Cost-Benefit Analysis of REDD+ Strategy Options

Technical Annex E

Final Report

Consulting Services Contract For the Development of A National REDD+ Strategy for Liberia

November 2016

This Technical Annex is part of a set of reports produced by LTS & NIRAS as part of the 'Consulting Services Contract For the Development of A National REDD+ Strategy for Liberia' commissioned by the Forestry Development Authority as part of its Readiness Preparation Proposal (R-PP) Implementation Grant from the Forest Carbon Partnership Facility.

The complete set of reports can be found here:
http://www.ltsi.co.uk/projects/liberia-national-redd-strategy-consultation/

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Acronyms

BAU	Business as usual
CBA	Cost benefit analysis
CFMA	Community Forest Management Agreement
CO_2	Carbon dioxide
ENNR	East Nimba Nature Reserve
EU	European Union
FDA	Forest Development Authority
FMC	Forest Management Concession
NGO	Non-governmental organization
NPV	Net-present value
PA	Protected Area
REDD	Reduced Emissions for Deforestation and Degradation
RIL	Reduced Impact Logging
R-PP	Readiness Preparation Proposal
SFM	Sustainable Forest Management
USD	United States Dollar
VPA	Voluntary Partnership Agreement

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1. Background and approach

The Cost-Benefit Analysis (CBA) of REDD+ strategy options in Liberia aims at supporting the national REDD+ strategy development. Four strategic priorities were identified by the REDD+ strategy development team in consultation with REDD+ stakeholders in Liberia. For these four, key activities were defined for assessment in the framework of this CBA (Table 1).

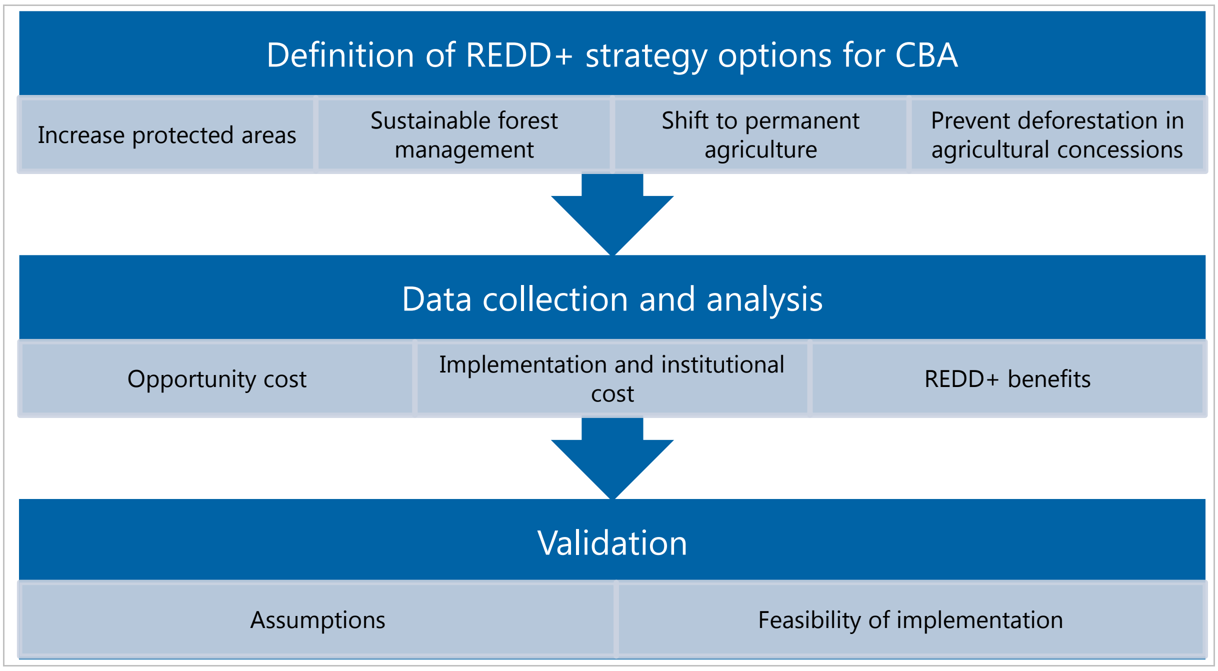
Table 1: Focus of the cost-benefit analysis

Strategic priority	Focus of CBA
1. Reduce emissions from deforestation and degradation by supporting the sustainable use of forest resources by communities, addressing shifting agriculture, charcoal production, pit sawing in particular	• Reduce shifting agriculture by increasing the area of land under permanent agriculture: Intensify agriculture on already severally degraded areas growing annual crops and tree crops in a commercial setting
2. Sustainably manage commercial forestry, to reduce impact of logging in areas conceded (or proposed) as Forest Management Contracts, Community Forest Management Agreements or other designations where commercial forestry may occur	• Strengthen Forest Management Contracts (FMC) • Strengthen Community Forest Management Agreements (CFMA)
3. Conserve forest carbon stocks by completing and managing a network of Protected Areas, including existing and Proposed Protected Areas and proposed conservation priority areas.	• Law enforcement and management of existing and proposed PAs will be improved, including community livelihood programs.
4. Reduce emissions from deforestation by protecting high carbon stock and high conservation value forest in agricultural and mining concessions.[1]	• Conservation of High Carbon Stock (HCS) and High Conservation Value (HCV) forest in concessions.
[1] Mining concessions were not included in the Cost-benefit analysis	

Approach and methodology

The assessment was conducted in three steps, beginning with the prioritization of REDD+ strategy options as outlined above.

Figure 1: Workflow for the cost-benefit analysis

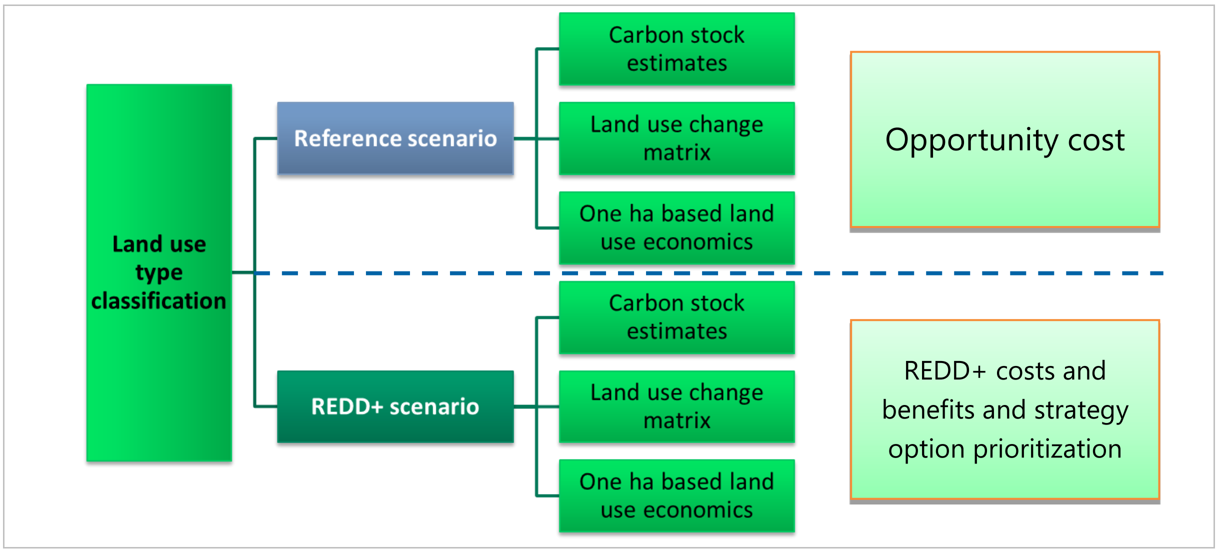


REDD+ cost and benefit analysis requires four key data sets:

- Land cover and land use classification
- Land use change matrix over a certain time period
- Carbon stock for land cover and land use classes
- Land use economics (one hectare economic models)

Based on these data sets the opportunity cost – for the reference scenario, and the REDD+ costs and benefits for the REDD+ scenario can be derived (Figure 2).

Figure 2: Approach for assessing opportunity costs and REDD+ benefits



Source: UNIQUE

The information required for the CBA was compiled from published and unpublished literature on Liberia, and direct communication from experts working in Liberia in the fields of conservation, forestry and agriculture. Where data from Liberia was not available, information from neighboring countries was used and complemented by global data. The list of literature used is available in Annex 1.

For data analysis we used the REDD+ cost element assessment tool (WB, 2013).

Methodology constraints

The REDD+ CBA relies directly on the results of the assessment of Land Use, Land Use Change Drivers, Forest Law, Policy and Governance. Such assessment have been done as part of Liberia's REDD+ Readiness preparations but the evidence available from existing national data sets is limited. For a comprehensive REDD+ strategy option CBA the following information would be necessary, but was limited or not available:

Land use change detection and land use change matrix (incl. spatial quantification of drivers)

Carbon stock assessment for land uses

National land use change and GHG emissions reference level (preliminary data was provided by Winrock)

Land cover, use and land use change assumptions

To the extent possible, information on actual land use was compiled using a variety of literature sources and the recent land cover data compiled by Forest Development Authority (FDA) and JV Metria/GeoVille (2015). Table 2 shows the assumed relationship between land cover and land uses. Unregulated forest and shifting cultivation constitute by far the biggest land uses in Liberia.

Table 2: Land cover and land use classes use for the assessment

Land cover class 2015	Area	Land use class	Area	Share within land cover class
Forest cover >80%	4,589,270	Protected area	200,000	4%
		Forest (not regulated / protected)	2,889,270	63%
		Forest regulated logging	1,008,137	22%
		Forest unregulated logging	291,863	6%
		Rubber plantations	200,000	4%
30%< Forest Cover <80%	1,986,495	Agroforestry	45,000	2%
		Shifting cultivation	1,941,495	98%
Forest Cover <30%	1,529,949	Smallholder oil palm	20,000	1%
		Industrial oil palm	26,300	2%
		Shifting cultivation	1,383,649	90%
		Intensive agriculture	100,000	7%
Other	1,550,348	Other (excl. clouds)	1,550,348	
Total mapped area	9,656,062		9,656,062	

Source: Land cover classes: GeoVille 2015

The rate of deforestation applied to the business as usual (BAU) scenario is based on a preliminary value provided by Winrock (Table 3). The rate of forest degradation/deforestation for the REDD+ scenarios was assumed to be reduced by 50%.

Table 3: Deforestation and degradation rates for BAU and REDD+

	Land cover class			
	Forest cover class > 80%		30% < Forest Cover < 80%	
	BAU[1]	REDD+	BAU[1]	REDD+
Deforestation and forest degradation	0.23%	0.115%	0.74%	0.37%

[1] Winrock, Personal communication from Katie Goslee. Rates reflect forest cover change between 2002-2012. The final values may differ from the ones used here.

No rates were available for forest degradation. They are assumed to be the same as for deforestation. Forest degradation in the context of this CBA is understood as a conversion from the forest cover class > 80% to the 30% < x < 80% cover class.

Deforestation and degradation with REDD+ is assumed to be half as high as in the BAU scenario.

Preliminary carbon stock values for the three land cover classes were likewise provided by Winrock. However, as values provided were not land use specific, they had to be supplemented with values from the literature (IPCC 2003 & 2006 and other). Further details are provided in Annex 4.

To put opportunity cost into perspective to the likely scale of land use change and potential emissions the following land use change matrix was used. Values in Table 4 show the current and future predicted area for a given land use. Planned and unplanned land use changes taking place between today and the end of the assessment period are reflected by the changed total.

Table 4: Land use change matrix for BAU and REDD+

Land cover	Land use and land use change From:	To:	Area Currently ha	BAU[1] ha	REDD+[1] ha
Forest cover >80%	Forest (not used, not protected)	Remaining without protection status	2,900,000	2,500,000	900,000
		Sustainable logging in FMC (sustainable V, RIL)	0	0	1,000,000
		Protected forest	200,000	300,000	1,100,000
		Industrial oil palm	n/a	170,000	0
	Conventional logging in FMC	Remaining FMC (conventional)	1,000,000	900,000	500,000
		Sustainable logging in FMC (sustainable V, RIL)	0	0	500,000
	Unregulated logging	Remaining unregulated	300,000	300,000	160,000
		CFM (Chainsaw milling)	0	0	140,000
	Rubber plantation	No change	200,000	200,000	200,000
Forest cover 30-80%	Shifting cultivation (long cycles)	No change	1,900,000	1,400,000	1,400,000
		Commercial agriculture (improved)	0	0	50,000
		Industrial oil palm	n/a	170,000	250,000
	Agroforestry	Agroforestry (improved)	45,000	50,000	90,000
Forest cover <30%	Shifting cultivation (short cycles)	No change	1,400,000	1,800,000	1,400,000
		Commercial agriculture (improved)	0	0	50,000
		Industrial oil palm	30,000	170,000	200,000
	Intensive agriculture	Commercial agriculture (improved)	100,000	100,000	100,000
	Smallholder oil palm	No change	20,000	20,000	20,000
Other			1,600,000		
Total			9,700,000		

[1] Area after 25 years, i.e. after planned and unplanned land use changes. Unplanned land use change = deforestation and degradation. The sub-totals of the BAU and REDD+ scenario for the individual land cover classes differ from the current area due to planned conversion to other land uses and deforestation/degradation.

Sources: Land cover: FDA and JV Metria/GeoVille (2015), land use: various sources – refer to Annex 1, Winrock personal communication; Figures presented are rounded values.

Economic modelling

Economic 1-hectare models were developed for the land uses listed in Table 5 to compare the financial performance under business as usual (BAU) and REDD+. Under REDD+, land management will change to more sustainable forms, contributing to reducing pressure on forests, reducing the impact of forestry, and retaining and increasing carbon stocks.

The economic comparison is based on net-present value over 25 years.[1] Costs and revenues were discounted using a rate of 15%, reflecting the high cost of capital in Liberia. A complete list of assumptions is provided in Annex 2-4.

Table 5: Land uses under BAU and REDD+

Land use	Business as usual	REDD+
Protected areas (PA)	The existing 3 PAs will remain protected areas with similar management activities and intensity. Encroachment of the protected areas for livelihood activities, artisanal mining and others continues, leading to conflict, deforestation and forest degradation.	Management of existing PAs will be intensified; incl. alternative livelihood measurements in nearby communities and additional PAs (see R-PP) will be gazetted. ➢ Deforestation and degradation will be reduced.
Commercial logging	Logging takes place in concessions granted by government and on community controlled land. Logging standards in concession areas do not always conform to international best practice. In community forests logging standards are not applied. Many small scale logging business (chain saw millers) exist. They are largely unregulated and harvest in all forest types. Poor logging standards cause significant damage to residual stands and the amount of timber harvested exceeds the rate of regrowth. As a result forests are severally degraded and/or eventually converted to other land uses.	Commercial logging in concessions is further formalized. Companies adjust volume harvested per ha to rate of growth and apply Reduced Impact Logging (RIL). Community forests are formalised, and use similar standards to the above for commercial forestry. Alternatively communities can decide to protect forests allowing only very limited use of forest resources. Chainsaw millers are regulated and have to work according to minimum standards and cannot operate in formal logging concessions. Control of volume harvested is linked community forest plans. ➢ Deforestation and degradation will be reduced. ➢ Forestry will remain a profitable sector beyond one contract period.
Charcoal production	Charcoal production is frequently linked to clearing land for agriculture and replanting of rubber plantations, but likely takes place as a primary income generating activity in	REDD+ activities may seek to limit the impact of charcoal production on forests remaining forests by regulating access (e.g. linked to community forest management).

[1] The period of 25 years was chosen based on the common duration of concession agreements in agriculture and forestry.

Land use	Business as usual	REDD+
	forests as well, contributing to forest degradation. Production and trade is not regulated. Charcoal is the main energy source for Liberia's urban population; it can be assumed that consumption will increase in line with the growing urban population.	The use of better charcoal production technologies can increase conversion efficiency, reducing wood consumption. More efficient end user technologies can reduce overall consumption and alternative sources of energy can replace charcoal and fuel wood ➢ Degradation will be reduced.
Agro-forestry (example cocoa)	Agroforestry crops such as cocoa create little income due to sub-optimal stocking, old trees, very limited use of inputs and the poor quality produced. Market access is difficult. Little incentive exists to sustain agroforestry crops or invest into new ones/intensification; rather farmers rely on shifting cultivation converting more forest to agricultural land (see below).	With the aim to diversify livelihoods and provide alternative income for subsistence farmers currently relying on shifting cultivation cocoa production is intensified applying modern management practices, using better varieties and inputs, and creating value addition and marketing structures. ➢ Yield and profitability increase. Farmers have higher income from smaller land areas reducing the need for shifting cultivation and deforestation. Permanent agroforestry systems sequester carbon.
Shifting cultivation	The majority of farmers use shifting agriculture. Population growth leads to conversion of new forest areas and shortening cultivation cycles resulting in decreasing productivity. Subsistence farming is a major driver of deforestation.	A shift to permanent agriculture is encouraged, using better agricultural practises and inputs; raising yield and income and reducing the need to expand agriculture to forested areas. ➢ Deforestation will be reduced.
Rubber (smallholder farmers)	Rubber used to be an important cash crop for small and medium sized farmers. Plantations were overexploited during the conflict, are often very old and are now often unproductive. Prices for natural rubber are very low, leaving little incentive to rejuvenate existing plantations or invest in new ones.	The future of smallholder rubber in Liberia is not clear. Therefore, rubber was not a focus of the REDD+ CBA.
Oil palm	Farmers grow the local Dura variety dispersed on agricultural land or in small lots producing oil from the fruit for the local market. Several hundred thousand hectares of oil palm concessions, incl. out-grower schemes are planned. Concessions are expected to contribute significantly to deforestation.	Smallholder farmers will continue to grow oil palm for local consumption but also become part of the industrial supply chains. Conversion of existing agricultural land and forests to oil palm will take into consideration HCS and HCV areas and exclude them from conversion. Sufficient agricultural land and forest for community use is set aside as well. ➢ Deforestation will be limited to low carbon stock land cover types.

Land use	Business as usual	REDD+
Permanent agriculture (food crops, example rice)	Rice is grown in different systems. Most common is cultivation of upland rice in shifting cultivation. Inland swamps are used for lowland rice and are partly irrigated.	Intensification of the existing systems to increase yield and income per unit of land. ➢ Reduced need for shifting cultivation and deforestation.

2. Results

Summary

The cost-benefit analysis of REDD+ includes different aspects which have to be considered in parallel:

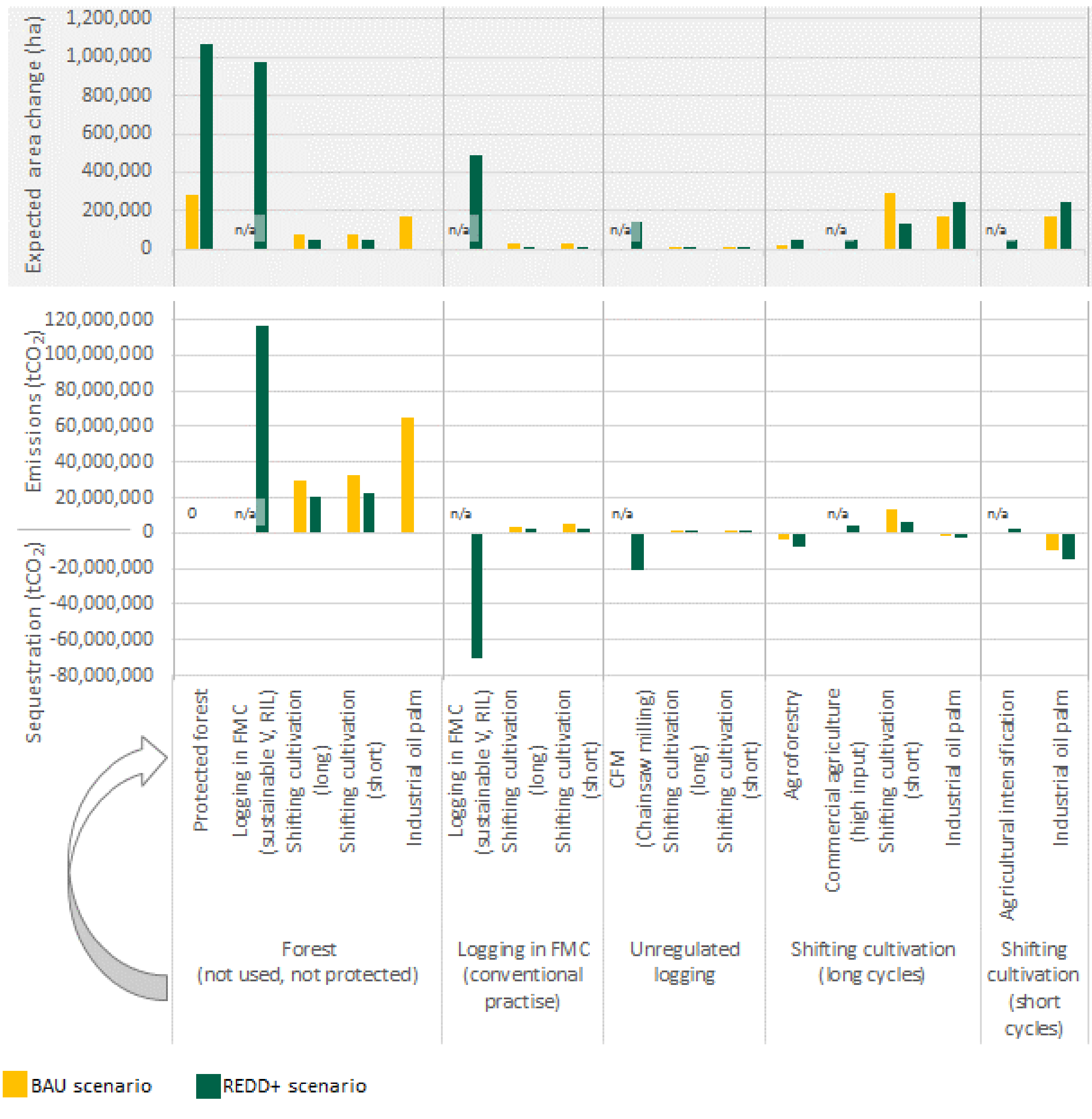
- The scale of implementation (e.g. area to be covered by, or farmers to be included in REDD+ activities)
- The likely emission reductions resulting from different land management practices (a function of scale of land use change and difference in carbon stock per unit of land between the two land uses)
- The opportunity cost of the land user as an indication for the level of effort required to change land management practices in order to reduce emissions
- Environmental and socio-economic benefits/impacts of REDD+ implementation (e.g. impact on biodiversity, employment and macro-economic development) and
- The implementation cost, e.g. creating an enabling environment for sustainable land management.

The **potential scale of the different land uses to be covered by REDD+** is indicated in Table 4 above. The biggest land use with significant carbon stock is forest without any protection or management status (2.9 million ha), followed by areas used extensively for agriculture (shifting cultivation with long management cycles) with 1.9 million ha. Both are threatened by deforestation and forest degradation.

The **combination of scale in terms of area potentially affected** (i.e. converted from one land use to another – planned or unplanned) **and resulting emissions or emission reductions** is shown in Figure 3 for the BAU and REDD+ scenarios. For example:

- If converting currently unprotected forest to oil palm an amount of carbon disproportionate to the comparatively small area converted is emitted.
- If allowing sustainable forest management on an area five times as big as forest land converted to oil palm less than twice as many emissions will be released while many qualities inherent to forests (carbon, biodiversity, watershed protection) will be retained.
- If current unsustainable logging practices are changed to more sustainable ones (FMC; CFM) GHGs will be sequestered.
- The case is similar for the expansion of agroforestry systems, although the area concerned is very small.
- Last but not least agriculture (incl. oil palm) can be intensified on already degraded land and will result in very few emissions per ha and, if implemented correctly, reducing pressure on forests.

Figure 3: Land use change and related emissions for BAU and REDD+ scenarios for Liberia



The upper figure shows likely land use changes over the next two decades assuming business as usual. Changes which will likely occur with REDD+ only are marked with n/a. The lower bar chart shows the associated emissions or removals, i.e. combine carbon stock change (tCO_2/ha) with the anticpated scale of land use changes. GHG emissions have positive values and GHG removals negative values.

The **opportunity cost** for the five land use changes/avoided land use changes which result directly in removals or emission reductions is shown in Figure 4. The opportunity cost of emissions avoided or GHG sequestered is an indication for the level of effort required to change land management practices in order to reduce emissions.

Expanding the protected area network and changing timber harvesting practices to more sustainable ones will result in additional costs/foregone economic benefits to the land user, i.e. emitting CO_2 in a business as usual setting would be profitable to the land user. To avoid doing so will result in additional costs/foregone economic benefits. This barrier can be overcome by passing on the cost directly to the state (e.g. for protection in form of PAs), by providing incentives (e.g. tax reductions for sustainably harvested timber) and stronger regulations and enforcement thereof.

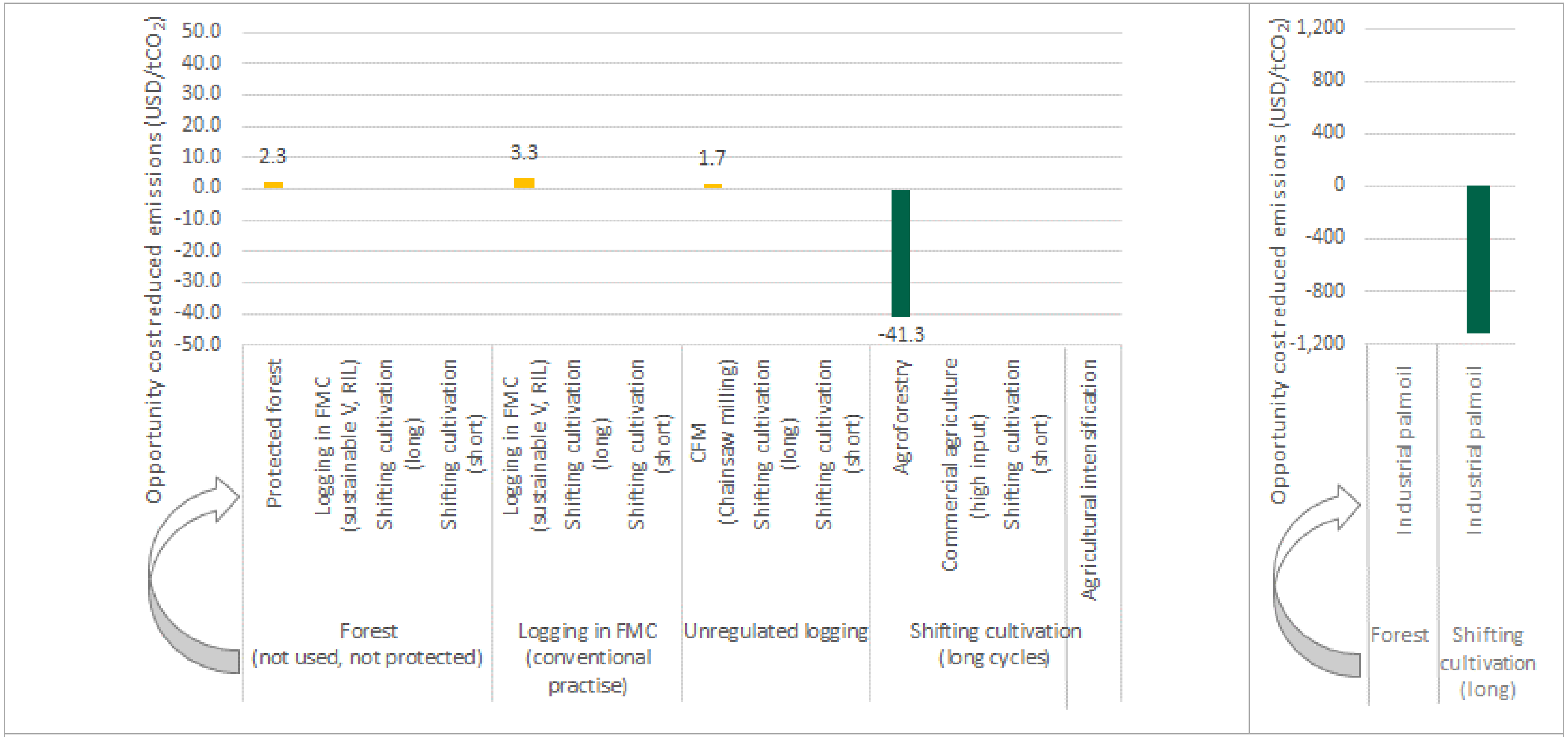
In contrast, agroforestry with permanent tree crops, but also the establishment of oil palm plantations on degraded land will sequester carbon and increase the financial benefit to the land user – a win-win situation. However, the negative opportunity cost is dependent on the creation of an enabling environment such as providing access to inputs, financial and technical services for smallholder farmers and e.g. investment ready land for oil palm concessions.

Other measures, such as allowing formalized sustainable logging in primary forest not covered through the protected area network (FMC, CFM) and intensification of agricultural uses on already degraded land will contribute to reducing deforestation by attributing a tangible value to forests and by reducing pressure on forests respectively. Neither activity will reduce emissions directly, hence, they are not included in Figure 4.

The **environmental impact of REDD+,** such as conserving biodiversity and protecting of water resources will be highest in undisturbed ecosystems. However, land uses retaining some of the original ecosystem structures (e.g. forestry and extensive agriculture) also retain part of their protective function. Positive **socio-economic changes** would result from the sustainable intensification of agroforestry and agriculture. Developments in agroforestry and agricultural can benefit in particular the rural population.

The estimated REDD+ **implementation cost** over 25 years is 1.7 billion USD (see Table 14). The establishment and maintenance of PAs alone is estimated to cost 750 million USD, constituting over 40% of the total cost. On a per hectare basis sustainable forest management (SFM) is the most attractive option with an estimated annual cost of < 10 USD/ha. Regulated access to forests for timber production will give these forests a certain status of protection while generating revenues. Interventions targeting the agriculture sector are comparatively expensive with annual costs in the range of 30 USD/ha but are highly complementary to forest conservation and have the potential to contribute to the economic development of Liberia.

Figure 4: Opportunity cost of avoided emissions in the REDD+ land use change scenario



The values presented combine the opportunity cost per ha (NPV) for REDD+ land management practices with the carbon stock change per ha (tCO_2). Values are only provided for land use changes that directly result in reduced emissions.

Bars in **yellow** indicate that implementing the land management comes at a cost to the land user (or in other words emitting CO_2 would be profitable), which means doing so will require incentives and regulation. Bars in **green** (negative values) indicate that the land management practice is profitable to the land user, i.e. will require little incentive. The opportunity cost for agroforestry are influenced by REDD+ activities such as providing access to inputs, financial and technical services, regulations and enforcement thereof. However, the cost of implementing these measures is not part of the opportunity cost calculation.

2.1 REDD+ opportunity cost

The REDD+ opportunity cost is the cost to the land user of forsaking the change from the current land use to another that leads to change of GHG emissions and economic performance of the land. Opportunity costs are important for the design of the REDD+ strategy because they indicate the economic incentive to the land user required to motivate a change of land use practices in support of forest protection. If current practices (land use changes) are very profitable, the opportunity costs of foregoing that profit will be high and land users will require a relatively large incentive to be persuaded to change their practice.

The profitability of land uses related to the four target strategies was calculated for the business as usual (BAU) scenario as well as for changes likely to occur with implementation of REDD+. A comparison of profitability, expressed as net-present value over 25 years, and carbon stocks for BAU and REDD+ are presented below for the four strategies.

2.1.1 Complete and strengthen the Protected Areas network

Protected Areas (PA) have the potential to protect forest and other high conservation areas from extractive and destructive uses. Currently three PAs have been gazetted and another three are being processed by parliament for gazettement. The Forest Development Authority is responsible for the preparation for gazettement and management of PAs. Frequently the FDA executes these tasks in close cooperation with environmental NGOs.

According to the last available budget the authority has approx. 3 USD/ha to manage the existing reserves (FDA, personal communication) and PAs in Liberia do not create revenues from e.g. tourism.[2] The low budget available limits the conservation forestry department of the FDA to crisis management rather than engagement in e.g. proactive conservation work with land users or effective enforcement of conservation laws. In comparison, the management of the recently gazetted East Nimba Nature Reserve (ENNR) co-funded by ArcelorMittal[3] and Conservation International is estimated to cost 30 USD/ha and includes conservation agreements with communities (development of alternative livelihood activities).[4]

The cost of establishing and effectively managing the protected areas network will therefore be considerably higher than the budget that is currently spent by FDA and partners. Without

[2] Part of the income from forest concessions is channeled towards PA management. However, it is not considered as an income created by PAs.

[3] ArcelorMittal has mining operations in the area. The engagement in the ENNR is part of ArcelorMittal's environmental offset program.

[4] ENNR, with < 12,000 ha, is a very small PA and located in a densely populated area. Accordingly the boundary-area ratio pressure by surrounding communities is likely higher than in other PAs or proposed PAs.

revenues offsetting the management costs PAs will come at a net-cost (Table 6). However, carbon savings can be substantial if compared to alternative land use forms.

30% of the tax revenues from commercial logging are meant to be directed towards conservation. Currently, this income is mostly diverted into general government expenditure, to meet other spending priorities, but it represents another potential source of income for Protected Areas. There are therefore substantial and currently untapped revenue streams that could offset the heavy costs of conservation. Another potential revenue stream is biodiversity offsets. This is the approach adopted by Arcelor Mittal that delivers substantially more funding for conservation of East Nimba Nature Reserve. It has been proposed as an approach for the mining industry as a whole in Liberia (Johnson, 2014) and is potentially applicable to other industries (including agricultural concessions) that result in the clearance of forest.

Table 6: Costs and benefit of forest conservation in protected areas

Parameter	Management		Change
	BAU	REDD+	
Cost in USD/ha over 25 years	78	736	
Revenues in USD/ha over 25 years	0	0	
NPV[1] in USD/ha after 25 years	- 45	- 424	- 379
Likely land use changes without protection: Carbon stock[2] change (tCO_2/ha) from undisturbed forest to	499	499	N/A
- Commercial logging (conventional practice)	234	n/a	- 265
- Commercial logging (sustainable)	n/a	379	- 120
- Agriculture	< 50	n/a	- 450
Economic benefit of changing from undisturbed forest to …	NPV$_1$ in USD/tCO_2		
- Commercial logging (conventional practice)	+ 2.5		
- Commercial logging (sustainable)	+ 1.5		
- Agriculture (Shifting cultivation)[3]	+ 1.6 to + 2.0		

[1] The discount rate is 15%. Values are inflation adjusted.

[2] Carbon stock includes above ground and below ground biomass.

[3] NPV depends on the intensity of agriculture, e.g. time until returning to the same plot of land.

Effective protection of protected areas requires a higher budget per hectare. In combination with the absence of any income generation in Liberia's protected areas the NPV becomes very negative.

Likely alternative uses of primary forests in BAU are logging and conversion to subsistence agriculture, especially along forest frontiers. In the REDD+ scenario allocation of currently unprotected forests to sustainable forest management may become an alternative option (lower form of protection). These uses, incl. sustainable forest management, will cause GHG emissions (lowering carbon stock) but create economic benefit to the land user, i.e. alternative land uses have an opportunity cost between 1.5-2.5 USD/tCO_2.

2.1.2 Sustainable forest management

Various forms of authorized forest management exist. Most notable are **Forest Management Concessions (FMC)** and **Community Forest Management Agreements (CFMA).** FMCs are large concessions usually exceeding 100,000 ha and produce timber for the export market. Additionally a few large CFMAs were licensed to private sector organizations but have been suspended due to controversy in the licensing process. Several smaller CFMAs have been granted directly to communities against the background of the proposed Land Rights Act (strengthening land tenure and land use of communities). The required process, incl. development of management plans was heavily supported by NGOs and development partners. These CFMAs focus on forest conservation. Individuals or groups (commonly referred to as **chainsaw millers**) harvesting timber where it is accessible are not regulated. Timber available in rural and urban markets stems from these sources.

Commercial forest management has been the focus of the Liberian economy in the past and has been scrutinized in the framework of several studies as well as the Voluntary Partnership Agreement (VPA) with the EU[5] over the last years. Accordingly potential impacts of logging concessions on forests and economics are fairly well documented. A sustainable forest management standard exists. However, it is likely not always well implemented by companies due to lacking enforcement. Volume harvested per hectare over the length of the FMC (25 years) is suspected to exceed the increment over the same period by far (Shearman, 2009). A reduction of volume harvested to sustainable levels would likely have a significant impact on the profit of logging companies, reducing NPV (25 years) from ca. $650 USD/ha to < $200 USD/ha (Table 7). The change in management could result in an increase in carbon stock of ca. 150 tCO_2/ha over time (time horizon depending on state of degradation). If the Government of Liberia is to achieve its policy objective of having a timber industry that generates employment and revenues for the long term, a shift to sustainable forestry is necessary.

[5] Part of Forest Law Enforcement, Governance and Trade (FLEGT)

Table 7: Cost and benefit of forest management in FMC

Land use	Parameter	Management		Change
		BAU	REDD+	
Forest Management Concessions (FMC) BAU: conventional logging REDD+: sustainable forest management	Cost[1] in USD/ha	3,695	1,056	
	Revenues[1] in USD/ha	4,825	1,363	
	NPV[1,2] in USD/ha	651	177	- 474
	Carbon stock[3] in tCO_2/ha	234	379	+ 145
	Economic cost of changing from BAU to REDD+, NPV in USD/tCO_2			- 3.3

[1] Cost, revenue and NPV for FMC presented were calculated over a timeframe of 25 years. Round wood is exported to overseas destinations.

[2] A discount rate of 15% was applied. Values are inflation adjusted.

[3] Carbon stock after 25 years. Includes above ground and below ground biomass.

Both cost and revenues in FMC are to a large extent driven by volume harvested but are also influenced by area based fees. As a result costs in sustainable forest management (REDD+) decrease less than revenues resulting in lower NPV. The lower NPV will result in opportunity cost of USD 3.3/tCO_2 in order to avoid emissions from unsustainable forestry.

Chainsaw millers harvest without any permits or pay only a small fee to communities who claim ownership of a certain forest. This fee can be in-kind (sawn timber) or paid in cash. The estimate for log volume harvested by chainsaw millers ranges between 280,000 and 650,000 m^3/year (FDA, 2009). In unregulated circumstances the NPV of chainsaw milling is just below $300 USD/ha (harvesting of all trees with market value) (Table 8). The REDD+ scenario assumes regulation of chainsaw millers through communities adhering to sustainable forest management standards through Community Forest Management. Communities would benefit from timber harvests through a fee to be paid by the chainsaw millers. The NPV of the chainsaw miller in this scenario is much lower, with only $ 34 USD/ha. The lower harvesting volumes will result in higher carbon stocks.

Table 8: Cost and benefit of unregulated harvesting versus CFM

Land use	Parameter	Management		Change
		BAU[4]	REDD+[5]	
BAU: Unregulated timber harvesting by chainsaw millers REDD+: Community forest management (CFM)	Cost in USD/ha	857	11	
	Revenues in USD/ha	1,166	13	
	NPV[1,2] in USD/ha	295	34	- 261
	Carbon stock[3] in tCO_2/ha	234	379[6]	+ 145
	Economic cost of changing from BAU to REDD+, NPV in USD/tCO_2			- 2.0

[1] Cost, revenue and NPV were calculated over a timeframe of 25 years. Sawn timber is sold in rural and local markets.

[2] A discount rate of 15% was applied. Values are inflation adjusted.

[3] Carbon stock after 25 years. Includes above ground and below ground biomass.

[4] Cost and revenues occur in year 1 only, i.e. no long term management costs are considered.

[5] The REDD+ scenario assumes that chainsaw milling is linked to sustainable CFM management. I.e. additional costs apply (fee to the community) and harvesting volume/ha*year is much lower (equal to volume increment/year). Cost for REDD+/CFM excludes operational/management cost by the communities as no experiences were available at the time of data collection. The additional costs and lower volume harvested will result in opportunity costs of USD 2 per tCO_2.

[6] The value given assumes use of timber only (as in commercial forest management, Table 7). However, carbon stock is likely lower as additional uses such as fuel wood collection and charcoal production may apply to community forests.

Charcoal production and trade is an important economic activity. Annual charcoal consumption in Liberia is estimated to be 130,000 tons (van der Plas 2011 and GoL LISGIS 2008) which is approx. equivalent to 1.5 million cubic meter wood. Charcoal production seems to be largely linked to land clearing for agriculture as well as the rehabilitation of rubber plantations. The extent of charcoal production in primary forest is unknown.

Charcoal production is generally speaking a labor intensive activity creating little value for the wood used. Table 9 provides estimates of the economic return per hectare for different scenarios. Most woody biomass suitable for charcoal production may be easily available in subsistence farming were shifting cultivation is used. Where waste wood from timber harvesting activities is used, less biomass is available per hectare – especially if applying sustainable forest management. In all cases charcoal production can increase the economic benefit of the land user.

However, charcoal production can be a driver of forest degradation and deforestation, especially if other income opportunities in rural areas fail (subsistence agriculture, employment) and charcoal production is delinked from agriculture or timber harvest.

Accordingly, policies should focus on:

- Livelihood development in rural areas (especially for groups more likely to be landless such as young people)
- Integration of charcoal production with other land uses
- Reducing consumption, e.g. by promoting improved stoves and other source of energy for cooking.

Table 9: Economics of charcoal production

Item			Land clearing: shifting cultivation		Linked to timber production: use of waste wood	
			Every 3-4 years	Every 7-8 years	Unregulated forest use	Sustainable management
Impact on forest status			n/a	Deforestation	Severe forest degradation	Forest degradation
Wood quantity		t/ha	20	40	8	0.1
Quantity of charcoal produced		t/ha	3	6	1	0.01
Cost	Labor	USD/ha	54	109	22	0.3
	Wood	USD/ha	15	31	n/a	n/a
Charcoal value		USD/ha	240	480	98	1.1
Profit		USD/ha	170	341	76	0.9
Charcoal production linked to the different land uses and management systems happens at different intensity (100% of woody biomass vs. use of parts only) and frequency (linked to the dominant land use). In sustainable forest management annual use of the same amount/ha is assumed. In reality production will happen every few years. That is assuming five year cycles profit would be $ 4.5 USD/ha or over 25 years $ 23 USD/ha.						

2.1.3 Intensification of agricultural production on non-forest land

Agriculture in the country is dominated by subsistence farmers producing food crops and palm oil for home consumption and to a limited extent for sale in the local market (e.g. rice and palm oil) or the export market (cocoa). Farming of food crops (rice, maize, cassava, vegetables) relies usually on shifting cultivation and little or no inputs such as fertilizer and other agro-chemicals are used. Likewise farmers cultivating tree crops tend to use local (unimproved) varieties and few if any inputs. As a result yields are low and product quality often not compliant with international standards (e.g. USAID 2015; GoL MoA 2007, personal communication CARI (Suakoko) and WIENCO).

Table 10 shows the difference in profitability of agroforestry and production of staple food crops with traditional versus improved management for two example crops: cocoa and rice. Economic benefit is estimated to be 15 to 20 times bigger than results achieved currently if applying modern agricultural practices, incl. use of inputs and improved varieties. Access to financial services and better markets also play an important role. Changes in management, while maintaining the same land use may cause small changes in carbon stock (±). For the purpose of this assessment they are considered to be negligible.

Table 10: Cost and benefit of permanent agricultural production systems

Land use	Parameter	Management		Change
		BAU	REDD+	
Agroforestry: Example cocoa	Cost[1] in USD/ha	7,346	17,290	
	Revenues[1] in USD/ha	8,800	33,000	
	NPV[1,2] in USD/ha	499	7,682	7,183
	Carbon stock[3] in tCO_2/ha	261	261	± 0
	Change in NPV in USD/tCO_2 BAU to REDD+			n/a
Commercial food crops: Example rice (upland)	Cost[1] in USD/ha	2,317	11,850	
	Revenues[1] in USD/ha	2,667	20,000	
	NPV[1,2] in USD/ha	203	4,719	4,220
	Carbon stock[3] in t CO_2/ha	10	10	± 0
	Change in NPV in USD/tCO_2 BAU to REDD+			n/a

[1] Cost, revenue and NPV presented were calculated over a timeframe of 25 years.
[2] The discount rate of 15% is applied.
[3] Carbon stock/ha includes above ground and below ground biomass.
Under REDD+ farmers benefit have access to technical services, finance, inputs and better access to markets. Production systems still rely on manual labor.

A comparison of agroforestry and commercial agriculture with shifting cultivation is provided in Table 11. Commercial agriculture and agroforestry without the use of modern farming practices cannot compete with shifting agriculture; i.e. farmers have little incentive to change to permanent farming systems requiring less land.

However, in an enabling environment yields can be increased substantially making permanent farming economically more attractive than shifting cultivation. The direct impact in terms of emissions is positive for a shift to agroforestry with crops such as cocoa; GHG will be sequestered. If converting shifting agriculture systems to permanent cropping systems such as rice, cassava or maize carbon stocks will be reduced. Accordingly such change should be preferentially limited to sites which are already considered open land (forest cover < 30%).

Higher yield per unit of land can help to reduce the expansion of agricultural land into forests. However, more profitable agriculture and access to e.g. export markets may create a reverse incentive leading to accelerated forest conversion if not supported by an appropriate legal framework and enforcement.

Table 11: Economic comparison of agricultural production systems BAU vs. improved farming

Production system		Products	NPV[1] (USD/ha)	Carbon stock[2] (tCO_2/ha)
Subsistence farming: shifting cultivation	Cycle: 7-8 years	Mixed food crops and fruit	815	95
Agroforestry with commercial tree crops	Traditional: low input	Example: cocoa	499	261
	Improved		7,682	
	Economic cost/benefit of changing from (7-8 year cycle) to agroforestry, NPV in USD/tCO_2:			
	Traditional agroforestry		- 2	
	Improved agroforestry		+ 41	
Subsistence farming: shifting cultivation	Cycle: 3-4 years	Mixed food crops and fruit	742	47
Commercial agriculture Staple food crops	Traditional: low input	Example: rice	203	10
	Improved		4,719	
	Economic cost/benefit of changing from shifting cultivation (3-4 year cycle) to commercial agriculture, NPV in USD/tCO_2:			
	Traditional agriculture		- 15	
	Improved agriculture		+ 107	

[1]NPV presented was calculated over a timeframe of 25 years with a discount rate of 15%.

[2]Carbon stock/ha includes above ground and below ground biomass.

In improved production systems farmers have access to technical services, finance and inputs and better access to markets. Production systems still rely on manual labor. Farming applying improved agroforestry creates a win-win situation: carbon stock and economic benefits increase in comparison to shifting cultivation. Intensification to commercial agriculture will always result in GHG emissions but creates an economic benefit to the farmers only if applying better agricultural practices.

2.1.4 Development of oil palm plantations

Oil palm plantations are a special case of agricultural intensification, driven by the big and growing international demand for palm oil and the resulting high benefit for growers. Oil palm investments in Liberia are implemented by few big companies, together holding concessions for over 550,000 ha. To date an estimated 30,000 ha of industrial oil palm plantations exist. Oil palm plantation development foresees the establishment of out-grower schemes on approx. 15% of the total developed area. While out-grower schemes have not yet been established in Liberia, it is a common system in South-east Asia, in particular in Indonesia. Large scale oil palm development is frequently associated with deforestation and land use conflicts with the resident population.

Table 12 provides an overview of economic returns from different land uses, comparing them to industrial oil palm plantations. Returns to out growers selling the unprocessed fruit are over 20 times higher than returns from forestry or traditional farming systems. The net-benefit to communities from land rent and employment for plantations established by the concessionaire is lower, but still approx. eight times higher than income from traditional land uses.

Seen from a purely climate point of view oil palm plantations can be both detrimental and beneficial, depending on the land use they replace. If replacing forests otherwise used for timber production up to 270 ton of carbon dioxide will be released. However, if oil palm plantations are established on non-forest land (forest cover < 30%) carbon will be sequestered. However, similar to other crops grown at large scale the conversion of mixed farm/forest land to oil palm will reduce biodiversity and may have negative impacts on watersheds (erosion, pollution with agro-chemicals etc.).

Oil palm developments can be beneficial if strong environmental and social safeguards are put into place, amongst them not to convert forest land to oil palm, leaving sufficient agricultural land for subsistence agriculture and sharing benefits from the oil palm investment fairly with the communities giving their land to the developer.

Table 12: Economic benefit of industrial oil palm plantations versus other land uses

Production system		Products	NPV[1] (USD/ha)	Carbon stock[2] (tCO_2/ha)
Subsistence farming: shifting cultivation	Cycle: 7-8 years	Mixed	815	95
	Cycle: 3-4 years		742	47
Agroforestry with commercial tree crops	Traditional: low input	Example: cocoa	499	261
Forestry[3]	Destructive	Timber, charcoal and NTFP	368	234
	Sustainable		43	379
Traditional oil palm		Oil for the local market	5,056	106
Industrial oil palm	Land rent, employment	Oil for industrial purposes	4,309	
	Out-growers[4]		13,242	
	Economic benefit of changing **from shifting cultivation (3-4 year cycle)** to oil palm, NPV in USD/tCO_2 **sequestered**:			
	Land rent, employment		+ 61	
	Out-growers		+ 214	
	Economic benefit of changing **from forestry** to oil palm, NPV in USD/tCO_2 **emitted**:			
	Land rent, employment		+ 16	
	Out-growers		+ 48	

[1]NPV presented was calculated over a timeframe of 25 years with a discount rate of 15%.

[2]Carbon stock/ha includes above ground and below ground biomass.

[3] See section 2.1.2 and Table 8 for details.

[4] Oil palm plantations are established with the help of the concessionaire, providing all inputs and mechanical land preparation. The farmer sells fruit bunches to the company and pays back the initial development cost from the proceeds.

In out-grower systems farmers have access to technical services, finance and inputs and a secured markets for the fruit produced. Alternatively communities benefit from land rent (through the community development fund) and employment. Both systems provide much higher economic returns than traditional farming systems or forestry. As a result both emission of CO_2 (if converting forest) as well as sequestration of CO_2 (if converting shifting cultivation to oil palm) is related to an economic benefit per tCO_2 emitted/sequestered. Not converting forest would result in an opportunity cost per tCO_2 emission avoided, whereas oil palm established on degraded land creates a win-win situation.

2.1.5 Comparison of land use change options

The economic impact of changing land use or management is shown in Figure 5. Land use changes where the difference between the new land use and the former land use is positive are beneficial to the land user, i.e. have a positive opportunity cost. If the difference is negative the change would come at an economic cost to the land user.[6]

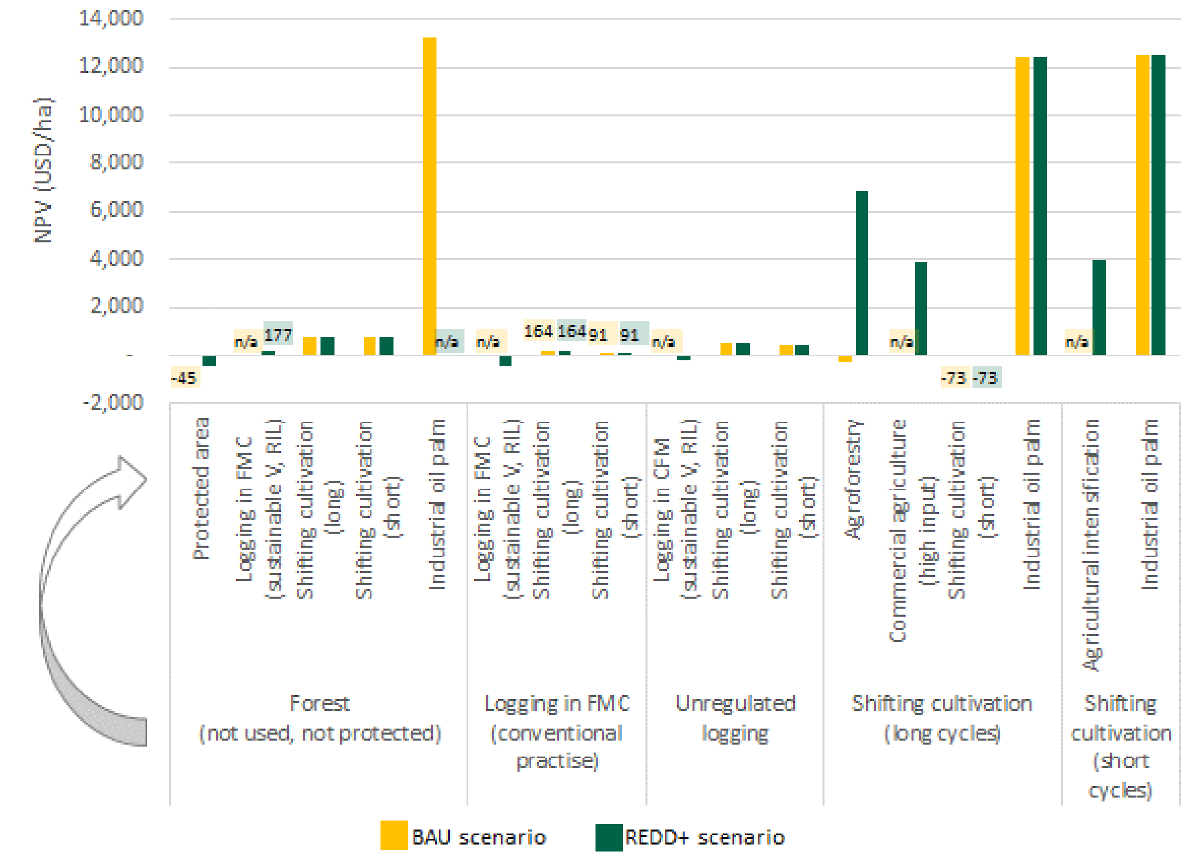
- Under BAU all land use changes from forest to some form of agriculture have high opportunity cost as the NPV for forestry is comparatively low.
- The shift from unsustainable forest uses to more sustainable ones comes at a cost to the land user. That is logging companies and chain saw millers will be allowed to harvest less timber per hectare and must apply reduced impact logging (RIL) reducing the profitability of their businesses – while ensuring continued timber use for future generations.
- To protect forest, convert shifting cultivation into permanent agroforestry/agriculture[7], or reduce the time until returning to the same plot of land come as a cost to the land users in the BAU scenario, i.e. are not attractive to the land user.
- Particular high is the incentive to change from other land uses to industrial oil palm plantations[8] with an opportunity cost of more 12,500 USD/ha.
- If agricultural extension and rural financial services, and inputs are available (REDD+) agroforestry and intensive agriculture become attractive.

[6] For example changing from shifting agriculture with long cycles to shorter cycles will result in lower yields and lower income. The change does not make sense from an economic point of view but may happen anyway due to population growth and reduced land availability.

[7] Example cocoa: currently farmers have very limited access to inputs, technical advice and poor access to markets. As a result yields and prices per kg cocoa are low, making cocoa farming less profitable than shifting agriculture. Refer to section 2.1.3 for details.

[8] Industrial oil palm refers to oil palm monocultures being part of or linked to oil palm concessions.

Figure 5: Net-present value for BAU land REDD+ scenarios



Bars reflect the change in profitability if changing from one land use to another for the BAU and REDD+ scenarios. Profitability is expressed the difference in net-present value (NPV) calculated over a period of 25 years at discount rate of 15%.

Not all land use changes apply in both scenarios. These are shown as n/a.

A switch to oil palm is always highly profitable to the land user. Harvesting of timber in currently unused forest is more profitable under BAU than REDD+, as less timber is harvested in the latter. A change from the currently unsustainable harvesting practices to sustainable practice will result in reduced benefit to the logging companies/chainsaw millers. A shift from shifting cultivation to permanent agroforestry or agriculture become profitable only in the REDD+ scenario – where inputs, finance and technical services are available.

2.2 Implementation cost

Implementation cost is defined as costs related to the direct implementation of REDD+ strategies; but also includes creating an enabling environment for the implementation of activities contributing to REDD+ by government, civil society and private sector. An overview of possible measures for the four strategies included in the CBA is provided Table 13. Cost assumptions for these activities are provided in Annex 3.

Table 13: REDD+ implementation measures

Strategy	Activities
a) Complete and enforce a network of Protected Areas	• Formulate guidance and rules on compensation for foregone use (also applies for CFMA conservation forests) • Design and implement compensation / alternative livelihood projects • Increase FDA capacity
b) Maintain logging and other extractive forest uses at sustainable levels	• Adjust taxation / fee regulations • Design rules and guidance for SFM and RIL • Formalize, regulate and train chainsaw millers • Design regulations for commercial use and conservation forestry for community forests • Provide legal, technical, managerial guidance and assistance to communities, chainsaw millers and concessionaires • Enforcement
c) Reduce shifting agriculture by increasing the area of land under permanent agriculture	• Improve access to finance, access to inputs (availability and e.g. subsidies) and access to markets • Increase value adding activities • Provide technical assistance on modern agricultural practices and conservation agriculture
d) Develop industrial oil palm plantations in an environmental and socially responsible way	• Implement international/national standards for conservation of HCS and HCV forest. • Establish the set-aside HCS/HCV forest as conserved areas, with associated protected area planning and management activities. • Provide incentives and alternative livelihoods to communities in and around plantations to relieve pressure on set-aside forest.

Implementation costs depend on the scale of implementation; i.e. how many households will be targeted or how big an area will be covered by the REDD+ activities. The potential scale in terms of area was derived from the most recent land cover assessment (GeoVille, 2015) and land use as identified above (see Table 4).

The estimated REDD+ programmatic cost over 25 years is 1.7 billion USD (see Table 14). The establishment and maintenance of PAs alone is estimated to cost 750 million USD, constituting over 40% of the total cost.

On a per hectare basis sustainable forest management (SFM) is the most attractive option with an estimated annual cost of < 10 USD/ha. Regulated access to forests for timber production will give these forests a certain status of protection while generating revenues. Interventions targeting the agriculture sector are comparatively expensive with annual costs in the range of 30 USD/ha but are highly complementary to forest conservation and have the potential to contribute to the economic development of Liberia.

Table 14: REDD+ program cost and potential emission reductions

Strategy	Area		Program cost[1]		Average annual emission reductions[1]
	thousand ha		million USD	USD/ha*a	t CO_2/a
a) Complete and enforce a network of Protected Areas	Current area	200	750	24	Annual: 800,000 Total: 20,000,000
	Additional area	1,000			
b) Maintain logging and other extractive forest uses at sustainable levels	Current	1,000	520	9	Annual: 1,600,000 Total: 40,000,000
	New	1,300			
c) Reduce shifting agriculture by increasing the area of land under permanent agriculture	Agroforestry tree cash crops	90	95	21	Supporting emission reductions in a) and b); Carbon sequestration may be possible
	Commercial food crop production	200	340	34	
d) Develop industrial oil palm plantations in an environmental and socially responsible way	Current	30	5	12	Carbon sequestration may be possible if oil palm is developed on non-forest land only
	Additional area[2]	400			
Total	Forests	3,500	1,710	N/A	60,000,000
	Agriculture	720			

[1] Program cost and emission reductions are calculated for a timeframe of 25 years (common length for concession agreements). Annual cost per ha will be higher to begin with, and then gradually reduce with improving management standards and capacities, and additional areas included in the activities.
[2] Only ca. 75% of the total concession area are expected to be developed into oil palm plantations.

2.3 Potential REDD+ benefits

The CBA results are largely dictated by estimates of private profit and changes in carbon stocks / CO_2 emissions. However, the implementation of REDD+ can create other benefits which tend to be 'non-market' benefits and therefore are hard to measure. Nonetheless these can be important to the overall weighing of net benefits and the public good.

Environmental benefits other than climate change mitigation are e.g. conservation of biodiversity, and protection of soil and water resources. Examples for socio-economic benefits are climate change adaptation, economic development and improving food security.

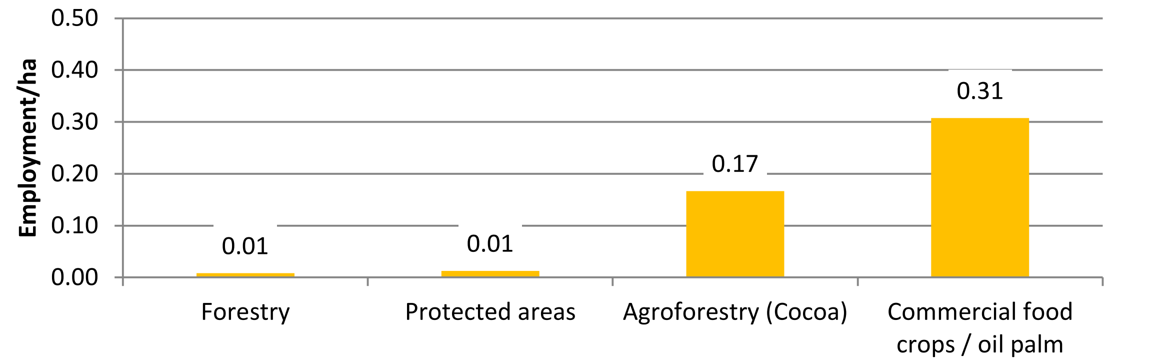
Emissions and potential emission reductions for selected land use changes are provided in section 2.1.5. Conversion of currently not utilized forest areas will result in net emissions. However, these can be reduced significantly by giving forests a protected status either as PA or in form of logging concessions (e.g. FMC and CFM) thus reducing deforestation. The **financial net-benefit** of REDD+ is difficult to quantify, given that costs are highly dependent on the selected strategy and scale of implementation. Currently the scale for results-based payment for emission reductions is limited (e.g. FCFPF Carbon fund, Germany REDD Early Mover Program, Norway). Assuming a price of USD 5/t CO_2 (as in the ERPA with Costa Rica and currently paid by the FCPF Carbon Fund) the implementation of protected areas as well as sustainable forestry at full scale is likely to result in a substantial net-cost (Table 15), even when lowering the average management costs for PAs considerably. However, in particular investments in sustainable forestry will ensure continued benefits from forests for the country for future generations. The combination of PA with forestry (e.g. as buffer around PAs) should be explored.

Table 15: Potential REDD+ benefit

		Protected areas	Forestry
Emission reductions	Million tCO_2	20	40
Implementation cost	Million USD	750	520
REDD payments USD/tCO_2 \$5	Million USD	100	200
Net-deficit	Million USD	- 650	- 320

Socio-economic change is measurable as e.g. part of the population gainfully employed, per capita income, agricultural yield, and number of food secure households; but is influenced by a variety of factors going well beyond REDD+ measures such as population growth and development of markets. Significant gains in yield and subsequently economic success can be generated by improving agriculture standards and creating an enabling environment (see section 2.1.3 above). Thus, in the long term [government] investments into agriculture will be paid back in e.g. tax revenue and reduced need for aid in rural areas. A comparison for the potential gain in employment is presented in Figure 6 as number of people employed in a given land use. Both forest conservation and large scale commercial forestry employ few people in comparison to smallholder agroforestry cash crops such as cocoa, which require approximately 17 people per 100 ha, and food crops which employ about twice as many again (assuming modern agriculture but not mechanized).

Figure 6: Employment generated in different land uses



Employment stated is for improved management. Employment in agriculture includes self and informal employment. Land management relies on manual labour rather than mechanised systems.

Sources: Karsenty, 2007

Environmental benefits can be quantified in terms of e.g. number of species or area of ecosystems preserved and area of watersheds protected (erosion, pollution); but are difficult to quantify in economic terms as [apart from very few exceptions] no markets for these services exist. **Biodiversity and protection of water resources** will be highest in undisturbed ecosystems. However, land uses retaining some of the original ecosystem structures (e.g. forestry and extensive agriculture) also retain part of their protective function. In the case of the above mentioned land uses high carbon stocks can thus be linked to protective function. However, the correlation does not apply to single species plantations such as rubber, oil palm and timber species such as pine and eucalyptus.

3.Conclusions

3.1 Conclusions from Cost-Benefit Analysis on REDD+ strategy options

Strategic priority 1: Reduce shifting agriculture by increasing the area of land under permanent agriculture

Improved management of agricultural land will result in a clear net gain to farmers / investors. Additionally, agroforestry if implemented on degraded land has the potential to sequester carbon. Improved management of annual crops and related yield gains will contribute to reducing pressure on forests. However, considerable public sector investment will be required to change agricultural practices in Liberia.

Strategic priority 2: Maintain logging and other extractive forest uses at sustainable levels

Similar to forests in protected areas, sustainably managed forests can store a lot of carbon per ha and retain many of the other values inherent to natural forest (e.g. biodiversity and water shed protection). Contrary to PAs, commercial forestry does create revenues making it very suitable to private sector involvement both at small (CFM) and large scale (e.g. FMC). Additionally the financial burden of the government for implementation of sustainable forest management is considerably lower than forest conservation.

Strategic Priority 3: Complete and enforce a network of Protected Areas

Both carbon stock per ha and up-scaling potential are high, putting PAs high on the list of REDD+ strategy options. However, effective PAs in Liberia will be costly to establish and manage and do not collect revenues (other than potential REDD+ payments).

Strategic Priority 4: Develop industrial oil palm plantations in an environmentally and socially responsible way

Industrial oil palm developments can be beneficial for the country, provided that forest land and sensitive areas (e.g. near streams, wetlands) are excluded from development and that communities within the concession area truly benefit from the development be that as out-growers, through employment or in the form of community benefits. Communities should always retain enough farmland to ensure their livelihoods.

3.2 Recommendations for REDD+ strategy development

Potential REDD payments cannot not cover all investments and costs envisioned in the REDD+ strategy. Additionally, funding sources to meet these costs cannot, at this stage, be fully identified. The bi-lateral agreement with Norway for results-based payments provides one important source, and income from voluntary carbon credit schemes are likely within the next five years, although on a small scale. Accordingly, the potential REDD+ payments can only be seen as a trigger for a REDD+ friendly development pathway for the forestry and agricultural sectors, rather than the sole means to it.

REDD+ investments must be prioritized weighing the potential GHG emission reductions, cost of interventions and likely impact on the socio-economic development potential of Liberia. For example sustainable forest management comes at low public cost (but high private sector cost) and can generate substantial GHG emission reductions in comparison to e.g. agriculture. Stimulating agroforestry crops as an alternative to shifting cultivation requires significant public expenditure but also creates multiple benefits – contributing to reduced deforestation and carbon sequestration and economic development in rural areas.

Effectively managed protected areas can be very expensive. Cost efficiency can be improved by concentrating PAs on large areas. Wherever possible alternative revenue streams (e.g. biodiversity) should be identified.

Sustainable forest use can be a mechanism for forest protection. SFM should be seen as an alternative and/or complementary approach to PAs, with the combination likely being less costly. However, if SFM is to have a protective function it must be supported by better regulations, enforcement and alternative livelihoods for people relying on forests (similar to PAs).

Private sector will carry a large share of the financial burden of implementing SFM, in particular in terms of reducing annual allowable cut to a sustainable rate. To support the transition from current logging practices to more sustainable ones, more and better evidence regarding the impact of different logging practices on long term sustainability of forestry must be generated.

Agricultural intensification (including oil palm) increases profit per unit of land and can reduce the need for agricultural expansion if combined with effective land use planning and a better legal framework and its enforcement.

The burden on REDD+ finance can be reduced by increasing reliance on private sector in the outreach to farmers.

Community forestry is gaining increasing attention. However, it is not a panacea and lessons learned from African community forest management must be taken into account. Considerable investment in capacity development will be required and a simple but effective standard for CFM must be developed.

Lastly, **the scenarios presented here must be constantly revised and adapted** as new/more information becomes available as a basis for adjustments to the REDD+ strategy.

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Annex 1: Literature cited

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Annex 2: Assumptions land use models

a) Complete and enforce a network of Protected Areas

Costs current PA management

Item	Value	
Current FDA funding conservation department	900,000	USD/yr
Area currently managed by FDA	289,112	ha
Management cost per ha	**3**	**USD/ha*yr**

Source: FDA budget 2015/2016

Costs East Nimba Nature Reserve (ENNR) management

Item	Value	
Management cost	220,000	USD/yr
Conservation agreements with communities	5,000	USD/agreement
# of conservation agreements	24	
ENNR management cost per ha	**29**	**USD/ha*yr**

Source: personal communication CI and ArcelorMittal

Existing protected areas

Protected area	Area
East Nimba Nature Reserve (ENNR)	11,553
Sapo NP	180,400
Lake Piso	97,159
Total	**289,112**

b) Maintain logging and other extractive forest uses at sustainable levels

Forest management concessions – general input values

Item	Cost / revenue	Source	Comments / assumptions
Contract fee	1,000 USD/contract*yr	FDA 2007: Regulations	
Area fee FMC	2.5 USD/ha*yr	FDA 2007: Regulations	Applicable to the total concession area
Coupe inspection fee	0.5 USD/ha*yr	FDA 2007: Regulations	Applicable to the operational area
Waybill fee	0.25 USD/m^3	FDA 2007: Regulations	Applies to contracts covered by CoC system only
Export license fee	100 USD/shipment	FDA 2007: Regulations	
Log export fee	5 % of USD/m^3	FDA 2007: Regulations	2.5-10% of FOB price per class
Log stumpage fee	5 % of USD/m^3	USAID 2013: Commercial forest revenue projections	Based on stumpage value, i.e. the FOB minus all operational cost; 2.5-10% of FOB price per class
Community benefit	1.5 USD/m^3	USAID 2013: Commercial forest revenue projections	
CoC fee	1.4 % of USD/m^3	USAID 2013: Commercial forest revenue projections	Of FOB
Bid premium	4.7 USD/ha*yr	SGS 2015	
Tax burden harvested timber	106 USD/m^3	USAID 2013: Commercial forest revenue projections	
Tax burden exported timber	172 USD/m^3	USAID 2013: Commercial forest revenue projections	
Port handling charges	20 USD/m^3	USAID 2013: Commercial forest revenue projections	
Operational and overhead cost[1]	110 USD/m^3	USAID 2013: Commercial forest revenue projections	Average value
FOB average	204 USD/m^3	SGS 2015	
[1] Includes harvest, transport and overhead cost not covered otherwise.			

Forest management concessions and CFMAs [1]

FMC/CFMA	Area
FMC A	119,240
FMC B	57,262
FMC C	59,332
FMC F	254,583
FMC I[2]	131,466
FMC K	266,910
FMC P	119,344
CFMA 1[3]	49,444
CFMA 2	135,776
CFMA 4	66,150
[1]CFMAs issued before 2011 [2]Area used for NPV calculations – the average concession area = 126,000ha. [3]The value was corrected from 494,444.	

Source: personal communication FDA

Estimated annual cost and revenue FMC – Business as usual

Cost / revenue item	Value	Source / assumptions
Operational and overhead cost	16,184,779 USD/yr	Volume harvested: 23.7 m^3/ha (Shearman 2009) = 124,498 m^3/yr
Fixed fee	2,200 USD/yr	
FOB based tax / fee: export	1,268,569 USD/yr	
FOB based tax / fee: stumpage	459,330 USD/yr	
FOB based tax / fee: CoC	355,199 USD/yr	
Area based tax/fee	942,885 USD/yr	
Volume based tax / fee	217,872 USD/yr	
Revenue	**25,371,373** USD/yr	
Profit	**5,940,540** USD/yr	
1 hectare model		
Taxes/fees	25 USD/ha	Calculated across the total concession area
Operational and overhead costs	123 USD/ha	
Revenue	193 USD/ha	
Profit	45 USD/ha	

Estimated annual cost and revenue FMC – Sustainable forest management

Cost / revenue item	Value	Source / assumptions
Operational and overhead cost	4,571,730 USD/yr	Volume harvested: 6.7 m^3/ha (Shearman 2009) = 35,167 m^3/yr
Fixed fee	2,200 USD/yr	
FOB based tax / fee: export	358,334 USD/yr	
FOB based tax / fee: stumpage	129,747 USD/yr	
FOB based tax / fee: CoC	100,333 USD/yr	
Area based tax/fee	331,294 USD/yr	w/o bid premium: it is assumed that the bid premium is abolished.
Volume based tax / fee	61,543 USD/yr	
Revenue	**25,371,373** USD/yr	
Profit	**5,940,540** USD/yr	
1 hectare model		
Taxes/fees	7 USD/ha	Calculated across the total concession area
Operational and overhead costs	35 USD/ha	
Revenue	55 USD/ha	
Profit	12 USD/ha	

Estimated cost and revenues – unregulated timber harvest

Item	Value	Source	Assumptions
Operational cost	45 USD/m^3 sawn timber	FDA 2009: Chainsaw Logging in Liberia	Volume harvested: 23.7 m^3/ha (Shearman 2009) Recovery sawn timber from logs: 31% (FDA 2009: Chainsaw Logging in Liberia) Standard plank: 0.06 m^3 No management costs apply
Transport cost	60 USD/m^3 sawn timber	Personal communication FDA & Chainsaw millers union; FDA 2009: Chainsaw Logging in Liberia	
Sawn timber levy	11 USD/m^3	Personal communication FDA	
Total Cost	857 USD/ha		
Revenue	1166 USD/ha		
Profit	**310 USD/ha**		

Estimated cost and revenues – regulated timber harvest in CFM

Item	Value	Source	Assumptions
Area fee	0.8 USD/ha*a	FDA regulations	30% of the area fee as paid in FMC (USD 2.5/ha) goes to the community
Community benefit	0.4 USD/ha*a	USAID 2013: Commercial forest revenue projections	USD 1.5m^3 as paid in FMC goes to the community Harvestable volume: 6.7 m^3/ha once in 25 years (Shearman 2009) =0.3 m^3/ha*a
Operational cost	45 USD/m^3 sawn timber	FDA 2009: Chainsaw Logging in Liberia	Volume harvested: 6.7 m^3/ha (Shearman 2009) Recovery sawn timber from logs: 31% (FDA 2009: Chainsaw Logging in Liberia) Standard plank: 0.06 m^3 CFM management costs are not included as no experiences exist.
Transport cost	60 USD/m^3 sawn timber	Personal communication FDA & Chainsaw millers union; FDA 2009: Chainsaw Logging in Liberia	
Sawn timber levy	11 USD/m^3	Personal communication FDA	
Total Cost	11 USD/ha*a		
Timber revenue	13 USD/ha*a		
Profit	**2 USD/ha*a**		

Charcoal production – general input values

Item	Value	Source	Assumptions
Roadside price of charcoal	80 USD/t	Buchanan Renewables 2012	
Conversion wood to charcoal	15 %	Van der Plas 2011	
Cost of wood	2.3 USD/t	Personal communication Charcoalers Union, van der Plas 2011,	Average value from different sources
Cost of labor	18 USD/t charcoal	FAO 1987	Assuming USD 3.5/man day
Available biomass	80 t/ha	IPCC 2006	Shifting cultivation 7-8 year cycle; only half of the biomass is useful for charcoal production
	40 t/ha	IPCC 2006	Shifting cultivation 3-4 year cycle; only half of the biomass is useful for charcoal production
	8.2 t/ha	Shearman 2009, FDA 2009: Chainsaw Logging in Liberia	After unsustainable timber harvest: 69% of 23.7 m^3/ha, wood density 0.5 t/m^3
	0.1 t/ha*a		After sustainable harvest: 69% of 6.7 m^3/ha, wood density 0.5 t/m^3; annual harvest

c) **Reduce shifting agriculture by increasing the area of land under permanent agriculture**

Agroforestry using the example of cocoa – business as usual

Item	Value	Source	Assumptions
Establishment: Inputs[1] Labor	 150 USD/yr 1 350 USD/yr 1	Personal communication ACDI/VOCA	Labor excludes clearing; it is assumed that land was used for food crops previously or trees are planted in secondary forest
Inputs[1] thereafter	0 USD/ha*yr		No use of inputs
Management cost	45.5 USD/ha*yr	GoL, EC 2001	Assuming USD 3.5/man day
Harvesting cost	105 USD/ha*yr	GoL, EC 2001	
Farm gate price (dry beans)[2]	1 USD/kg	USAID 2015: Liberia market study; Personal communication WIENCO	
Revenue from yr 4 onwards	400 USD/ha*yr		
Time until maturity	3 yrs		
Productive period	22 Yrs		
Yield (dry beans)[3]	400 kg/ha*yr	Personal communication WIENCO	

[1] Tools and seedlings in year 1; Fertilizer, pesticide and fungizide from year 2 onwards

[2] Grade 2 cocoa beans

[3] According to other sources current yield is even lower (~ 200 kg/ha*yr): GoL 2010, GoL Cacao Export Strategy 2014-18

Agroforestry using the example of cocoa – improved management

Item	Value	Source	Assumptions
Establishment: Inputs[1] Labor	 650 USD/yr 1 350 USD/yr 1	Personal communication ACDI/VOCA	Improved seedling material Labor excludes clearing; it is assumed that land was used for food crops previously or trees are planted in secondary forest
Inputs[1] thereafter	250 USD/ha*yr	Personal communication WIENCO and ACDI/VOCA	
Management cost	140 USD/ha*yr	GoL, EC 2001	Assuming USD 3.5/man day
Harvesting cost	315 USD/ha*yr	GoL, EC 2001	
Farmgate price (dry beans)[2]	1.5 USD/kg	USAID 2015: Liberia market study; FFI 2014	Better management, harvesting and processing practices lead to improvement in quality
Revenue from yr 4 onwards	1,500 USD/ha*yr		
Time until maturity	3 yrs		
Productive period	22 yrs		
Yield (dry beans)	1,000 kg/ha*yr	Personal communication WIENCO	

[1] Tools and seedlings; fertilizer, pesticide and fungizide are applied from year 1 onwards
[2] Grade 1 cocoa beans

Commercial food crops using the example of upland rice – business as usual

Item	Value	Source	Assumptions
Labor cost	278 USD/ha	USAID 2009: Liberia rice study	No use of inputs Shifting cultivation, 3 yr cycle: only 1/3 of cost applies for 1 ha model
Farm gate price (rough rice)	0.4 USD/kg	Personal communication FED and Nimba County Agricultural Office	
Yield (rough rice)	800 kg/ha	USAID 2009: Liberia rice study	Shifting cultivation, 3 yr cycle: only 1/3 of the yield applies for 1 ha model
Profit	**14 USD/ha*yr**		

Commercial food crops using the example of upland rice – improved management

Item	Value	Source	Assumptions
Production cost	474 USD/ha	Personal communication FED	Includes land clearing, management and harvest Using improved seed and fertilizer
Farm gate price (rough rice)	0.4 USD/kg	Personal communication FED and Nimba County Agricultural Office	
Yield (rough rice)	2,000 kg/ha	USAID 2009: Liberia rice study	
Profit	**326 USD/ha*yr**		

Oil palm – traditional management, incl. processing to palm oil

Item	Value	Source	Assumptions
Establishment: Inputs Labor	 0 USD/yr 1 154 USD/yr 1	Personal communication ACDI/VOCA and GROW, UNIQUE expert estimate from West Africa	Dura variety, wild seedlings and no input = 0 Assuming USD 3.5/man day
Management cost yr 2 and 3	210 USD/ha*yr	GoL, EC 2001	Assuming USD 3.5/man day
Management cost yr 3 onwards	175 USD/ha*yr	GoL, EC 2001	
Harvesting cost	70 USD/ha*yr	GoL, EC 2001	
Processing of fruit	245 USD/ha*yr	GoL, EC 2001; Ofosu-Budu et al 2013	Manual processing of fruit
Product price: palm oil	1.2 USD/l	USAID 2015: Liberia market study; USAID 2009: NTFP	
Palm oil/fruit	0.2 l/kg	FFI 2014	
Revenue from yr 5 onwards	1,017 USD/ha*yr		
Time until maturity	4 yrs	Personal communication ACDI/VOCA and GROW	
Productive period	21 Yrs		
Yield (FFB)	4,000 kg/ha*yr	GoL, EC 2001: 6,000 kg/ha*yr Ofosu-Budu et al 2013: 2,000 kg/ha*yr	

Industrial oil palm plantations

Item	Value	Source	Assumptions
Land rent	5 USD/ha*a	GVL concession agreement	
Inputs Year 1 Year 2 & 3 Thereafter	 975 USD/ha 212 USD/ha*a 320 USD/ha*a	Personal communication ACDI/VOCA, UNIQUE expert estimate from West Africa	
Establishment	154 USD/ha		
Management cost year 2 & 3	62 USD/ha*a	GoL, EC 2001	
Management cost thereafter	102 USD/ha*a	UNIQUE expert estimate from West Africa	
Interest rate for out-growers development cost	15 %		The development cost is paid back in 8 installments from year 5 onwards
Time until maturity	4 Years	Personal communication ACDI/VOCA, UNIQUE expert estimate from West Africa, USAID 2015: Liberia market study	
Productive period	21 Years		
Max. yield FFB	2,000 t/ha		1st yield in year 4 after establishment, peak yield in year 9
Product price: FFB	0.1 USD/kg	UNIQUE expert estimate from West Africa and Indonesia	
Employment	0.2 person/ha	Average from ADB 2012, GVL (website) and Savoure 2015	
Employment benefit	295 USD/ha*a		Assuming wages of 4.2 (mean between minimum wage and GVL wages) and 312 working days per year

Rubber plantations

Item	Value	Source	Assumptions
Establishment: Inputs[1] Labor	 555 USD/yr 1 305 USD/yr 1	UNIQUE expert estimate from West Africa	Assuming USD 3.5/man day
Management cost from yr 2 onwards	87.5 USD/ha*yr	GoL, EC 2001	
Harvesting cost	438 USD/ha*yr	GoL, EC 2001	
Inputs	45 USD/ha*yr	UNIQUE expert estimate from West Africa	Cups and tools for rubber collection
Product price (wet rubber)	0.8 USD/l	FFI 2013: REDD Wonegizi; GoL 2007	At buying stations
Revenue from yr 7 onwards	640 USD/ha*yr		
Time until maturity	6 yrs		
Productive period	19 Yrs		
Yield (wet rubber)	800 kg/ha*yr	GoL 2010	

Subsistence agriculture – shifting cultivation

Income	Value	Source	Assumptions
Long cycle (7-8 yrs) Short cycle (3-4 yrs)[2]	333 USD/ha*yr 220 USD/ha*yr	Based on GoL, EC 2001, values are inflation adjusted	Mixed crop system Yr 1: Rice Yr 2: Cassava/vegetables Yr 3: Plantain/banana Yr 5-7: Slowly reverting back to secondary forest

[1] The income only applies every 7-8 or 3-4 years respectively in the cashflow of the 1 ha model.
[2] Reduced income of approx. 65% of long cycle due to loss in soil fertility.

Annex 3: Assumptions implementation cost

Protected areas

Cost type	Cost	Justification (source)
• Formulate guidance and rules on compensation for foregone use (also applies for CFMA conservation forests) (year 1 and 2)	100,000 USD/yr	
• Design and implement compensation / alternative livelihood projects	In year 1: 5,900,000 USD Thereafter increasing by 29 USD/yr per additional hectare	Based on the annual cost (reserve management and community conservation agreements) for East Nimba Nature Reserve as estimated by CI and ArcelorMittal
• Increase FDA capacity		

Forestry

Cost type	Cost (USD/yr)	Justification (source)
• Adjust taxation / fee regulations	1,500,000	Abolishment of bid-premiums (for new concessions already not applicable anymore) will result in approx. 20% reduction of tax/fees, or ca. USD 1.5/m^3 extracted
• Design rules and guidance for SFM and RIL (year 1 and 2)	250,000	Expert estimate?
• Formalize, regulate and train chainsaw millers		
1st five years	100,000	
Subsequently until year 10	50,000	
• Design regulations for commercial use and conservation forestry for community forests (year 1 and 2)	250,000	
• Provide legal, technical, managerial guidance and assistance to communities, chainsaw millers and concessionaires		Based on the budget requested by FDA for the FY 2015/2016 (research and development, commercial forestry, community forestry, legal verification)
• Enforcement		Increasing the area under active management (FMC, CFMA) requires additional resources
Year 1	5,700,000	
Thereafter increasing until year 10	15%	

Reduce shifting agriculture, increase permanent agriculture

Cost type	Cost (USD/yr)	Justification (source)
• Improve access to finance • Improve access to inputs (availability and e.g. subsidies) • Improve access to markets and value addition • Provide technical assistance on modern agricultural practices and conservation agriculture	per farmer targeted: 210 Year 1-6: 37,800,000 Year 7-12: 18,900,000 Thereafter decreasing by 5%/yr	Conservation International 2009 Approx. 40,000 farmers grow cocoa, 15,000 oil palm (FFI, 2014) and > 150,000 rice and other food crops. Assuming role out of the agricultural program across the country, but targeting only approx. half the farmers in the 1st phase.

Annex 4: Average carbon stocks for different land use classes

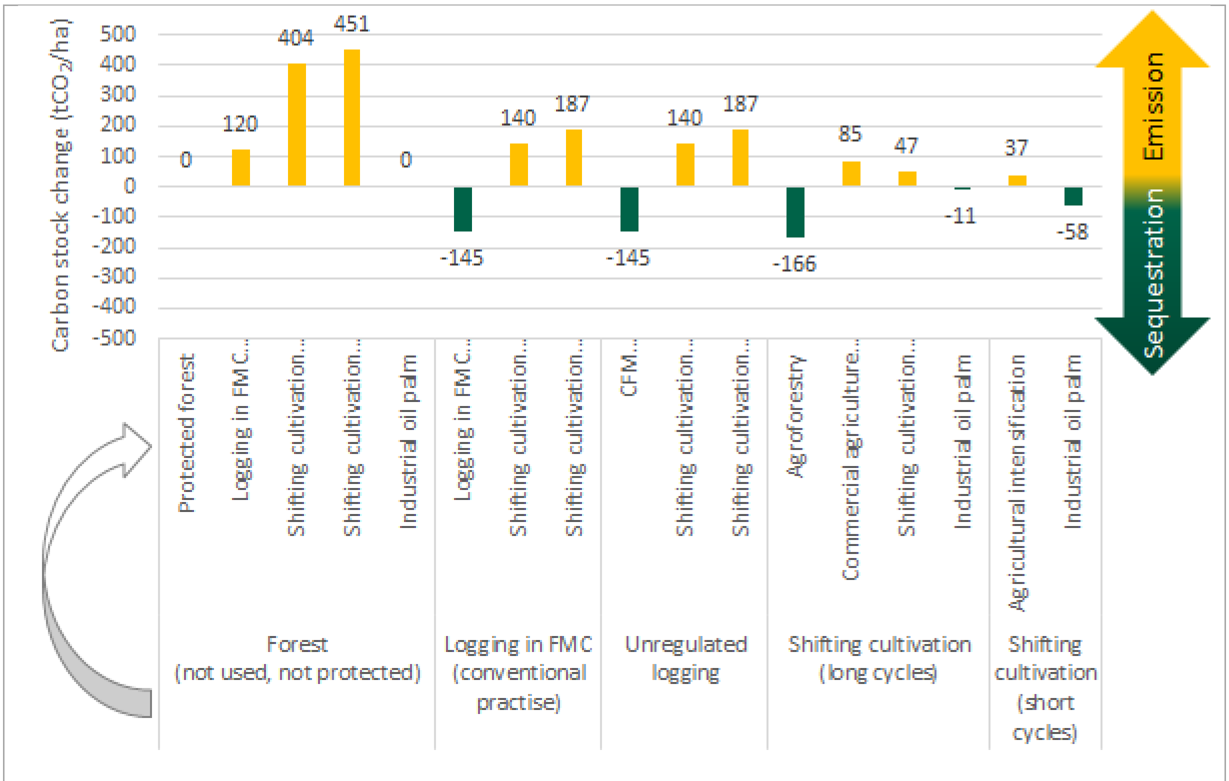
Land use class	AGB	BGB	AGB+BGB	Comments/Source
	tCO$_2$/ha			
Forest in PA or not utilized	364	135	499	Preliminary data. Winrock, personal communication and IPCC 2006
Forest logged over (conventional – BAU)	171	63	234	Putz et al. 2012, % of undisturbed forest
Forest logged over (sustainable management)	277	102	379	Putz et al. 2012
Agroforestry (cocoa, long term average)	210	51	261	Carodenuto et al. 2015
Shifting cultivation (7-8 year cycle, long term average)	69	26	95	IPCC 2006
Shifting cultivation (3-4 year cycle, long term average)	34	13	47	IPCC 2006
Rubber plantations (long term average)	N/A	N/A	170	Carodenuto et al. 2015
Oil palm (long term average)	N/A	N/A	106	Carodenuto et al. 2015
Permanent agriculture, annual food crops (rice)	10	0	10	IPCC 2006

Winrock recommended to use carbon stocks as identified by Baccini et al. for the three land cover classes identified by GeoVille (2015) in the cost-benefit analysis. However, the differences in carbon stock between the three land cover classes do not reflect the substantial changes to biomass caused by different land uses. Accordingly only the value for Forest > 80% was used in this cost-benefit analysis. All other values were taken from other literature sources as listed above.

Forest Class	Carbon stock (Baccini et al.) t CO_2 ha^{-1}	Assumed land uses in the CBA
Forest >80%	364	Primary forest - with and without logging
Forest 30-80%	317	Plantation, agroforestry, shifting cultivation (>7 yrs rotations) = sec forest
Forest <30%	291	Oil palm, intensive agriculture

Annex 5: Land use and carbon stock changes with REDD+

Anticipated carbon stock changes under REDD+



Bars shows emissions (positive) and removals for the different land use changes with REDD+ implementation.

A shift to sustainable logging practices from unsustainable ones, as well as implementation of agroforestry on former agricultural land will result in GHG removals (carbon sequestration). The same applies for oil palm plantations if established on already degraded lands.

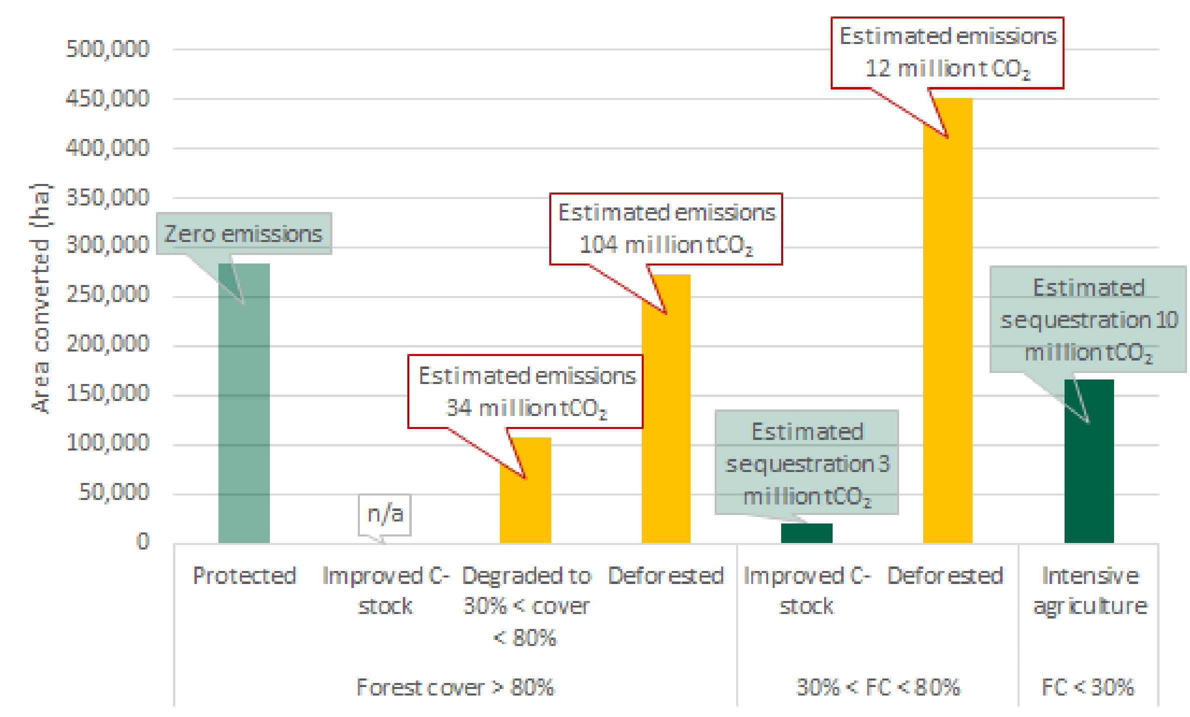
Even with REDD+ implementation deforestation and forest degradation will occur, releasing GHG. Changes from degraded land (shifting cultivation) to more intensive land uses such as commercial agriculture will cause emissions but considerably less than from converting forest to agricultural land. That means REDD+ activities that result in agricultural intensification while avoiding deforestation of a similar size of land will have a positive impact in terms of net avoided GHG emissions.

Annex 6: GHG emissions and removals for land cover classes for BAU and REDD+

The expected GHG emissions for the different land uses were summarized for the land cover classes as identified by GeoVille 2015 (see Table 2 above).

Under **business as usual** deforestation of [relatively] intact forests (Forest cover > 80%) is expected to take place on an area of ca. 250,000 ha and constitutes the biggest source of GHG emissions, followed by degradation from forest to the next land cover class (Forest cover between 80% and 30%). Intensification of agriculture (oil palm on non-forest land) will result in GHG removals.

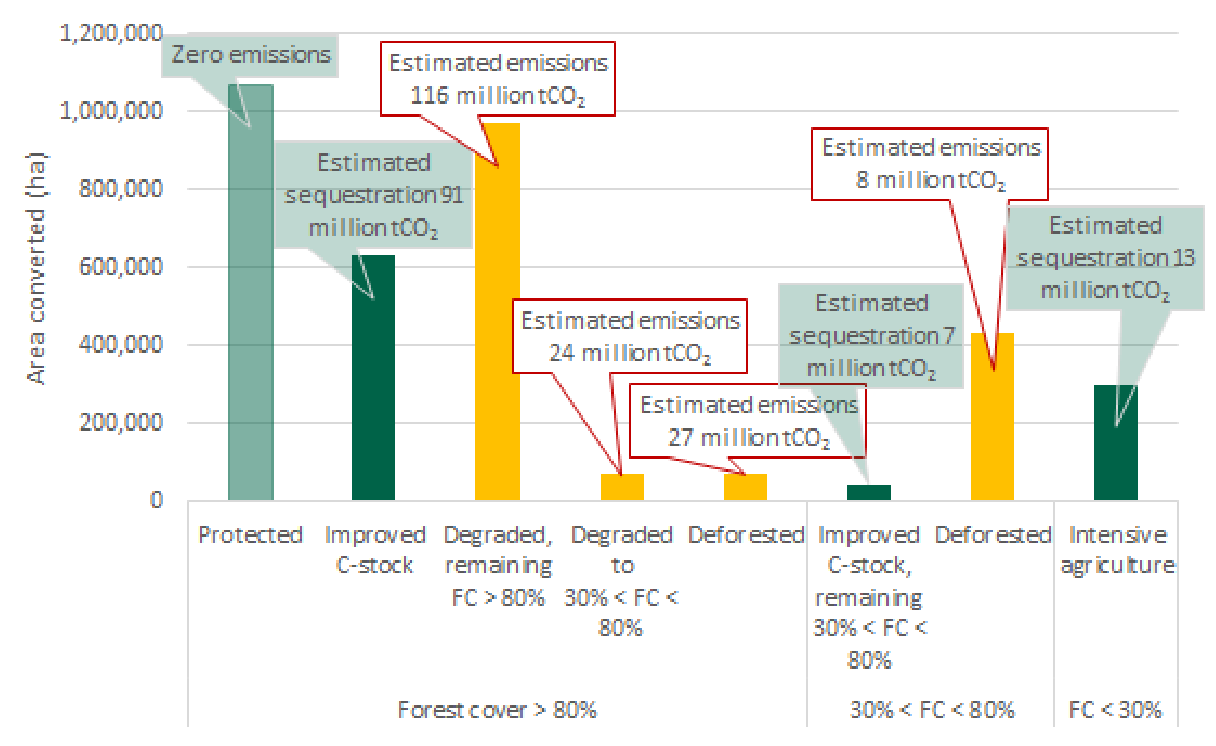
Forest cover change and related emissions for BAU for Liberia



Bars show the area within a Forest cover class (FC) which is expected to be protected, degraded or deforested, or where CO_2 sequestration is likely to take place. Green bars stand for carbon sequestration or the protection from degradation/deforestation and yellow bars for areas where degradation/deforestation will occur. Boxes show the net-GHG emissions.

With **REDD+** the main source of emissions will be sustainable logging in to date undisturbed forests, while helping to avoid deforestation. This will be largely offset by changing management practices in already logged forests and the resulting removals. REDD+ measures targeting forest protection and sustainable management must cover a very large area (approx. 2.5 million ha) and variety of activities to achieve significant emission reductions. REDD+ measures targeting the sustainable intensification of agriculture will take place on a much smaller area. However, the measures required will likely be just as expensive as forest protection and sustainable forest management.

Forest cover change and related emissions for REDD+ for Liberia



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