans to set aside certain areas for conservation).

[7] Referring to both above and belowground biomass. Total biomass carbon stocks are compared here because that is the manner in which the miombo woodlands comparator values were reported.

Minang et al, (2014) found that 40 of the African countries involved in REDD+ mention agroforestry as a strategy in implementing REDD. However, it is important for UN-REDD partner countries and forest-rich nations that consider agroforestry an interesting policy or measure (PAM) to start operationalizing it through REDD+ National Strategies/Action Plans and/or investment plans.

Agroforestry can be included in REDD+ strategies, as ways to reduce drivers of deforestation through **1)** shifting demand for land (land sparing) as a sustainable intensification pathway, **2)** providing alternative sources of products otherwise derived from forest over-exploitation or conversion, and **3)** as opportunities for profitable labour absorption in a sustainable intensification pathway. On-farm timber and fuelwood production can avoid leakage from forest protection efforts.

From a review of emerging REDD+ sub-national projects across various countries, Alemagi et al. (2014) observe a number of challenges for integrating agroforestry such as getting good quality planting material, agronomical understanding of optimal shade, unclear rights to land, trees and carbon, poor market infrastructure, long waiting periods for recovery of investments (sometimes up to 3 years) and labour shortages. It is crucial to have a broader enabling environment in place to make implementation a success. Land and tree tenure need to be made more secure and road-blocks against marketing of tree products including timber and charcoal need to be replaced by provisions that work together with key stakeholders.

Other financial incentive options for promoting agroforestry

Beyond potential REDD+ results-based payments for the carbon removed through agroforestry systems, mechanisms of internalising the other ecosystem values from agroforestry can be explored. Some examples are outlined below.

Payments for ecosystem services (apart from REDD+) can be used to promote agroforestry in watershed uplands using payments from downstream water users such as power generating companies, irrigation schemes and water utility companies. However, given the low coverage of downstream companies with capacity and willingness to pay, these mechanisms may require joint financing or co-investment including private sector, government and development funds. Due to difficulties in implementing direct buyer-seller PES in Africa, systems of incentivising of agroforestry in watersheds have evolved to pilot more multi-stakeholder approaches such as the Nairobi Water Fund by the Nature Conservancy aimed at improving land use in the upper Tana watershed.

***Sustainable certification* schemes**, which are already in operation for coffee and cocoa also offer some scope for incentivising agroforestry. However, the barriers to their expansion need to be addressed e.g., the high upfront costs and difficulty in sustaining the required controls and inclusion of smallholder and remotely located farmers.

Using fiscal instruments to improve profitability of agroforestry systems. The analysis in this report has shown that agroforestry systems provide a range of non-carbon ecosystem service benefits to the national economy. Without economic incentives it will be difficult to convince farmers and landholders to change their land use in favour of agroforestry. Fiscal incentives (tax exemptions or input subsidies) or grants could be used to incentivize public and private actors that manage land to move towards agroforestry enhancing su*stainable i*ntensification aimed at improving productivity and profitability not only of the main crops, but also of tree products such as timber and fruits.