ASSESSING CARBON NEUTRAL OPPORTUNITIES IN HALCYONS CAMEROON OPERATIONS

INTRODUCTION

This report presents the findings of a complete supply chain greenhouse gas (GHG) balance assessment carried out for Halcyon Agri in Cameroon. The objective of this study was to understand how GHG emissions resulting from the cultivation and management of Halcyon Agri rubber systems compare with the carbon (C) sequestration and C pool function of Halcyon Agri rubber and other land use systems combined. Based on these results, better decisions can be made on how to further reduce emissions resulting from the management and processing of rubber, and on which land use and management options are most promising not only in further enhancing C sequestration and storage at the plantation level and other land use systems found within the concessions, but also in positively contributing to enhancing ecosystem services and as such more resilient landscapes.

The study includes a carbon footprint assessment from the management and cultivation of rubber for the two plantation sites of Hevecam and Sudcam including net carbon emissions of the processing facilities located at the former site. In addition, the report provides an overview of the C sinks and pools of the various land use systems found within the boundaries of the two concessions which include differently aged rubber systems, areas of High Conservation Value (HCVs), other forest areas and community land managed for food production.

The study goes on to assess how different land use management options compare with regards to their C impact and concludes by summarising the overall GHG or C balance that Halcyon Agri achieves through their current management strategies. Finally, recommendations are made on how C impacts could further be improved which would achieve the simultaneous objectives of climate change mitigation and positioning Halcyon as a company proactively contributing to the well-being and protection of the natural environment and local livelihoods.

METHODS

Carbon Footprinting

The calculation of GHG emissions released across Halcyon's Cameroon rubber supply chain, also known as 'carbon footprint' analysis, was carried out according to the PAS 2050:2011 specification for the assessment of the lifecycle greenhouse gas emissions of goods and services (BSI, 2011). This analysis includes emissions of all gases known to contribute to global warming: nitrous oxide (N_2O), methane (CH_4) and carbon dioxide (CO_2); each gas is assigned a 'CO_2 equivalent' value according to its potential to contribute to global warming compared with CO_2, so that the effects of all gases can be summed and presented as a single figure, known as 'CO_2-equivalents' (CO_2e).

The terms 'carbon footprint' and 'GHG emissions' are used interchangeably throughout this report depending on the context but have the same meaning. Direct (Scope 1) GHG emissions from the entire supply chain as well as indirect (Scope 2 and 3) emissions are included here. The field-level baseline assessment gathered data to calculate GHG emissions from the supply chain, beginning at the concessions and the cultivation of rubber up to the port of export including upstream inputs and processes and downstream wastes. In order for the rubber carbon footprint calculations to be representative of the Halcyon Agri supply chain, primary data were gathered through questionnaires, where the inputs to and outputs from each step of the rubber supply chain were captured.

Rubber supply chain stages that have been considered within the assessment are cultivation, harvesting, processing and transport.

Emissions associated with supply chain stages beyond the port of export fall outside of the boundaries of this carbon footprint study and are therefore excluded from the calculation.

RAINFOREST ALLIANCE

Emissions associated with the cultivation of rubber were calculated using the Cool Farm Tool (CFT). The tool is applicable to all countries in the various regions across the globe. CFT is non-crop-specific but the scope is limited to the parameters that can be selected within it. These are laid out in the table below:

Table 1: Scope for carbon footprint calculations

Scope definition	Eligible scope under CFT
Scope 1 Direct emissions and emission removals within the farm boundary or which are owned or controlled by the farmer	• Fuel and energy use (on farm and contracted) • Soil management practices • Incorporated crop residues • Fertility and biomass inputs • Land use changes • Carbon sequestration by woodland • Waste and waste water
Scope 2 Emissions associated with the generation of purchased electricity used on the farm	• Electricity production
Scope 3 Indirect emissions associated with the production, processing, distribution of inputs in to the farming systems. This also includes embedded emissions in machinery, building materials and farm infrastructure	• Production of fertilisers • Primary processing • Primary distribution

In addition to the CFT, processing emissions were estimated by using and already existing environmental impact assessment tool developed by TruCost[1] for Halcyon. Based on that, all electricity emissions were calculated according to Defra (2015) data for country specific grid electricity, which includes generation (Scope 2), and transmission and distribution losses and well-to-tank (Scope 3) phases. Land use change (LUC) emissions were also calculated separately by use of the carbon footprint tool CAFCA[2] which follows IPCC guidelines. LUC emissions are based on historic deforestation events that have occurred within the last 20 years and have been annualised over a 30-year period to align with the rotation length of the concession model.

Carbon Sequestration

Rubber plantations

Carbon sequestered within rubber plantations was calculated based on the estimated biomass development rates of rubber trees over a 30-year period.

For rubber trees, the level of carbon sequestered in above- and belowground biomass was calculated based on the allometric equation and a tree census for both concessions that included details on stocking density, height and diameter at breast height (DBH). For carbon stock estimation, we estimate the above ground biomass using the latest allometric pantropical tree model of Chave et al. (2014) which uses tree height, stem diameter and wood density as covariates. In order to estimate carbon content from the biomass, we assumed a 47.5% biomass to carbon conversion rate (Whittaker & Likens, 1973; Brown, 1997; Losi et al., 2003; Nasi et al., 2009).

[1] TruCost ESG Analysis (2019) Environmental Impact Assessment tool Hevea Connect
[2] Noponen MRA (2012) Carbon and economic performance of coffee agroforestry systems in Costa Rica and Nicaragua.

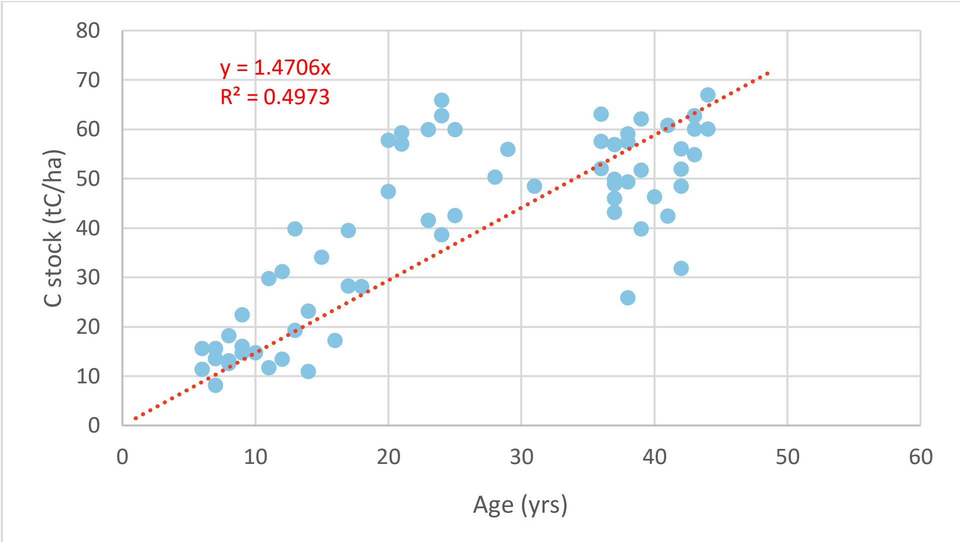

Fig. 1 Annualised carbon stock development of rubber systems in Hevecam based on provided tree census and biomass calculated based on Chave et al. (2014).

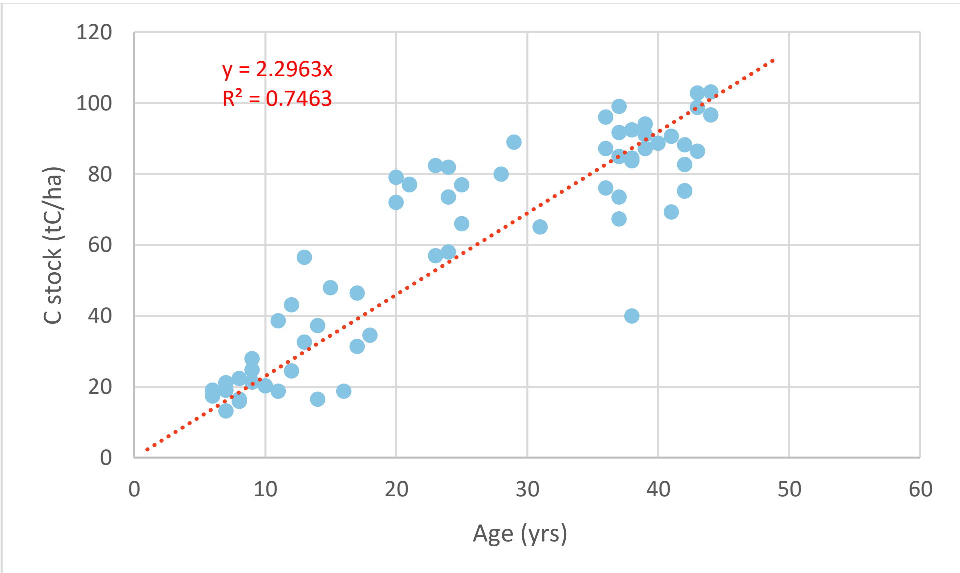

Fig. 2 Annualised carbon stock development of rubber systems in Sudcam based on provided tree census and biomass calculated based on Chave et al. (2014).

Based on this the biomass is estimated for each individual tree (including all stems for multi-stemmed trees) using the equation below:

$$AGB = 0.0673 \times \left(\rho D^2 H\right)^{0.976}$$

Where AGB is aboveground dry biomass (in kg); ρ is wood density (in g/cm³) D is diameter at breast height (in cm) and H is the height (in metres).
The underground or belowground biomass (BGB) is usually computed using the assumption that, for each individual tree, BGB represents 20.5% of the above ground biomass (Mokany et al., 2006). Therefore, the total biomass of every tree will be 1.205 * AGB.

It is noted that Chave et al (2014[3]) provides an allometric function for biomass estimates for trees in pantropic regions in general and is not specific to rubber. However, in reviewing the literature we found no applicable data for Cameroon but instead a series of studies that compared biomass stocks of differently aged rubber systems across the globe. Plotting the results of this study (Nizami et al. 2014[4]) we achieved a similar C stock development curve (y = 2.6149x ; r^2 = 0.95) to the one for Sudcam (y = 2.2963; r^2 = 0.75) which justifies its usage. Hevecam's C development curve is significantly lower as the plantation has on average much lower stocking densities per hectare than Sudcam (327 vs 480 trees/ha) and has not been managed as consistently in the past.

To account for differences in age structure and C sequestration rates of rubber plantations, C sequestration has been annualized over a 30-year rotation length. For the C assessment we have assumed a 'complete' rotation system; in Cameroon traditionally three rubber management regimes can be found: so-called managed, extended, and complete rotations (Egbe et al., 2012). Complete rotation entails clear-felling and replanting the entire plantation every 30 years; for managed rotation harvesting spans a five year period, with 33% of the plants cut at age 26 and 28 years, and the final fraction at the end of the cycle at 30 years with simultaneous replanting; for extended rotations half of the plantation is cut down and replanted at 30 years, and the other half 10 years later. These three regimes in rubber plantations were all found to have different carbon sequestration abilities and the impacts of switching Halcyon's current management system of complete rotation will be discussed as part of the LUC scenarios in the results section.

The C impacts of managing a rubber plantation according to a complete rotation system can be observed in Fig. 3. As highlighted by the read horizontal line, although C stocks naturally increase in aboveground C pools, over a longer time horizon ABG C stocks of plantations can be considered in a steady state. Similarly, soil organic carbon stocks (SOC) will eventually reach an equilibrium state determined by previous land use, time since that land use change has occurred and the current management system.

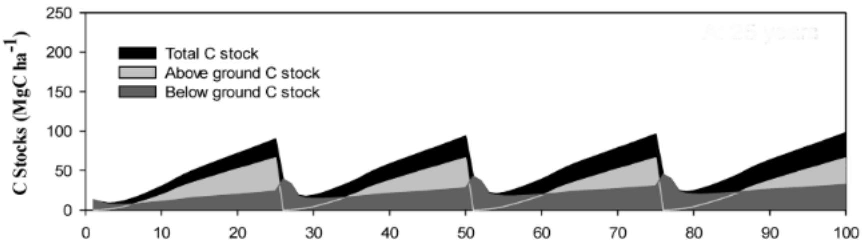

Fig. 3C stock dynamics of a 'complete' rotation system

To account for C losses from the rubber system, tree extraction has been estimated based on an averaged replanting plan across the two concessions for the next 15 years. Replanted areas are assumed to have been clear felled at rotation age of 30 years. To account for potential C benefits that could arise from processing the timber into long lived timber products it has been assumed that 50% of the harvested biomass i.e. branches and leaves are left in the field; 43% provides woodfuel for dryer kilns and woodchip to replace rubber processing kerosene burners; 1% is considered unrecoverable waste; leaving 6% of biomass for processing into sawn timber for export.

Limitations and uncertainties

The largest and most uncertain parts in the carbon assessment are tree biomass and avoided emissions reductions at the plot and landscape level. In the absence of field research this study relied on secondary sources for information about C stocks and uncertainties in estimates at different levels was often unavailable. In addition, although soil C stocks pose a significant C pool, these have not been taken into account in this study due to the high variability of soil C stocks and their development under differing land use systems after land use change.

[3]Chave et al. (2014) Improved allometric models to estimate the aboveground biomass of tropical trees. Global Change Biology 20 (10).

[4] Nizami SM, Yiping Z, Liqing S, Zhao W,Zhang X (2014) Managing Carbon Sinks in Rubber(Hevea brasilensis) Plantation by Changing Rotation length in SW China. PLoS ONE 9(12).

Protected Forest Areas – HCVs and other forests

To calculate avoided emission reductions, the USAID AFOLU Carbon Calculator Tool[5] was used to estimate emissions impacts from protecting forests, which include avoided emissions from deforestation, sequestered emissions in forest areas that would have been deforested under the business-as-usual scenario ("foregone sequestration"), and avoided mineral soil emissions from conversion of forest to cropland.

Model calculations are based on data such as deforestation rate, soil carbon content, and peat bulk density for Cameroon East. The estimates are based on the assumption that no further forested area would be deforested or degraded into the future and full protection and conservation of existing forests is guaranteed. Leakage, the impact of avoided deforestation leading to deforestation occurring elsewhere as a result of this activity have not been taken into account.

Values used to calculate avoided deforestation for Sudcam and Hevecam respectively have been identified either based on comprehensive literature review or are default values provided by the model and are as follows:

- Deforestation rates without concession protection: 1.03[6]%/yr and 0.25[7]%/yr
- Annual forest growth for forest < 20 years: 4.63[6] tC/ha and 4.7[6] tC/ha
- Annual forest growth for forest > 20 years: 1.43[6] tC/ha and 1.46[6] tC/ha
- Soil carbon stock: 43.22[6] tC/ha and 44.7[6] tC/ha
- Forest carbon stock: 269[8] tC/ha and 171[9] tC/ha.

Modelling land use scenario options

To assess the C impacts of various land use options that Halcyon might want to consider as part of their quest to achieve positive climate and wider landscape and ecosystem impacts, the USAID AFOLU carbon assessment tool was used to estimate C outcomes.

RESULTS CARBON FOOTPRINTS

The overall carbon footprint (CF) for Hevecam is estimated at 96,632 tCO_2e per year (26,330 tC/yr) which equates to 4.45 tCO_2e/ha/yr (1.21 tC/ha/yr) across the land use systems that are associated with the production of rubber (around 21,725 ha in total) or around 3.42 tCO_2e/tonne of rubber/yr. Around 80% of the total area CF are made up of LUC emissions, due to the conversion of forest areas to rubber (Fig 4.).

Excluding the LUC emissions to better understand management impacts, the major emission hotspots (Fig. 5) in Hevecam are associated with nutrient management, fertilizer application and production, which account for over 80% of the entire footprint at Hevecam.

There are currently a mix of productive (mature) and unproductive (immature) systems in operation with various areas being renewed and others coming into production gradually over the next year so it is difficult to estimate with certainty how the overall CF (excluding LUC emissions) will develop. However, based on the current understanding of the rubber systems (age of immature systems and replanting schedule) we estimate the total area CF to increase by around 35 - 40% per annum.

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[5] http://www.afolucarbon.org/

[6] Saatchi et al. (2013) Benchmark map of forest carbon stocks in tropical regions across three continents. PNAS 108

[7] USAID AFOLU tool default value for region

[8] Saatchi et al. (2013) Benchmark map of forest carbon stocks in tropical regions across three continents. PNAS 108 (24); Gonmadje et al. (2017) Altitudinal filtering of large-tree species explains above-ground biomass variation in an Atlantic Central African rain forest. Journal of Tropical Ecology 33(2)

[9] Zapfack et al. (2013) Deforestation and Carbon Stocks in the Surroundings of Lobéké National Park (Cameroon) in the Congo Basin. Environment and Natural Resources Research; Vol. 3 (2).

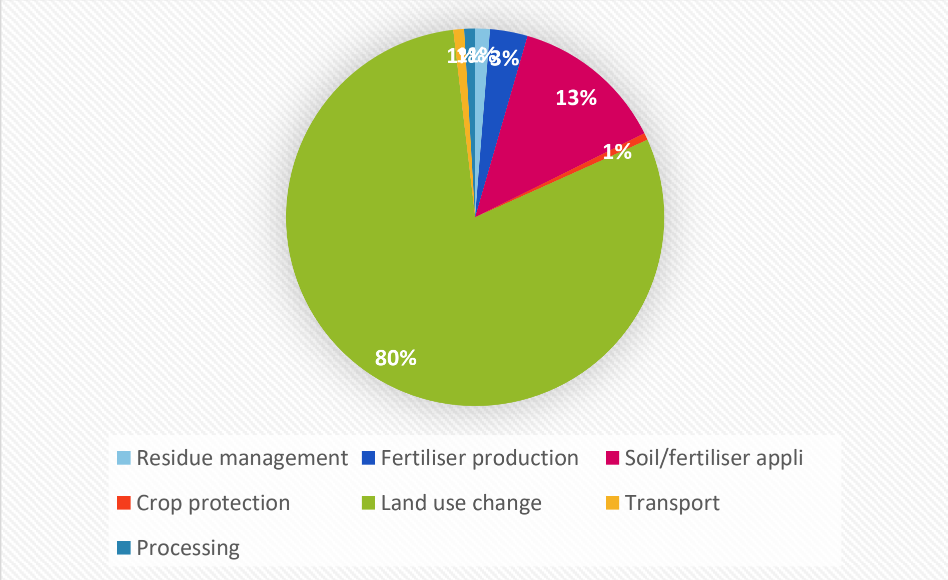

Fig. 4 Percentage breakdown of total Hevecam rubber plantation CF including LUC (tCO_2e/yr)

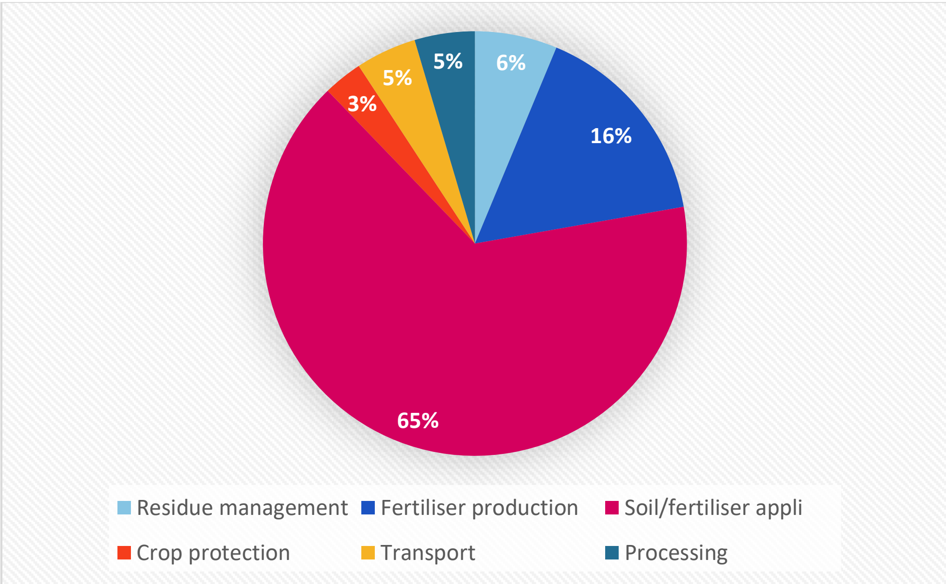

Fig. 5 Percentage breakdown of total Hevecam rubber plantation CF without LUC (tCO_2e/yr)

As can be observed from figure 5 which shows the emission hotspots without LUC emissions (i.e. emissions sources that can be reduced subject to improved management and efficiency), transport, crop protection, residue management and processing all have a comparatively low contribution to the overall CF. This means any changes that lead to potential improvements in those emission hotspots would have a relatively low impact on the overall CF at its current level. For example, improving processing through switching to a 100% renewable energy mix could lead to a reduction of maximum 5% of the overall CF at its current level. The largest sources of emissions in Hevecam relate to fertiliser and soil management, contributing together over 80% of the CF when LUC is excluded (Fig. 5).

For Sudcam, the overall CF is estimated at 413,883 tCO_2e per year (112,775 tC/yr) which equates to 41.90 tCO_2e/ha/yr (11.42 tC/ha/yr) across the land use systems that are associated with the production of rubber (around 9,877 ha in total) or around 43.69 tCO_2e/tonne of rubber/yr. 98% of the total footprint are made up of LUC emission alone (Fig. 6).

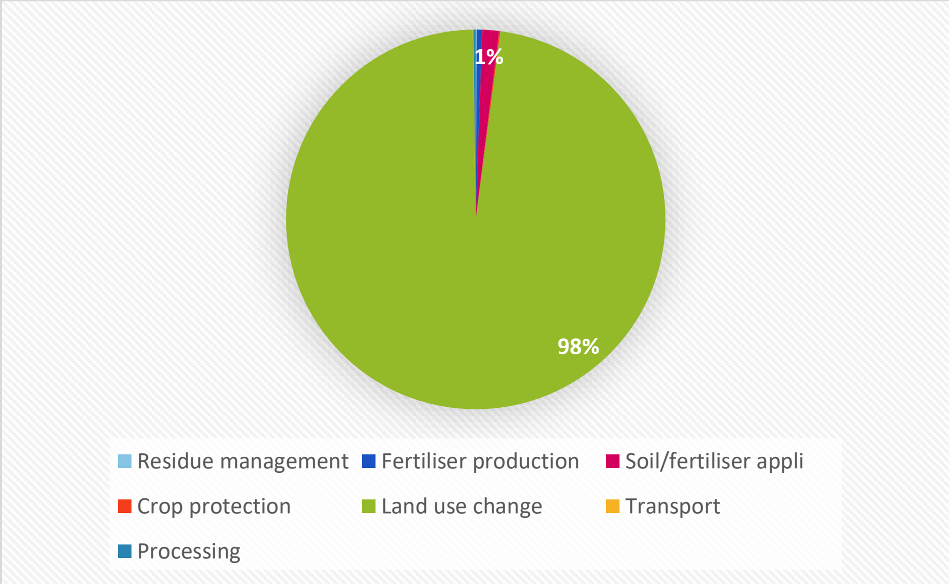

Fig. 6 Percentage breakdown of total Sudcam rubber plantation CF including LUC (tCO_2e/yr)

Again, excluding the LUC emissions to better understand management impacts, the major emission hotspots in Sudcam (Fig. 7) are associated with fertiliser and soil management, which account for over 80% of the total CF.

Similar to Hevecam, there are currently a mix of productive (mature) and unproductive (immature) systems in operation with various areas being renewed and others coming into production gradually over the next year. As such, it is difficult to estimate with certainty how the overall CF will develop over time, but based on the current understanding of the rubber systems in Sudcam (age of immature systems and replanting schedule) we estimate the total area CF to increase significantly, due to over 90% of rubber plantations currently being unproductive. Conversely, the per tonne of rubber footprint will reduce once production increases with systems coming into production and maturing as emissions per unit yield will decrease assuming that management inputs remain the same.

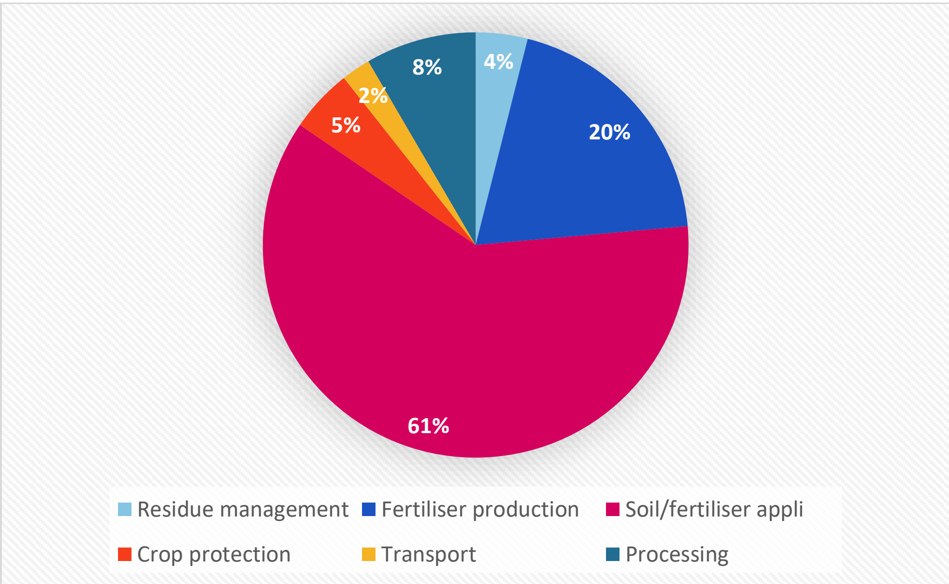

Fig. 7 Percentage breakdown of total Sudcam rubber plantation CF without LUC (tCO_2e/yr)

Similar to the results in Hevecam, transport, crop protection, residue management and processing transport contribute together less than 20% of the overall CF and as such any changes to these elements would create a smaller impact on the overall CF at its current level.

RESULTS CARBON STOCKS AND SEQUESTRATION

In Hevecam the highest C stocks were found in the mature rubber plantations and within the protected HCV area, with between 41.84 – 125.25 tC/ha (due to the varying age structure) and 200 tC/ha respectively. Table 1 outlines the current total average C stocks that were estimated for the various land use systems in Hevecam including an annual sequestration rate as calculated based on the methods outlined above.

Table 1: Current C stocks and sequestration rates for the different land use types in Hevecam

Land use type	Area (ha)	Average total C (tC)	C sequestered (tC/yr)
Immature 1	6,271	73,655	9,219
Immature 2	2,562	30,146	3,767
Mature 1	12,756	1,067,448	18,752
HCV	16,158	2,762,933	0*
Mixed (forests)	9,053	1,593,147	9,958

*Assumed to be in a steady state

In Sudcam the highest total C stocks were found in the immature rubber plantations and within the mixed forest areas with stocks between 5.22 – 18.27 tC/ha and 169.26 – 182.7 tC/ha respectively. Table 2 outlines the current total average C stocks that were estimated for the various land use systems in Sudcam including and annual sequestration rate as calculated based on the methods outlined above.

Table 2: Current C stocks and sequestration rates for the different land use types in Sudcam

Land use type	Area (ha)	Average total C (tC)	C sequestered (tC/yr)
Immature	8,850	103,943	20,267
Mature	918	16,772	2,102
HCV	3,504	942,576	0
Mixed (forests)	31,093	5,471,746	43,530

RESULTS AVOIDED LAND USE CHANGE EMISSIONS

A major benefit is created, both in terms of ecosystem service provision and in climate mitigation potential, through protecting existing forest areas (mixed and HCVs) that account for a total of 59,808 ha across the two concessions.

Based on the methodology outlined above and assumed current deforestation rates for the regions, we estimate that the storage of 39,967 tCO_2e (10,890 tC) and 242,468 tCO_2e (66,068 tC) are being protected through avoided deforestation and forest degradation in Hevecam and Sudcam respectively (Table 3).

RESULTS GHG BALANCE

Based on the results of the annual CF, C sequestration and avoided emissions, the following GHG balance of the concessions under investigation have been calculated (Table 3).

Overall both concessions present a positive GHG balance of 12,116 tCO_2e (3,301 tC) and 10,773 tCO_2e (2,936 tC) for Hevecam and Sudcam respectively (table 3). However, one should note that GHG benefits achieved through protecting existing C stocks in standing biomass and soil C depend heavily on current deforestation rates. That is to say, if deforestation rates are to decrease over time, the calculated GHG benefit of forest protection will drop accordingly. As the protected C stocks in forests create the biggest GHG benefit, the impact on avoided emissions reductions through a drop in anticipated deforestation rates would have a significant impact on the overall C balance of the concessions. For example, a drop in the regional deforestation rate for Sudcam from the current 1.03% to 0.93% would lead to a negative balance, -12,767 tCO_2e (-3,479 tC), and as such a net emitter.

As part of their efforts to reduce GHG emissions, the Government of Cameroon, through its Nationally Determined Contribution (NDC), is committed to reducing emissions by 32% by 2035 from its projected baseline of 2010 emissions. The forest sector is therefore expected to contribute significantly towards this goal of the NDC via implementation of the Reduced Emissions from Deforestation and Forest Degradation mechanism (MINEPDED, 2017) and as such the above estimates and results need to be considered in this context i.e. deforestation rates and with that avoided emissions reductions are set to drop.

Nevertheless, this should not detract from the fact that protecting and conserving existing forests must be of utmost priority regardless of the estimated emissions reductions that are being achieved through avoiding further conversion.

Importantly however, rubber systems also play a crucial role in climate mitigation, by balancing out emissions from the cultivation and processing of rubber through sequestering C in biomass and soil. In Hevecam, C sequestration in rubber is around six times the value of the CF. Even including LUC emissions (the majority of the concession has been in production for over 40 years and as such only includes small areas that have been converted more recently), we estimate a net GHG balance of 19,843 tCO_2e (5,407 tC) (table 3). It would be important to revisit this assessment however in the future when more areas have come into production and thus the area CF may have increased significantly.

In Sudcam, the C sequestration rate in rubber is about 10 times the value of the CF (table 3). However, due to the large CF caused by land use change associated with the production areas, the net GHG balance is significantly negative at -331,790 tCO_2e (-90,406 tC) presenting a massive and continued emissions source.

Table 3 – GHG balance for the two concessions, Hevecam and Sudcam, Cameroon

Results	Hevecam				Sudcam			
	tC	tCO2e	tC/ha	tCO2e/ha	tC	tCO2e	tC/ha	tCO2e/ha
Total CF rubber production	5,315	19,506	0.24	0.90	2,646	9,711	0.27	0.98
Total GHGs LUC	21,015	77,126	0.97	3.55	110,129	404,172	11.15	40.92
Total CF rubber (production + LUC)	26,330	96,632	1.21	4.45	112,775	413,883	11.42	41.90
Total C sequestered - rubber	31,737	116,475	1.47	5.39	22,369	82,093	2.29	8.40
Total C sequestered - other	9,958	36,547	1.1	4.04	43,530	159,756	1.4	5.14
Total C sequestered (rubber + other)	41,695	153,022			65,899	241,849		
Total GHGs avoided	10,890	39,967	0.87	3.2	66,068	242,468	4.58	16.8
Total GHG balance rubber system	5,407	19,843	0.25	0.91	-90,406	-331,790	-9.15	-33.59
Total C benefit forests	20,848	76,514	0.83	3.04	109,598	402,224	3.17	11.63
Total C loss - timber extraction	22,954	84,241	1.06	3.88	16,256	59,661	1.65	6.04
Total GHG balance concession	3,301	12,116	0.07	0.25	2,936	10,773	0.07	0.24

ASSESSING C NEUTRALITY OPTIONS

The main objective of this study was to assess and define opportunities for achieving carbon neutrality within Halcyon's supply chain. The following sections are an overview of the components inherent to achieving C neutrality, core requirements that need to be met and alternatives that could be considered in the absence of meeting those criteria.

Carbon Offsetting

Carbon offsetting is a way for individuals or entities such as companies to invest in activities to take responsibility for the carbon emissions caused by their own activities. The principle of carbon offsetting is simple: an emitter pays a separate entity to create a carbon benefit equivalent to the amount that they emit, to effectively neutralise the carbon impact of their activity.

There are three main steps to offset CO_2 emissions:

- Establish an emissions baseline by calculating a CF. This can be done for a whole organisation or for a specific activity or supply chain.
- Develop a C reduction strategy to reduce emissions by making activities more efficient or less carbon intensive
- Balance out (offset) remaining emissions through investing into activities outside your supply chain/stakeholder network that generate verified emission reductions (VERs).

For offsets to be accepted under a cap and trade system or against verified emissions targets or claims such as carbon neutrality, the emission reductions should be generated through projects verified and certified under specific programmes such as the Clean Development Mechanism or Verified Carbon Standard.

In addition, and important to note, for the assessment of the CF we followed the methodology outlined under PAS2050. However, while forest management activities are recognised to result in additional carbon storage in managed forests through the retention of forest biomass, this potential source of storage is not included in the scope of this PAS and as such would could not be third party verified claims.

C neutrality and third-party verification

The various standards considered for carbon neutrality claims have different requirements and principles including around the recognition of different types of emission reductions (see Annex C for more detail). However, with most of these standards requiring third party validation and verification of claimed offsets, achieving and claiming carbon neutrality generally requires the purchase of VERs from carbon offset projects.

In addition, most standards currently do not allow accounting for avoided LUC in a supply chain carbon footprint and as such cannot be used to achieve carbon neutrality. This is further complicated by the fact that C standards have very rigorous definitions of how LUC needs to be accounted for, disqualifying any projects that have experienced LUC within their boundaries within the last 10 years.

Importantly, the main barrier to achieving the recognition of HCV and forest protection as verified emission reductions relates to the 'additionality' concept.

Within a specified project boundary, additionality is the most important determinant of a project's effectiveness in reducing greenhouse gas emissions into the atmosphere. The concept of additionality for carbon projects is enshrined in Articles 3.4, 6.1, and 12.5 of the Kyoto Protocol to ensure that real and measurable GHG emission reductions are achieved. In a forest carbon project, additionality shows net greenhouse gas emission savings or sequestration benefits over and above business-as-usual. To ascertain if a project is additional or not, certain elements of the project are assessed relative to a hypothetical baseline scenario in which there is no carbon offset market.

Project specific additionality tests are commonly based on a CDM additionality tool which evaluates whether the offset project is dependent on offset project revenue (investment test) or whether it has overcome significant implementation barriers (barrier test). Using the CDM additionality test as a basis, several iterations of the additionality test have been developed by organisations like VERRA and Climate Trust.

Assessment of the additionality of a possible carbon project in Halcyon's concession area was based on:

- Legal and regulatory test: This requires that the project is in regulatory surplus i.e. that it exceeds any existing legal requirements;
- Implementation barriers test: These include financial, technological, and socio-cultural barriers;
- Timing test: This looks at the time that the project was required to start and whether it started before hand;
- Common practice test: This requires that the technology or practice used by the project must not be in common use.

As part of the additionality assessment, credible alternative land use scenarios must be identified and subjected to the test that the proposed project is put through. Credible alternative land use scenarios to the proposed Halcyon project (HCV and forest protection) include the following:

- Rubber plantations

- Land clearance by smallholders for food and housing.

With regards to the legal and regulatory test, all land use scenarios identified are following mandatory applicable legal and regulatory requirements. The project area falls within a logging concession which can be planted with rubber after a government approved private sector actor has removed all trees of economic value usually for timber. Alternative use of the land to support smallholder farming and for housing are also within government allowed land uses as well as using the land as a biodiversity corridor that will improve biological diversity. The latter alternative use is in line with Cameroon's efforts to reduce emissions from deforestation and forest degradation especially for SUDCAM which is close to the Dja Forest Reserve. There is currently no regulation for zero deforestation practices except for government incentives to encourage the practice by private sector. The proposed project is therefore not mandated by any law, policy, statute or regulatory framework. The project therefore passes the first step to be assessed for implementation barriers.

Based on the implementation barriers test, the project faces certain risks. As a concession granted by the government, there is a risk that a change in policies or laws can result in the re-possession of the concession area by the state for other land uses. Furthermore, given that management changes can take place in the company including change in priorities, there is a risk of lacking consensus on future management decisions (e.g., with respect to land-use) that will support conservation efforts aimed at avoiding emissions from land use change. Existing issues between the state, Halcyon and local communities around natural resources management decisions may further be exacerbated and increase the risk of social conflict among interest groups in the region where the project takes place and as such would be considered barriers to the additionality component of the project.

The project and its associated GHG reductions cannot be considered additional as the project involves an approach (i.e. avoid land use change) that is likely to be employed for reasons other than reducing GHG emissions such as biodiversity conservation, improving suitability of environment for rubber plantations, and lands left untouched due to unsuitability for rubber. GHG reduction needs to be a decisive reason for the project. As part of the tests, a timing test was conducted. This test assesses whether the project was initiated after a certain date, in -line with additionality requirements. In the case of the Halcyon project, the action of avoiding emissions through forest protection was already in place before any interest to pursue a GHG reduction project. It is therefore difficult to prove against the implicit assumption that since the project started before the required date (e.g. before the start of a GHG program) it was motivated by GHG reductions.

Under the Common Practice Test, the project must reduce GHG emissions below levels produced by "common practice" technologies that produce the same products and services as the GHG project. Based on scenario estimations, the GHG emissions avoided are not significantly below levels of common practice of the approach used elsewhere. It seems the only real reason for the project is to conform to common practice for the same reasons as other actors in the forest carbon credit market. Therefore, a project in Halcyons concessions would not be considered additional.

Carbon Insetting

A slightly different approach to offsetting, and potential alternative suitable for the Halcyon project, is that of carbon insetting. It consists of identifying and supporting actions that are of relevance (and benefit) to the company's or organisation's stakeholders rather than investing into activities outside those boundaries. A benefit of the insetting approach is that it helps to reduce emissions along the supply chain, and can create a long-term competitive advantage: as cap and trade schemes are extended as part of the NDCs, the price of carbon will be increasingly reflected in the price of goods and services. Supply chains with low emissions will be more competitive than those with high emissions.

In addition to that, although strongly recommended, there are currently no globally adopted requirements for verification or certification of the achieved emissions reductions as is the case with offsetting projects. This means that the generated emissions reductions cannot be used within market-based cap and trade systems unless they are third party verified according to accepted carbon accounting methodologies as outlined above. However, as long as there is transparency about the methodologies used and a responsible monitoring and reporting system is maintained, the insetting approach can generate some real benefits as projects are more likely to be maintained for the long-term as they will be embedded within the boundaries of one or other of the stakeholders participating.
If communicating externally about the positive climate impacts of the current activities taking place in Halcyons Cameroon operations is of importance then the approach of C insetting is currently the only viable option. The fact that there are no options for third party verification of those impacts, coupled with

the challenges posed by some of the eligibility criteria as outlined above, mean that any statements (not claims) would need to be very clear and transparent in communicating the methodologies employed. This report and the included detail on applied methodologies and calculation could serve this purpose.

OPPORTUNITIES TO FURTHER CREATE POSTIVE CLIMATE IMPACT

The following sections present recommendations based on the above described results, for Halcyon to consider in further improving its climate performance through land management and processing activities.

Reducing the CF - Cover cropping & soil nutrient management

Cover crops are long and short-duration, non-harvested crops grown between primary crops for the purpose of soil protection, improvement, and nutrient capture and retention. Cover cropping was observed for some of the sites and if applied across the operations at 10% field coverage could reduce the footprint significantly by 10% and 8.6% for Hevecam and Sudcam respectively.

This stands in contrast with the CF results for processing and transport across the two sires which account on average for 3.5% and 6.5% respectively but may be more costly to achieving emissions reductions.

In addition to cover cropping, the importance of soil nutrient management cannot be overemphasized. As shown in figures 4-7, it represents the biggest emissions source, accounting for over 80% of the CF at both operations (when LUC emissions are removed). Therefore identifying methods to reduce fertilizer consumption and associated soil emissions, whilst maintaining per ha yield, will be paramount to reducing the overall CF. It was observed that whilst fertilizer is applied across the operations in immature and mature systems, the mature concession in Hevecam is not receiving any fertilizer inputs yet achieving higher yields. This suggests that some level of soil assessment is already conducted to establish fertilizer needs according to localized requirements. In addition, site specific fertilizers have already been developed based on climate, soil and plant nutrient requirements. However, opportunities may exist to further fine-tune fertilizer applications, by making them specific to in situ nutrient requirements, and improving the timing and method of fertilizer application (to ensure that a greater % of the applied nutrient is absorbed by the plant, and less volatilized), thus enabling CFs to be further reduced.

Rehabilitation/reforestation of degraded land areas

One of the greatest opportunities to achieving big climate wins is that of rehabilitating large areas of degraded land through reforestation. Cameroon has a commitment under the African Forest Landscape Restoration Initiative (AFR100), a country-led effort to restore 100 million ha of land across Africa by 2030, to accelerate forest restoration to enhance food security, increase resilience to climate change and combat rural poverty. In 2017, Cameroon pledged to the initiative with a commitment to restore 12 million ha. There are currently no payments for ecosystem services under this initiative, but the financial disbursement design is unclear at this stage and future benefits might be made available. This initiative contributes to the Bonn challenge, which is a global effort to bring 150 million ha of the world's degraded and deforested lands into restoration by 2020 and 350 million ha by 2030.

Based on calculations using the AFOLU tool described within the methodology section to estimate avoided land use change emissions, it is estimated that a reforestation project to rehabilitate degraded land areas in the concession at the scale of 1,000 ha could generate C reductions of up to 7,670 tC per year annualized over a 30 year period.

An investment opportunity for Halcyon to consider is the Land Degradation Neutrality Fund (LDN Fund). Land Degradation Neutrality as recognised by the United Nations Convention to Combat Desertification (UNCCCD) is a state whereby the amount and quality of land resources necessary to support ecosystem functions and services and enhance food security remains stable or increases. Achieving land degradation neutrality means practicing one or more of the several sustainable land management approaches such as landscape restoration and agroforestry to reduce and reverse land degradation and achieve significant environmental and social benefits in tandem.

LDN is embedded in the sustainable development goals as target 15.3 with important implications for other goals like Climate Action and No Poverty. To facilitate the achievement of land degradation neutrality, a long-term fund (debt/equity) to finance profit generating SLM and land restoration projects that also meet strict environmental and social standards, has been instituted. The LDN Fund is promoted by the UNCCD Global Mechanism and Mirova, with the latter as the fund managers.

The LDN Fund which has secured over $100m of commitments from investors, is set to support projects and programmes in the sectors of Sustainable Agriculture; Sustainable Forestry, and other land use related sectors. As a rubber company interested in restoration of its landscape, the LDN Fund is ideal in supporting plans by Halcyon. The eligibility criteria of the fund include:

- Demonstrating clear benefits of land rehabilitation and/or degradation avoidance
- Demonstrating other co-benefits such as climate change mitigation/adaptation, biodiversity protection, and showing clear benefits to local communities.
- Establishing a robust E&S risk management as an integral component of the project
- Showcasing that the financing is additional and complementary to existing commercial funding sources and traditional development funds
- Project coverage of a large expanse of area for high impacts achievements
- Generation of positive financial returns vis-à-vis an established appropriate risk profile.

With the LDN Funds worldwide coverage and its prioritization of 80% of the funds to projects in developing countries, this provides a strong opportunity for Halcyon to tap into the funds for its Cameroon land restoration plans, given that the target allocation for invested capital is 60% sustainable agriculture, 30% sustainable forestry, and 10% other SLM related sectors.

If Halcyon plans to restore lands via several approaches including through the adoption of out grower schemes, a focus on promoting low carbon agriculture practices and other sustainable actions in these out grower programmes, and showcasing the development impacts that the project will have, would qualify it as a potential investment that LDN Fund could support. Through the pursuit of LDN, Halcyon could then achieve avoided land use change emissions, and several other ecosystem benefits, which though cannot be claimed under any of the Carbon Standards mentioned and examined earlier, can be used in projecting the sustainability image of the company. In addition to financing from LDN Fund if selected, Halcyon would be able to benefit from the added provision of technical assistance as per the LDN Fund Technical Assistance Facility which increases positive impacts and reduces commercial and ESG risk. Part of the Technical Assistance is to coordinate learning and knowledge sharing which would further be beneficial to Halcyon's sustainability efforts.

Timber processing

Based on Halcyons plans to construct a sawmill further GHG could be achieved through C stored in long lived wood products. Based on the current rotation model of the plantation, all of the rubber trees are being clear felled at the age of 30 years and then left in the field to decompose. However, processing the timber into wood products would allow to account for GHG benefits through the C that is being stored in the timber. Based on the replanting schedule for the next 15 years (an average of 757 ha/yr with a tree density of 430 trees) and assuming a 6% recovery rate from the clear felled timber it is estimated that across the plantations a GHG benefit of 358 tC or 1312 tCO_2e per annum could be achieved.

Rubber Agroforestry

Rubber intercropping is already a type of agroforestry system, as rubber is a tree. Tree density in standard rubber monoculture is ca. 550 trees/ ha with 6- to 8-m inter-rows, leaving 75% of the soil surface uncultivated opening the opportunity for additional of other plants or trees. The most commonly found types of intercropping systems are presented here:

Temporary rubber intercropping system

A temporary intercropping system allow to plant diversity of plants at different stages of development of the production system. Usually intercropping with light demanding crops such as maize, pineapple, banana, cassava among others during plantation establishment is a common practice. Other crops like pepper can be added at after 5 – 7 years of establishment.

Permanent rubber intercropping system

The second intercropping approach is to establish or keep perennial crops when rubber plantations start to develop a shade environment and maintain the crops during the whole rubber production cycle. Typical examples are cocoa, tea, coffee, or species belonging to the ginger family. Typically, those crops are grown together with shade trees under moderate shade of 20–50 %. These crops are original components of the forest understory, and the respective systems evolved from forests Rubber would function as the "shade tree" in this type of system.

With a strongly reduced number of rubber trees (160 trees or ca. 1/3rd of the standard) cocoa could be grown with economic success. Consequently, a considerable increase in rubber row distance, to e.g. 16–20 m, is a common feature of permanent rubber intercropping, often accompanied by the establishment of narrow rubber double rows with a row distance of only 2–2.5 m. This results in a similar number of rubber trees with a respective yield per hectare compared to the standard spacing and, together with the intercrop, allows for a better land use efficiency (LER). In some coffee-rubber systems, producers used a 2.5 m wide rubber-double rows alternate with 10 rows of coffee with a respective row distance of 2 m. This results in a spacing of 24 m between rubber rows.

Timber oriented rubber intercropping system

Besides the commonly promoted intercrops such as tea, coffee, or cocoa, timber trees can also be considered for a rubber intercropping system. While rubber timber itself developed from a waste-product into an economically important component of rubber plantation management there are also reports on the integration of timber trees into rubber.

If properly selected and established, only little labour input might be required to maintain them. Since regular harvests as in food crops are of no concern, the labour challenge is mitigated. Reported tree species are for example teak (*Tectona grandis*) and Neem (*Azadirachta indica*) in Thailand. Since teak is a light demander, its integration needs to be done during the early establishment phase of rubber.

The C sequestration potential of rubber plantations can be essentially increased in the case of transformation from monoculture to agroforestry systems. A comparison of C stocks for such systems was done in the work of Palm et al. (1999)[10] and in the study of Lusiana (2014)[11] for Indonesia. In the first case, total C stocks increased from 46 to 89 tC/ha when rotational (30 years) and permanent jungle-rubber were compared. In more recent studies by ICRAF (Lusiana, 2014)[12], C stocks increased from 38 to 91 tC/ha if rubber monoculture was substituted by a rubber agroforestry system.

Moving from monoculture plantations to agroforestry systems also distinctly improves biodiversity and other ecosystem services, leading to multilateral positive solutions[13,14].

For more detail on species selection, constraints and other management considerations please refer to Annex B.

Rubber tapping

An aspect that this study did not look into but might warrant more research is the consideration of total C sequestered through collected latex during rubber plantation development. Rubber yield naturally varies depending on environmental conditions, management and clone but have been shown to result in cumulative C stocks of 14–33 tC/ha during 20 years of tapping of rubber trees in one rotation.[15]

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CONCLUSION

Carbon sequestration in the rubber systems at both sites far outweighed the GHG emissions associated with the cultivation and processing of rubber. However, when taking into account emissions from historical land use change (which includes deforestation), this positive balance is quickly negated, in the case of Sudcam by a factor of five. Nevertheless, large amounts of C are currently stored in the various land use systems that can be found within the concessions; both existing natural forests and HCVs hold significant carbon stocks that contribute to climate mitigation and as such should be protected due to this important benefit. Currently however, there do not exist any internationally accepted standards enabling payments for C storage/sequestration which would be applicable to the land under the Halcyon concessions reviewed here.

However, Halcyon's current proactive efforts to halt further land use change and degradation in this region, coupled with the intent to support and implement activities that will lead to further climate benefits and, more broadly, ecosystem and livelihood resilience, are lauded and should be continued and highlighted as an industry role model. This report lays out various opportunities to further enhance the climate positive impact created by Halcyon's concessions and their supply chains, which whilst not translating to direct financial benefits in the form of carbon payments, will lead to long term gains through a more resilient supply chain and a differentiated position in the marketplace.

ANNEX

Annex A

Standards requirements and principles for carbon neutrality claims:

- The NEPcon Carbon Standard considers land use change emissions for product carbon management which assesses the full lifecycle of products. Avoided land use change emissions are not considered for corporate carbon footprint and cannot be claimed under NEPcon's corporate footprint carbon neutrality. Corporate footprint caters for emission scopes 1,2, and 3 which include company owned vehicles, fuel use in production, purchased electricity, transportation and distribution both upstream and downstream, and employee commuting, amongst others.
- The GHG Protocol Corporate Standard is for businesses organisations developing GHG inventories and reporting their emissions but not for quantifying reductions associated with GHG mitigation projects for use as offsets or credits. However, the protocol provides companies with guidance on how to develop inventories that provide an accurate and complete insight of GHG emissions form direct operations and along the value chain including companies whose impacts on sequestered atmospheric carbon is key for inclusion in inventories. The standard also accounts for scopes 1,2 and 3 emissions. When the protocol is used to account for sequestered atmospheric carbon, this can be used for strategic planning, educating stakeholders and identifying opportunities for improving the company's GHG profile.
- GHG Protocol Project Quantification Standard is used to quantify projects that ensue in reductions to be used as offsets. It has not been designed for use in quantifying corporate or entity wide GHG reductions. In addition, the project protocol does not require a demonstration of additionality and neither does the need to define the project boundary in relation to physical dimensions or ownership matters.
- The Plan Vivo standard is a certification framework mainly for community-based payments for ecosystem services programmes supports rural smallholders and community groups with improved natural resource management. It enables access to a range of funding sources and markets for ecosystem services with voluntary carbon credits inclusive. The organisation can consider this standard if it plans to work with rural smallholders and community groups to enhance ecosystems through improved natural resource management. The Plan Vivo standard can be used for the payments for carbon sequestration or GHG emission reductions. Quantifying and monitoring carbon or 'climate services', in tonnes of carbon dioxide equivalent (tCO2e), enables projects to generate Plan Vivo Certificates, representing Verifiable Emissions Reductions (VERs), which are issued into an online registry. Eligible project activities include projects that generate ecosystem service benefits and maintain or enhance biodiversity such as improved land use management structures to increase the provision of ecosystem services like reducing GHG emissions and/or increase carbon stocks.
- American Carbon Registry accounts for avoided land use change emissions for grasslands and shrublands into croplands. It is one of the few standards that looks at avoided land use change. However, under this methodology, tree biomass (above-ground and below ground) is conservatively excluded in both the baseline and project scenario. This implies that avoided land use change from non-conversion of tree biomass to cropland, to rubber plantation, or to any other use is not considered for carbon neutrality claims.
- Verified Carbon Standard (Verra) does not consider avoided emissions from land use change as part of its portfolio. It evidently focuses on projects that are reducing greenhouse gas emissions which can be purchased by other entities as offsets or for neutralization. AFOLU projects under this standard fall in the following categories: Afforestation, Reforestation and Revegetation; Agricultural Land Management; Improved Forest Management; Reduced Emissions from Deforestation and Degradation; Avoided Conversion of Grasslands and Shrublands; Wetlands Restoration and Conservation
- Carbon Footprint Standard Forestry-related projects do not qualify for CFS-Carbon neutral but qualify for CFS-Carbon assessed and for CFS-Carbon reduced

- Gold Standard provides requirements for land use and forest projects within activities of afforestation/reforestation and or agriculture. There is no reference to avoided land use change emissions counting as viable projects for verified emission reductions. As part of the criteria, the eligible area for the emission reduction project where there shall be no deforestation, should not meet the definition of forest 10 years prior to the project start date and at the start date.

Annex B – C Standards and C neutrality requirements

	Requirements/Certification Process	Validations and Verification	Costs	Additional Services/Tools
NEPCon Carbon Management Standard	Decide scope of certificate – i.e. Corporate Carbon footprint or Product Carbon footprint • **Quality requirements** - Corporate climate policy describing organisation's overall intentions to manage the carbon footprint - Training procedures established - Assign and define responsibility for one person to implement CFM system - Quality assurance and documentation • **Scope of footprint** - Define organisational boundaries - Choose a base year • **Calculate carbon footprint** - Choose calculation methods, data collection and emission factors - Allocate emissions to processes - Assess data quality and uncertainty • **Carbon footprint management plan** - Set reduction targets - Set offsetting targets (if applicable) - Define action plan to reduce emissions - Monitor and evaluate performance; the management plan may be revised yearly, and targets can be adjusted • **Reporting and public information** - make certification scope, calculation method and results publicly available • **CFM claims** - make accurate statements and claims - use on-product and off-product labels	• Independent verification and on-site audits. • CFM certificate valid for 5 years is issued and company listed in CFM certificate database • Annual audits undertaken yearly to verify compliance	Requires fill in forms for a service quote	• Training e.g. certification requirements • On-going support with experts in between audits
GHG Protocol Corporate Accounting and Reporting Standard (WRI and WBCSD)	• Setting organizational and operational boundaries • Tracking emissions over time • Identifying and calculating GHG emissions • Managing inventory quality • Accounting for GHG reductions • Reporting GHG emissions • Verification of GHG emissions • Setting GHG targets	• No standard for verification process		• Cross-sector tools applicable to several industries and business across sectors • Customized developing country-specific tools

	Requirements/Certification Process	Validations and Verification	Costs	Additional Services/Tools
				• Sector-specific tools designed for specific sectors and industries
Plan Vivo Standard	• Directly engages and benefits smallholders and community groups • Generate ecosystem service benefits and maintain or enhance biodiversity • Managed transparently and accountably, engages relevant stakeholders and complies with the law • Demonstrates community ownership - communities participate meaningfully through the design and implementation of plan vivos (land management plans) that address local needs and priorities • Generates real and additional ecosystem service benefits that are demonstrated with credible quantification and monitoring • Manages risks effectively throughout their design and implementation • Demonstrates positive livelihood and socioeconomic impacts • Share benefits equitably and transacts ecosystem service benefits through clear PES Agreements with performance-based incentives • One PV certificate equals one tonne CO_2e sequestered or avoided plus range of non-carbon benefits (adaptation, biodiversity protection, water provision, etc).	• Annual performance measurement. • Projects are independently validated by third party experts before a project is registered. • Verifications of registered Plan Vivo projects should take place at least every 5 years	• From PIN review to registration - >$8850 • Certificate cost per issuance band - <50,000 PVC p.a. = $0.40/PVC >50,000 PVC p.a. = $0.35/PVC	
American Carbon Registry	• AFOLU projects with a risk of reversal shall commit to a Minimum Project Term of 40 years. The minimum term begins on the Start Date, not the first or last year of crediting. • AFOLU projects may have different length of time for which a GHG Project Plan is valid, and during which a project can generate offsets against its baseline scenario. • GHG reductions and/or removals shall result from an emission mitigation activity that has been conducted in accordance with an approved ACR Methodology and is verifiable. • Own, have control over, or document effective control over the GHG sources/sinks from which the emissions reductions or removals originate. • Provide documentation and attestation of undisputed title to all offsets prior to registration. Title to offsets shall be clear, unique, and uncontested. • Prove additionality.	• ACR requires third-party validation of the GHG Project Plan by an accredited, ACR-approved VVB once during each Crediting Period and prior to issuance of ERTs. • Verification must be conducted by an accredited, ACR-approved VVB prior to any issuance of ERTs and at minimum specified intervals.		ACR's Tool for Risk Analysis and Buffer Determination

	Requirements/Certification Process	Validations and Verification	Costs	Additional Services/Tools
	• Maintain material regulatory compliance. throughout a reporting period. Projects out of compliance with regulatory requirements are not eligible to earn ERTs during the period of non-compliance. • AFOLU Project Proponents shall assess reversal risk and enter into a legally binding Reversal Risk Mitigation Agreement with ACR/Winrock that details the risk mitigation option selected and the requirements for reporting and compensating reversals. • Proponents of terrestrial sequestration or avoided conversion projects shall mitigate reversal risk by contributing ERTs to the ACR Buffer Pool or using another ACR-approved insurance or risk mitigation mechanism. • Address, account for, and mitigate certain types of leakage, according to the relevant sector requirements and methodology conditions. • Develop and disclose an impact assessment to ensure compliance with environmental and community safeguards best practices.			
Climate, Community & Biodiversity Standard	• Project goals, design and long-term viability • 'Without-project' land use scenario and additionality • Stakeholder engagement • Adequate human and financial resources for effective implementation • The project is based on an internationally accepted legal framework, complies with relevant statutory and customary requirements and has necessary approvals from the appropriate state, local and indigenous authorities. • Estimates of total GHG emissions in the project area under the 'without-project' land use scenario are described. • The project reduces GHG emissions over the project lifetime from project activities within the project area. • Increased GHG emissions that occur beyond the project area caused by project activities (leakage) are assessed and mitigated and accounted for in the demonstration of net climate impacts. • Climate impact monitoring assesses changes (within and outside the project area) in project-related carbon pools, project emissions and non-CO2 GHG emissions if relevant, resulting from project activities • 'Without-project' community scenario • Net positive community impacts • Project activities at least 'do no harm' to the well-being of other stakeholders • Community impact monitoring	• Requires independent validation/verification for CCB standard by independent third parties and Verra staff	• Without CCB label fee, > $8,000	

	Requirements/Certification Process	Validations and Verification	Costs	Additional Services/Tools
	• Original biodiversity conditions in the project zone and expected changes under the without-project land use scenario are described • Net positive biodiversity impacts • Negative impacts on biodiversity outside the project zone resulting from project activities are evaluated and mitigated. • Biodiversity impact monitoring assesses the changes in biodiversity resulting from project activities within and outside the project zone.			
Verified Carbon Standard (Verra)	• GHG emission reductions and removals and the projects or programs that generate them must be proven to have genuinely taken place. • GHG emission reductions and removals must be quantifiable using recognized measurement tools against a credible emissions baseline. • Where projects carry a risk of reversibility, adequate safeguards must be in place to ensure that the risk of reversal is minimized and that, should any reversal occur, a mechanism is in place that guarantees the reductions or removals will be replaced or compensated. • GHG emission reductions and removals must be additional to what would have happened under a business-as-usual scenario if the project had not been carried out. • All GHG emission reductions and removals must be verified to a reasonable level of assurance by an accredited validation/verification body with the expertise necessary in both the country and sector in which the project is taking place. • Each VCU must be unique and must only be associated with a single GHG emission reduction or removal activity. There must be no double counting, or double claiming of the environmental benefit, in respect of the GHG emission reductions or removals. • There must be sufficient and appropriate public disclosure of GHG-related information to allow intended users to make decisions with reasonable confidence. • Conservative assumptions, values and procedures must be used to ensure that the GHG emission reductions or removals are not over-estimated	Uses both independent third parties and Verra staff for desk and field audits	Without VCU issuance levy, the account opening fee and registration fee > $10,500	
Carbon Footprint Standard	• Forestry-related projects do not qualify for CFS-Carbon neutral but qualify for CFS-Carbon assessed and for CFS-Carbon reduced	By Carbon Footprint Standard or by an approved independent third party	For cost, need to contact team	Free online carbon calculator tools

	Requirements/Certification Process	Validations and Verification	Costs	Additional Services/Tools
	• Carbon credits must be purchased via a QAS approved carbon offset provider or that the credits have been retired on behalf of the company • Carbon offset retirements must be completed within 12 months • As a minimum requirement transparency should include: - For the Assessment: the methodology followed/used, the definition of the Scope and Boundaries, and the results of the assessment - For the Reduction: The Assessment transparency (as shown above), the tracked emissions over two or more years			
Gold Standard	Eligible project types are Afforestation & Reforestation Projects (A/R) and Agriculture Projects (AGR)	Uses third party Validation/Verification bodies		
GHG Protocol Project Quantification Standard	• Identify GHG assessment boundary i.e. identify GHG sources and sinks to be considered in quantifying a project's GHG reductions • Establish the baseline scenario as a reference case for the project activity i.e. baseline emissions, baseline procedure, baseline candidates • Monitor and quantify GHG reductions • Report GHG reductions	Third party verifiers to be used at the discretion of the project developer.		
PAS 2050: 2011 (BSI) (used by SGS Ghana Limited)	Can be used under self-validation or independent third-party verification			
PAS 2060 Carbon Neutrality	Determine the subject of the intended claim of carbon neutrality Quantify the carbon footprint of that subject using a recognized methodology • Develop a Carbon Footprint Management Plan and make a declaration of commitment to carbon neutrality in accordance with the requirements of this PAS • Take action to reduce the carbon footprint of the determined subject and establish the effectiveness of those actions • Re-quantify the carbon footprint of the determined subject, ensuring that subject is unchanged, to determine the residual GHG emissions, using the methodology applied during quantification • Introduce or take account of a previously initiated, offset programme to balance out the residual GHG emissions. Offset schemes identified as appropriate are clean Development Mechanism (Certified Emissions Reductions), Joint Implementation (Emission Reduction Units), EU	Entity pursuing carbon neutrality and independent third-party validators can use this specification for the validation of declaration of carbon neutrality. There are recognised standards and codes that are considered appropriate for use by independent third-party certification bodies assessing performance against PAS2060. These are ISO 14065, EA-6/0, BS EN ISO 14064 – 3, BS EN 45011, BS EN ISO/IEC 17021, GHG protocol.		There are several laid out permissible declarations in respect of carbon neutrality in accordance with the PAS 2060 and their conditions of applications that an entity can adopt.

	Requirements/Certification Process	Validations and Verification	Costs	Additional Services/Tools
	allowances, UK DECC Quality Assurance Scheme for carbon offsets and for non-Kyoto compliant schemes either Gold standard or Voluntary Carbon Standard • In the event that carbon neutrality has been achieved for the determined subject, make a declaration of achievement of carbon neutrality in accordance with the requirements of the PAS			

ANNEX C

RUBBER AGROFORESTRY

Table of Contents

Introduction

Rubber tree (*Hevea brasiliensis*) plantations are the main commercial sources of natural rubber, an essential raw material in several high-end manufacturing sectors, including the tyre industry. Rubber is a perennial plant grown traditionally as an important cash crop. The origin and production of natural rubber was mainly based on the exploitation of old forests in Amazonia in which *Hevea brasilensis* is a component of the annually flooded riverine habitat. Currently the world biggest producers are Thailand, Indonesia, Malaysia, Vietnam and India, accounting for more than 90% of the 11.5 million ha of rubber plantations worldwide (Langenberger et al., 2017; Vrignon-Brenas et al., 2019).

The rapid expansion of rubber tree plantations in recent decades has been accompanied by dramatic negative ecological and social impacts due to the conversion of natural forests to rubber monoculture plantations. Especially in South East Asia, large areas of primary forests have been converted into rubber plantation using a mono-cropping (Langenberger et al., 2017).
Rubber agroforestry arises as an option to achieve more sustainable natural rubber production. As rubber is already a tree, usually rubber agroforestry can also be called rubber intercropping. Ecologically, tagroforestry systems permanently stabilize the soil, represent additional structural elements in a plantation, and, depending on the species, can support different animal guilds. Socio-economically, they add to farmers´ product portfolio and represent a kind of a bank which might be able to buffer the consequences of price volatility of rubber (Snoeck et al., 2013).
In this document we will consider rubber agroforestry as more diversified systems designed and implemented by smallholder, and rubber intercropping as more implementable for larger plantations.

Rubber agroforestry and intercropping management schemes

Jungle Rubber

The exploitation of natural stands was by far the prevailing practice in Amazonia, although early descriptions of rubber tree planting and intercropping with cocoa can be found. Smallholders changed their traditional agricultural practices by integrating rubber in slash and burn agriculture or home gardens thus actually becoming the originators of 'jungle rubber'. Jungle Rubber is a ''balanced, diversified system derived from swidden cultivation, in which man-made forests with a high concentration of rubber trees replace fallows'' (Wibawa et al., 2006).

Jungle Rubber systems are a major reservoir of forest species itself and provides connectivity between forest remnants for animals that need larger ranges than the forest remnants provide. This leads to a diversified tree stand dominated by rubber, similar to a secondary forest in structure. While jungle rubber cannot replace natural forest in terms of conservation value, the question whether such a production system could contribute to the conservation of forest species in a generally impoverished landscape is very relevant (Wibawa et al., 2006).

Smallholder Rubber agroforestry

The real challenge for smallholder producers is to move from low yielding seedling-based jungle rubber to clonal rubber in order to increase yields. In several contexts this is already the case, such as in Thailand. Additionally, to the use of clonal rubber, producers could have more diversified agroforestry system with various sources of incomes in order to improve income resilience to overcome rubber price volatility (Snoeck et al., 2013).

The Rubber Agroforestry System (RAFS) is an innovative approach to improve the lives of smallholders by developing and promoting model farms with quality planting materials of high yielding rubber clones to meet farmers' requirements. This system also creates opportunities for income enhancement through integration of arable crops on the inter-rows during the immature phase of rubber. It also promotes the development of alternative livelihood options through the production of planting materials of domesticated high-value agroforestry tree crops and mini-livestock in matured plantations. Rubber farmer in Indonesia soften perceive these rubber agroforests as their 'rubber bank' in which secondary products can be gained such as fruit, timber, building, and handicraft materials

Rubber intercropping

Rubber intercropping is already a type of agroforestry system, as rubber is a tree. Tree density in standard rubber monoculture is ca. 550 trees/ ha with 6- to 8-m inter-rows, leaving 75% of the soil surface uncultivated opening the opportunity for additional of other plants or trees. Figure 1 shows different management schemes for rubber. Bellow three types of intercropping systems are presented (Vrignon-Brenas et al., 2019).

Temporary rubber intercropping system

A temporary intercropping system allow to plant diversity of plants at different stages of development of the production system. Usually intercropping with light demanding crops such as maize, pineapple, banana, cassava among others during plantation establishment is a common practice. Other crops like pepper can be added at after 5 – 7 years of establishment (Figure 1).

Permanent rubber intercropping system

The second intercropping approach is to establish or keep perennial crops when rubber plantations start to develop a shade environment and maintain the crops during the whole rubber production cycle. Typical examples are cocoa, tea, coffee, or species belonging to the ginger family. Typically, those crops are grown together with shade trees under moderate shade of 20–50 %. These crops are original components of the forest understory, and the respective systems evolved from forests Rubber would function as the "shade tree" in this type of system.

With a strongly reduced number of rubber trees (160 trees or ca. 1/3rd of the standard) cocoa could be grown with economic success. Consequently, a considerable increase in rubber row distance, to e.g. 16–20 m, is a common feature of permanent rubber intercropping, often accompanied by the establishment of narrow rubber double rows with a row distance of only 2–2.5 m. This results in a similar number of rubber trees with a respective yield per hectare compared to the standard spacing and, together with the intercrop, allows for a better land use efficiency (LER). In some coffee-rubber systems, producers used a 2.5 m wide rubber-double rows alternate with 10 rows of coffee with a respective row distance of 2 m. This results in a spacing of 24 m between rubber rows.

Timber oriented rubber intercropping system

Besides the commonly promoted intercrops such as tea, coffee, or cocoa, timber trees can also be considered for a rubber intercropping system. While rubber timber itself developed from a waste-product into an economically important component of rubber plantation management there are also reports on the integration of timber trees into rubber.

If properly selected and established, only little labor input might be required to maintain them. Since regular harvests as in food crops are of no concern, the labor challenge is mitigated. Reported tree species are for example teak (*Tectona grandis*) and Neem (*Azadirachta indica*) in Thailand. Since teak is a light demander, its integration needs to be done during the early establishment phase of rubber

	Monoculture	Intercropping -temporary-	Intercropping -permanent- 'short rotations'	Intercropping -permanent- 'long rotations'	Mixed System -permanent- "Jungle rubber"	Timber oriented systems
Plantation establishment	Intensive soil preparation; standard spacing	Intensive soil preparation; standard spacing	Intensive soil preparation; adapted spacing[a]	Intensive soil preparation; adapted spacing[a]	Derived from slash & burn	Transformation of existing plantations
"Light phase" year 1–3	Products: None	Products: annual/bi-annual crops—light demanders: corn, pine apple, banana, chili, … Alternatives: soil protection with cover legumes	Products: annual/bi-annual crops: corn, pine apple, banana, …	Products: annual/bi-annual crops: corn, pine apple, banana, … Products: perennial crops: tea, coffee, cacao, pepper, … Timber trees	Products: annuals (bi-annuals) , staple food: upland rice, corn, Cassava …	Products: annual/bi-annual crops—light demanders: corn, pine apple, banana, chili, … Alternatives: Soil protection with cover legumes
Transition phase year 3–7	Products: None	Products: perennial crops—shade tolerant: tea, coffee, pepper, … Alternatives: soil protection with cover legumes	Products: annual/bi-annual crops—light demanders[a] annual/bi-annual crops—shade tolerant: gingers, mushrooms, …	Products: perennial crops: tea, coffee, cacao, pepper, … Timber trees	Products: NTFP	Products: perennial crops: tea, coffee, cacao, pepper, … Timber trees Latex
"Shade Phase" year 7–30	Products: Latex	Products: perennial crops—shade tolerant: tea, coffee, pepper Until age 10–13! Latex	Products: annual/Bi-annual crops—light demanders[a] Annual/Bi-annual crops—shade tolerant: gingers, mushrooms, … Latex	Products: perennial crops: tea, coffee, cacao, pepper, … Timber trees Latex	Products: Latex (after year 10!) NTFP	Integration of tree species at an rubber age of 10–20 years Products: Latex Timber 'Species protection'
Replacement year +/−30	Products: Timber	Products: Timber	Products: Timber	Products: Timber	Products: Timber NTFP	Products: Timber transformation into forest???

[a] Only with adapted plantation design and widened row spacing, respectively

Figure 1. Rubber management schemes (Vrignon-Brenas et al., 2019).

Species for intercropping

Besides management aspects, such a tree density and distancing, the selection of the intercrop species is key for the success of he different management schemes of the rubber intercrop. Producer must consider the type of intercrop, whether temporary or permanent for select the species. Also, the planting time regarding the rubber. See figure 2 for the species that have been intercropped with rubber. Specie are mainly focused in South East Asia.

Initial intercrops

Annanas comosus (L.) Merr. / pineapple / f
Arachis hypogaea L. / groundnut / f
Cannabis sativa L. / hemp / r-m
Capsicum annuum L. / chili pepper / f
Citrullus lanatus (Thunb.) Matsum. & Nakai / water melon / f
Colocasia esculenta (L.) Schott / taro / f
Cucurbita spp.
Cymbopogon citratus (DC.) Stapf / lemon grass / f
Dioscorea alata L. / purple yam / f
D. cayenensis Lam. /yellow yam /f
Glycine max (L.) Merr. /soybean/ f
Gossypium spp. / cotton / r-m
Ipomoea batatas L. (Lam.) / sweet-potato / f
Manihot esculenta Crantz / cassava / f
Morinda officinalis F.C. How / morinda / m
Musa x paradisiaca L. / banana, plantain / f
Nicotiana spp. / tobacco / d
Oryza sativa L. / upland rice / f
Osteospermum spp. / African Daisy / o
Pachyrrhizus tuberosus (Lam.) Spreng. / yam bean / f
Passiflora edulis Sims / passion fruit / f
Phallus indusiatus Vent. / bamboo fungus/ d
Pisum sativum L. / pea / f
Pogostemon cablin (Blanco) Benth. / patchouly / d
Saccharum officinarum L. / sugarcane / f
Sorghum bicolor (L.) Moench / sorghum / f
Vigna radiata (L.) R. Wilczek / mung bean / f
Voandzeia subterranea (L.) Thouars / bambara groundnut / fs
Zea maiys L. / maize / f

Permanent intercrops

Acacia mangium Willd. / acacia / t
Afzelia sp. / t
Alpinia oxiphylla / Izhe / m
Amomum longiligulare T.L. Wu / hai nan sha ren / m
Ammomum villosum Lour. / sha ren / m
Amorphohallus konjac K. Koch / konjac / f
Anacardium occidentale L. / cashew nut / f
Annona reticulata L. / custard-apple / f
Aquilaria sp. / eaglewood / d
Archidendron pauciflorum I.C. Nielsen / dogfruit / f
Areca catechu / betel nut/ d
Artocarpus sp.
Azadirachta indica A. Juss. / neem tree / d, t
Betula alnoides Buch.-Ham. ex D. Don / alder birch / t
Calliandra sp. / false mesquite / t, r-m
Carica papaya L. / papaya / f
Cinamomum verum J. Presl / cinnamon / f
Cofea sp. / coffee / d
Dalbergia sp. / i.a. rosewood / t
Dipterocarpus sp. / t
Durio zibethinus Rumph. ex Murray/durian/f
Endospermum malaccense Benth. ex Müll. Arg. / t
Eucalyptus sp. / eucalyptus / t
Fagraea fragrans Roxb. ex Carey & Wall. /t
Garcinia mangostana L. / mangosteen / f
Gliricidia spp. / gliricidia / t
Gmelina arborea Roxb. ex Sm. / gmelina / t
Gnetum gnemon L. / gnemon / f
Hopea sp. / t
Lansium domesticum Corrêa / langsat / f
Macadamia sp. / macadamia nut / f

f: food - staple food & spice
t: tree – timber and multi purpose trees
d: drug – stimulant & medicine
r-m: raw material
o: ornamentals

Figure 2. Plant species for rubber intercropping (Vrignon-Brenas et al., 2019).

Constraints for intercropping

Light transmission

The integration of additional plants in rubber plantations faces several bio-physical challenges, mainly related to light availability and competition. Rubber plantations induce a fast drop in light transmission. Incident radiation in the inter-rows is sufficient during the first 4–5 years of the plantation for the development and growth of a soil cover of annual or perennial plant species. But, after three years of planting, light transmission is reduced in about 50%. Additionally, they show very low light levels at the ground after canopy closure (Figure 3). Therefore, the type of intercropping and planting time is essential to the success of a rubber intercropping. (Langenberger et al., 2017).

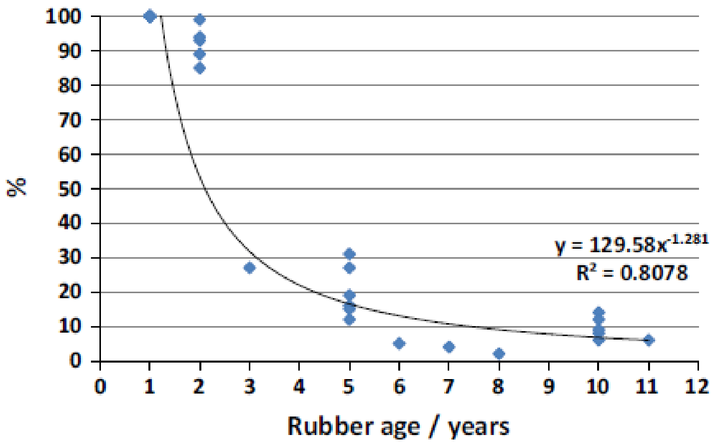

Figure 3. Light decrease in young rubber plantations (Plant density 300 – 600 trees/ha).

Water and nutrients availability

Intercrops do not only compete with rubber for light but also for water and nutrients. Rubber, although forming a remarkable taproot, is considered a so-called surface feeder, which establishes a dense root mat in the uppermost 30 cm of the soil. The roots of neighbouring rubber rows meet quite early in plantation life. For example, cocoa, often suggested as rubber intercrop, shows a similar root strategy as rubber, developing a tap root and a feeder-root system in the upper 20 cm of the soil, extending in a radius of up to 7 m from the stem thus overlapping with the rubber root system. And while Some authors claim that intercropping of cocoa and coffee in mature rubber plantations was not very successful due to root competition and therefore for water and nutrients (Vrignon-Brenas et al., 2019).

Opportunities for rubber intercropping systems

Fertilization management

Adding fertilizers during the immature period in rubber plantations has been shown to shorten the immature period and increase latex yield in the first years of production. Therefore, shortening the unproductive period. Also, an adequate nutrient management will improve nutrient availability therefore improving the overall productivity of the system. Nutrient management at the plot scale needs to be based on the combination of soil and leaf diagnoses and a balanced nutrient budget between soil NPK supply and NPK tree demand using agroecological practices, such as re-use of organic matter (cover crop and crop residues). Indeed, a soil diagnosis at the very beginning of the immature period would secure NPK supply during the first years of tree growth, while the nutrient budget would provide a long-term strategy for NPK application based upon predicted plant growth and soil functioning (Chotiphan et al., 2019; Vrignon-Brenas et al., 2019).

Management practices to avoid competition

The selection of the intercrop is essential to reduce competition. For example, ideally the plant species should be complementary to the main crop and not competitive. In case that the intercrop competes with rubber. Some practices can reduce competition between rubber and the intercropped crop. In Figure 4 is shown a trial in which trenches are made to reduce root competition between rubber and coffee (Vrignon-Brenas et al., 2019).

Figure 4. Trenches to avoid root competition between coffee and rubber (Vrignon-Brenas et al., 2019).

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