High Carbon Stock Forests Assessment

MOPP & CRC

Maryland, Grand Kru & River Gee Counties

Liberia

November 2016

Table of content

List of tables

List of figures

List of maps

Disclaimer

This report was compiled by TFT for the sole use of the company that requested the assessment. This report may not be relied upon or quoted by any other party without written agreement from TFT.

TFT exercised due care in preparing this report, but has not independently verified information provided by others. No other warranty, express or implied is made in relation to the conduct of the review and contents of this report. Therefore, TFT assumes no liability for any loss resulting from errors, omissions or misrepresentations made by others.

The use of this report by unauthorized third parties without written authorization from TFT shall be at their own risk, and TFT accepts no duty of care to any such third party. Any findings, opinions, or recommendations stated within this report are based on the circumstances and facts as existed at the time TFT performed the work. Any changes in such circumstances and facts upon which this report is based may adversely affect any findings, opinions, or recommendations contained in this report.

Abbreviations

AGB	Above Ground Biomass
CRC	Cavalla Rubber Corporation
DBH	Diameter at Breast Height
FPIC	Free Prior and Informed Consent
GIS	Geographic Information System
GVL	Golden Veroleum Liberia
HCS	High Carbon Stock
HCV	High Conservation Value
HDF	High Density Forest
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
LDF	Low Density Forest
MDF	Medium Density Forest
MOPP	Maryland Oil Palm Plantation
MoU	Memorandum of Understanding
NGO	Non-Governmental Organisation
OL	Open Land
PAP	Project Affected People
RBA	Rapid Biodiversity Assessment
S	Scrub
SIFCA	Société Immobilière et Financière de la Côte Africaine
SOP	Standard Operating Procedure
TFT	The Forest Trust
UICN	Union Internationale pour la conservation de la nature
YRF	Young Regenerating Forest

Introduction

The SIFCA Group engaged TFT to conduct a High Carbon Stock (HCS) assessment of 6 individual concessions covering a total area of 6825 ha in three different states of Liberia. This was SIFCA's first experience of HCS assessments in Liberia. The objective of the work was to:

- Ensure plantation development did not result in the conversion of High Carbon Stock forest areas, and
- Provide on the job training to SIFCA plantation teams to implement HCS methodology and integrate the results across future development areas

The assessment commenced in September 2016 with a visit to the sites, training and field sampling. TFT personnel Mr. Gerome Tokpa, Mr. Dominique Herman and Mr. Ibrahima Fofana led the assessment.

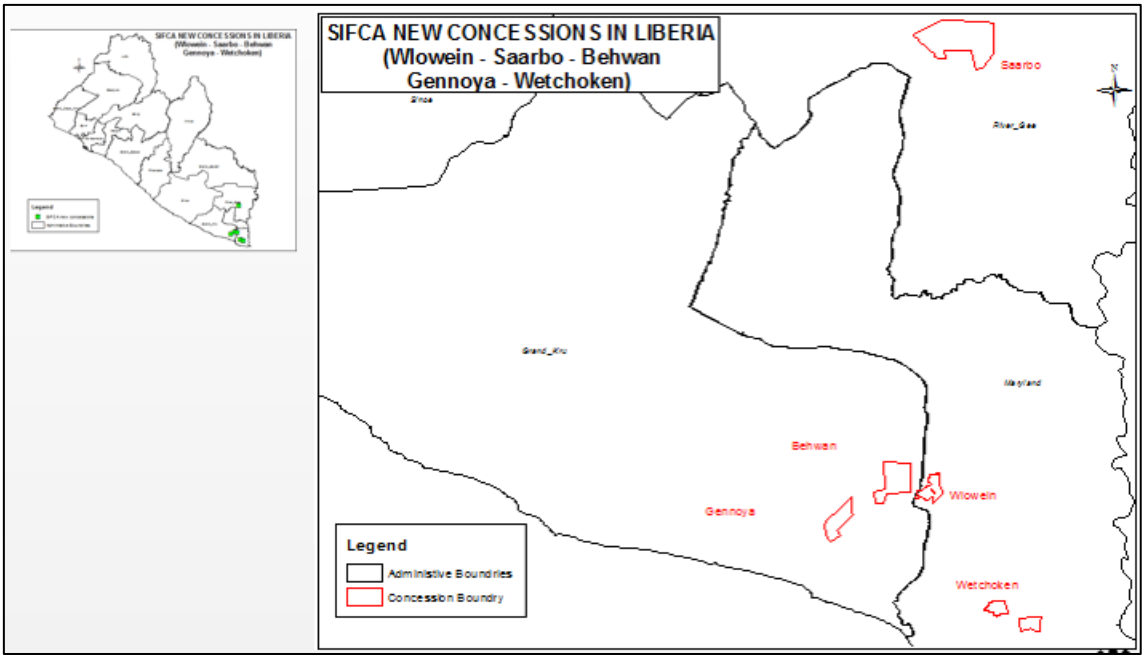
The HCS assessment followed the methodology developed and published by the HCS Approach Steering Group in the HCS Approach Toolkit. The methodology follows simple forest inventory processes to classify vegetation into various classes and generate carbon values per land cover strata. The results of this process are then run through a Decision Tree process that incorporates ecological and social (including participatory mapping and the right to Free, Prior, and Informed Consent – FPIC – of local peoples) factors for development on their lands and operational factors to determine a land use plan that incorporates the conservation of High Carbon Stock Forests.

Scope of assessment

This HCS assessment focused on six concessions that are situated in 3 neighbouring regions of East Liberia (Maryland, Grand Kru and River Gee). They are pictured in red in the map below.

Table 1: Concessions concerned with HCS assessment

Concessions	Company	Location	Surface (ha)
Wlowein	MOPP	Maryland	714
Wetchoken	MOPP		891
Behwan	MOPP	Grand kru	1740
Gennoya	MOPP		1000
Sarbo	CRC	River Gee	2480
Total	2	3	6825



Map 1: Localisation of Sifca concessions in Liberia

Objectives of this HCS Assessment

The main objective of this HCS assessment is to determine for each of the six concession:

- Identify potential areas of High Carbon Stock Forests to be conserved and maintained.
- Identify areas of potential development for palm oil or rubber development.
- Identify potential areas of expansion or development of future concessions.

This HCS assessment will propose land use planning suggestions that should be consolidated with participatory mapping derived from consultations with local communities.

Methodology

Two-Phased Approach

The HCS methodology involves two phases. Phase One consists in the stratification of the vegetation within the development area to determine potential HCS zones. Phase Two takes the result of Phase One to study, identify and determine the patches of potential HCS to be

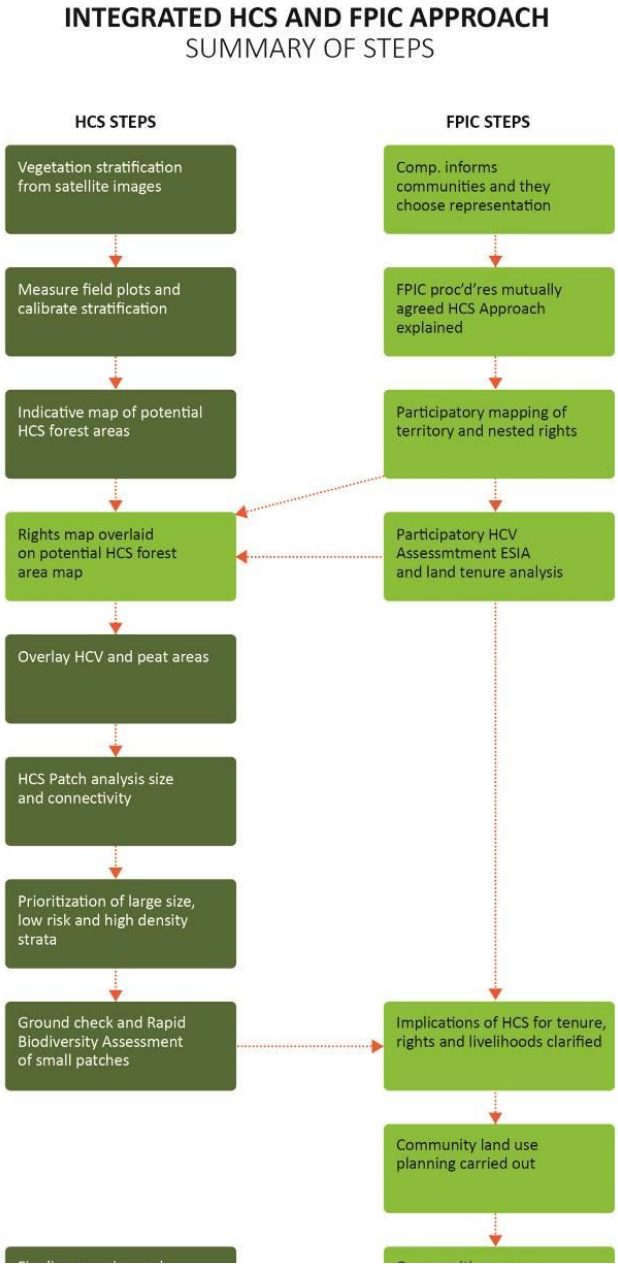


Figure 1: Integration of HCS and FPIC

incorporated into the land use plan for the development area. The two phases are illustrated below.

Phase 1 – Identifying potential HCS Forest Areas

Quantifying biomass and carbon stocks is one of the key components of addressing emission reductions from deforestation and forest degradation (Gibbs et al. 2007[1]), and a number of methodologies have evolved to do so. Many are based on the proportional relationship between aboveground biomass (ABG) and the product of wood density, tree diameter and total height (e.g. Chave et al. 2005[2], Brown 1997[3] etc.). Unfortunately, the assessment was not able to identify suitable studies or biomass equations that focused on Nigerian forests. In the absence of a locally suitable equation for this study TFT determined that the general allometric equation for Tropical Moist Forests developed by Chave et al. 2005[2] to be the most suitable. This is explained in more detail in the section called "Calculating Carbon and Biomass".

Given the scale of areas needing assessment and limited time and resources, a combination of remote sensing data analysis with ground-based field data provides an effective approach and forms the basis of the stratification step in the HCS analysis.

---

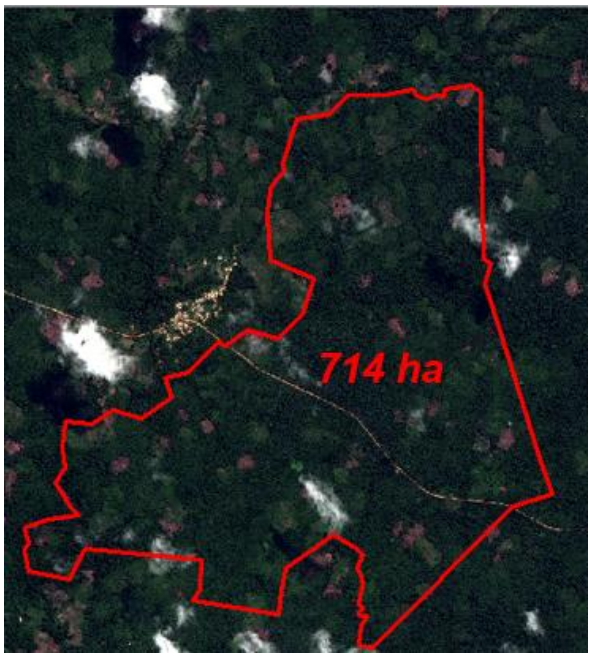
[1] Gibbs, H.K., S. Brown, J.O. Niles, J.O. and J.A. Foley (2007). "Monitoring and estimating tropical forest carbon stocks: making REDD a reality". *Environmental Research Letters* 2 (4): 045023.

[2] Chave, J., C. Andalo, S. Brown, M. A. Cairns, J. Q. Chambers, D. Eamus, H. Folster, F. Fromard, N. Higuchi, T. Kira, J. P. Lescure, B. W. Nelson, H. Ogawa, H. Puig, B. Riera, and T. Yamakura (2005). "Tree allometry and improved estimation of carbon stocks and balance in tropical forests." *Oecologia* 145: 87–99.

[3] Brown, S. (1997). "Estimating biomass and biomass change of tropical forests: A primer." *Rome: FAO Forest Resources Assessment Publication* No. 134

STRATIFICATION IMAGE ANALYSIS AND VEGETATION STRATIFICATION IN THE CONCESSION

The preliminary stratification process depends heavily on the quality of satellite imagery. The process of stratification starts with the optimisation of the visualisation of satellite imagery (Contrast, Saturation, Intensity etc…) and the projection of geospatial concession limits onto these satellite images. Example: Wlowein concession overlayed on a high resolution satellite image.



Once this step has been completed, the Vegetation Stratification can start. It is a process to stratify the land cover of an area into relatively homogenous classes using satellite imagery. Given the high quality of the imagery we had access to and the fact that the slight cloud cover interfered with the unsupervised stratification process, a Visual Stratification approach was favoured to complete the vegetation stratification:

Visual Stratification is based on a user with excellent knowledge and information of the land cover situation who is able to determine each land cover class from a very high resolution satellite image (1,5m resolution). This method is rarely used when the area being analysed is very large. Example: the Wlowein concession and a 500m buffer after a preliminary visual stratification

TFT completed a visual stratification using high resolution SPOT imagery (1,5m resolution). The image capture dates were from 2016 and 2014. The visual stratification was conducted by Ibrahima Fofana and Dominique Herman from TFT.

The visual stratification was done using Geographical Information System software (ArcGIS). Based on the results of the visual and unsupervised analysis the following 4 land cover classes (or strata) and their corresponding area in hectares was identified.

HCS assessments focus on potential HCS strata. Non-HCS strata are removed from further analysis. Although Open Land is generally recognized as containing very low levels of biomass, it remains important to take samples of these areas to confirm that the stratification is accurate. The potential HCS strata are defined below:

- **High Density Forest**: Close to intact forests, they present very little signs of degradation, close to primary forest state.
- **Low Density Forest**: Appears to be remnant forest but highly disturbed and recovering (may contain plantation/mixed garden)
- **Young Regenerating Forest**: Mostly young re-growth forest, but with occasional patches of older forest within the stratum. A lot of this strata is partially swampy forest in this concession.
- **Young Scrub**: Recently cleared areas, some woody growth and grass-like ground cover
- **Open Land**: Very recently cleared land with mostly grass or crops, few woody plants.

Socialization & Participatory Mapping

Prior to conducting fieldwork it is important to engage local communities to present the HCS concept and process. Ideally this should form part of the initial engagement with communities through the process of Free, Prior and Informed Consent (FPIC). Communities should be presented with a balanced proposal of development and conservation that incorporates the conservation of High Carbon Stock areas. Without presenting a balanced package, the risk is that communities will expect an area to be entirely developed when this may not be feasible based on HCV and HCS assessments.

Participatory mapping should be commenced and largely completed prior to conducting HCS assessments. Areas that communities identify as important to maintain for their livelihood should be excluded from HCS assessment as well as from development. Starting a HCS assessment without this data can lead to conflict with communities or an escalation of conflict where communities assert their right (whether legally acknowledged or not) to parcels of land.

HCS assessments normally begin with a socialization process with local communities, to explain the process and engage them in participatory mapping. For this study some socialisation work was conducted by Sifca community liaison officers and TFT to ensure that no conflict related to the concession exists.

Field Sample Distribution

Field samples for HCS assessments focus on assessing the land cover situation within potential HCS strata. Even though open land is likely to contain very low levels of carbon, the

HCS assessment process does seek to test a limited number of samples to confirm this assumption. The largest proportion of field samples is distributed in Young Scrub, Young Regenerating Forest and Low Density Forest.

Determining the appropriate number of samples to measure in each stratum is difficult to predict at the commencement of the field assessment unless locally available data on vegetation and biomass variability is available. In the absence of such data we took a precautionary approach and measured many sample plots. The plot sample distribution was random.

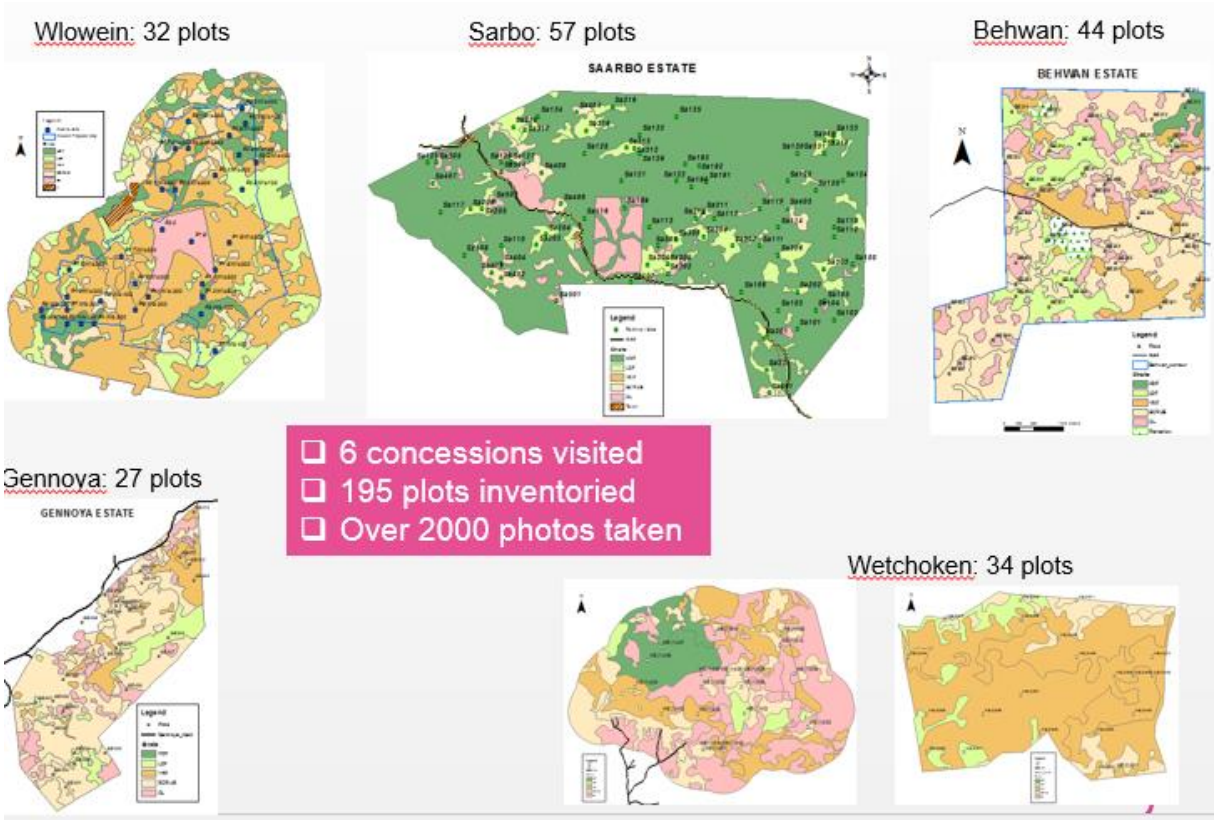
For the current assessment TFT and Sifca teams completed the measurement of 195 sample plots distributed across the 6 concessions that account for approximately 6825 ha of potential HCS strata. The focus was to measure plots in all of the potential HCS and non-HCS strata, namely Low Density Forest, Young Regenerating Forest, Young Scrub and Open Land. The majority of the plots are in LDF, YRF and YS stratum that represents a large part of the studied area.

The table below illustrates the number of plots per concession:

Table 2: Number of plots per concession

Concession	Surface area of concession (Ha)	Number of plots
Wlowein	714	32
Wetchoken	891	34
Behwan	1740	44
Gennoya	1000	27
Sarbo	2480	58
Total	6825	195

The maps below illustrate the plot sampling plans for each concession:



Map 2: Plot sampling plans for each concession

Sample Plot Measurement

High carbon stock (HCS) inventories aim to approximate the carbon pool of above-ground live biomass of large plant species (plants that have a diameter at breast height greater than or equal to 5cm). This includes both tree and non-tree species.

The measured carbon pool includes stem, stump, branches, bark, seeds and foliage. It excludes:

- Forest understory including small diameter plant species (below 5cm diameter at breast height), vines, epiphytes, and other non-tree vegetation components
- Below-ground biomass, i.e. living biomass of roots
- Deadwood
- Litter
- Soil organic matter

Sample plots consisted of two concentric circles from a centre point with a total area of 500m2 or 0.05ha. From a centre point, the first sub plot was measured by using a measurement tape of pre-measured rope that was firmly pulled to a distance of 5.64m. Within this radius around

the centre point measurement, teams measured all plants with a diameter at breast height (DBH) greater than or equal to 5cm. A second sub plot was then established by measuring a distance of 12.62m with a firmly pulled measurement tape or premeasured rope. All plants with a DBH greater than or equal to 20cm were measured. Thus in each plot, small diameter plants of 5cm up to 19.9cm were measured in the smaller plot (100m2 surface area), and larger plants with a diameter greater than or equal to 20cm DBH were measured within the entire plot area. Figure 2 below illustrates the plot design.

The measurement of the plots was performed by three teams trained by TFT, one team leader and 4 team members that were SIFCA' workers and people from the nearby community. Photos and field notes were taken at each plot to help enrich the data available for the analysis.

Plot measurements were compiled into an Access database for further analysis.

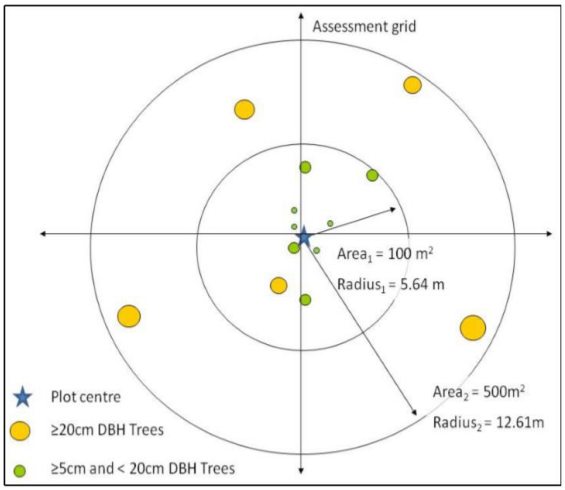


Figure 2: Plot measurements

Calculating Biomass and Carbon

The HCS assessment process uses allometric equations to estimate biomass. Allometric equations help estimate characteristics of a tree that are difficult to measure by instead measuring correlated attributes of the same tree. Field sampling in the Sifca concessions therefore only measured DBH, which was then used to determine the biomass of the entire plant above ground.

Many allometric equations exist around the world; some are specific to one forest type or tree species, others are more generic to cover a broader range of situations. Allometric equations are typically developed from large samples to improve accuracy.

In the absence of a locally suitable equation for this study TFT determined that the general allometric equation for Tropical Moist Forests developed by Chave et al. 2005 to be the most suitable. This equation integrates specific tree density and Diameter at Breast Height (DBH) to calculate biomass:

Moist forest stands:

$$\langle AGB \rangle_{est} = \exp\left(-2.977 + \ln\left(\rho D^2 H\right)\right) \equiv 0.0509 \times \rho D^2 H$$

AGB_{est}: Above Ground Biomass estimate, ρ: Wood specific gravity, D: Tree Diameter at 1,30m, H: Tree height

NB: During this assessment tree height was not measured, so it was considered proportional to the diameter of the tree

This biomass regression equation is developed from a set of data for broadleaf species from tropical regions. The biomass regression equation provides estimates of biomass per tree in kg. The equation applies to moist zones where rainfall approximately balances potential evapotranspiration (e.g. 1500-4000mm rain/year and a short dry season). The equation is considered applicable to the current study in the absence of local or regional specific equations. The biomass was then converted to carbon using the IPCC guidelines which provides a generic conversion factor of biomass to carbon. This conversion factor is 0.47 (IPCC 2006).

CORRECTION AND VALIDATION OF STRATIFICATION MAPS FOR EACH CONCESSION

Using the combined information of carbon values per plot, photos taken on each plot, satellite imagery and vegetation species information, the land cover stratification is revised to reflect the actual situation with more precision. The following diagram illustrates this process:

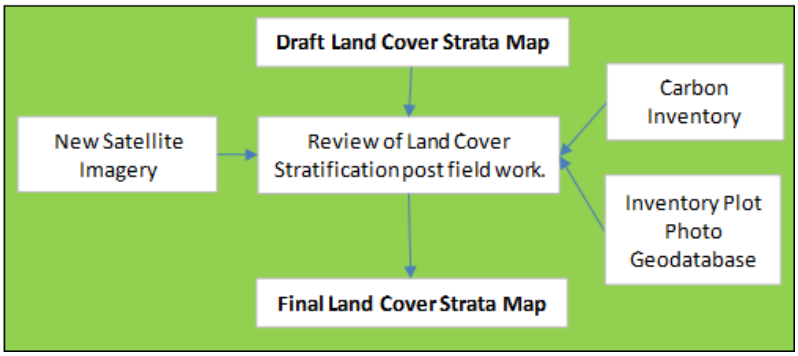
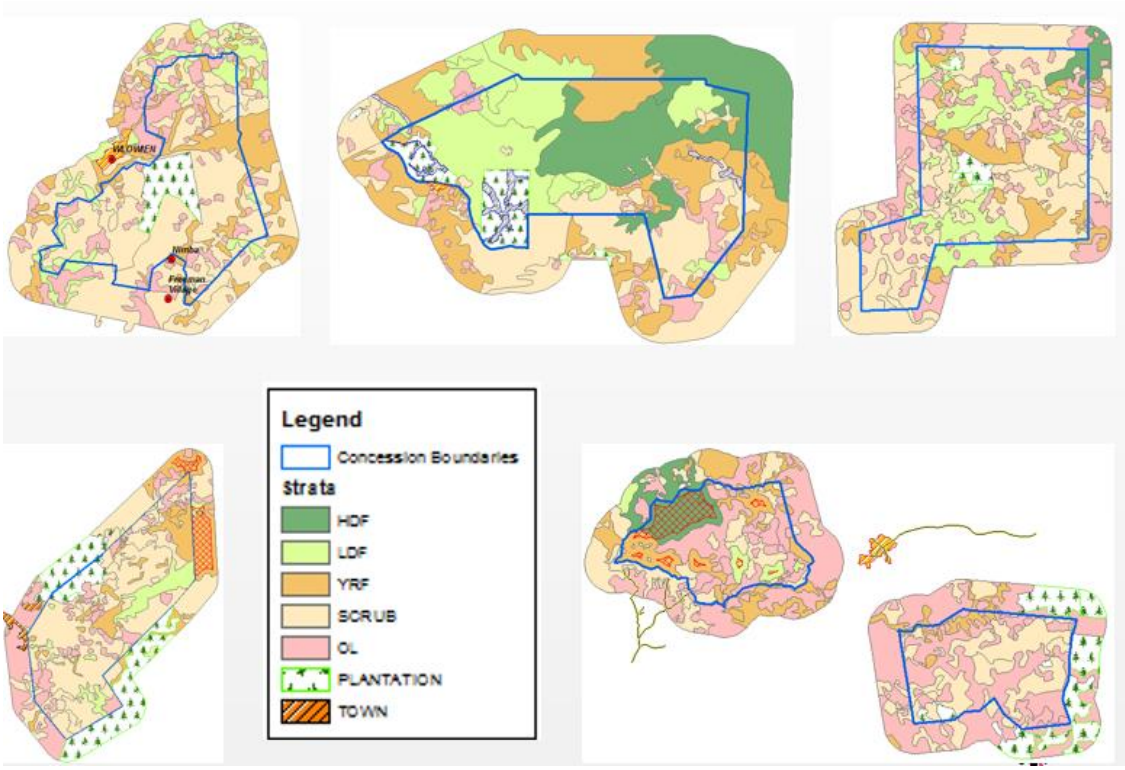


Figure 3: Correction and validation of stratification maps for each concession.

Here is an illustration of the combination of information used to determine the final stratification of an area:

Figure 4: illustration of the combination of information used to determine the final stratification of an area



Map 3: Results of the vegetation strata for each concession after the groundtruthing process and map revision

The maps on table 3 reflect the results of the vegetation strata for each concession after the groundtruthing process and map revision:

Table 3: Unsupervised stratification results

	HCS Strata						Non HCS Strata					
Concessions	HDF (ha)	%	LDF (ha)	%	YRF (ha)	%	SCRUB (ha)	%	OL (ha)	%	Plantation	%
Wlowein	0		44	6	84	12	409	57	109	15	68	10
Wetchoken1	76	18	24	6	104	25	70	17	150	35	0	0
Wetchoken2	0	0			24	5	203	44	220	48	11	2
Behwan	32	2	275	16	217	12	871	50	290	17	55	3
Gennoya	0	0	96	10	123	12	595	59	140	14	49	5
Sarbo	576	24	334	14	759	31	371	15	114	5	273	11

Phase 2 – Patch Analysis and Conservation

Once the potential HCS forest areas have been identified, they must be analysed and sorted via conservation science principles, conversion/encroachment risks and other aspects of the concession to determine the most viable ways to maximize HCS forest protection and restore ecologically viable areas of forest. This requires assessing the shape, size, connectivity, habitat quality and threats to ensure that it is possible for the conserved HCS areas to continue to be considered into the future and is ecologically viable. Based on HCS work completed in Indonesia and Africa, along with a recent round of peer review by key scientific specialists in their respective fields, a HCS Decision Tree has been developed to take these factors into account. The most recent Decision Tree is presented below (Figure 7).

Decision Tree Process

The Decision Tree takes the above results of stratification and sample plot measurements, along with other key information such as legal requirements (e.g. riparian areas and steep slopes) and High Conservation Value (HCV) areas to make decisions on appropriate management of actions for patches of HCS.

To assist with running the HCS assessment data through the Decision Tree a simple analysis was completed to merge HCS patches that were physically connected and to identify "core areas" of each patch. The core area is the most important part of the patch, ecologically speaking, because it has been protected from the forest "edge effects" of differences in light, temperature, soil moisture content and wind turbulence which start to occur as the forest is

fragmented. In the Geographical Information System (GIS), each patch is analysed to determine the size and shape of the core once the approximate forest edges are taken into account. As illustrated below some patches may have a large overall area, however due to the shape of the patch the core area is much smaller.

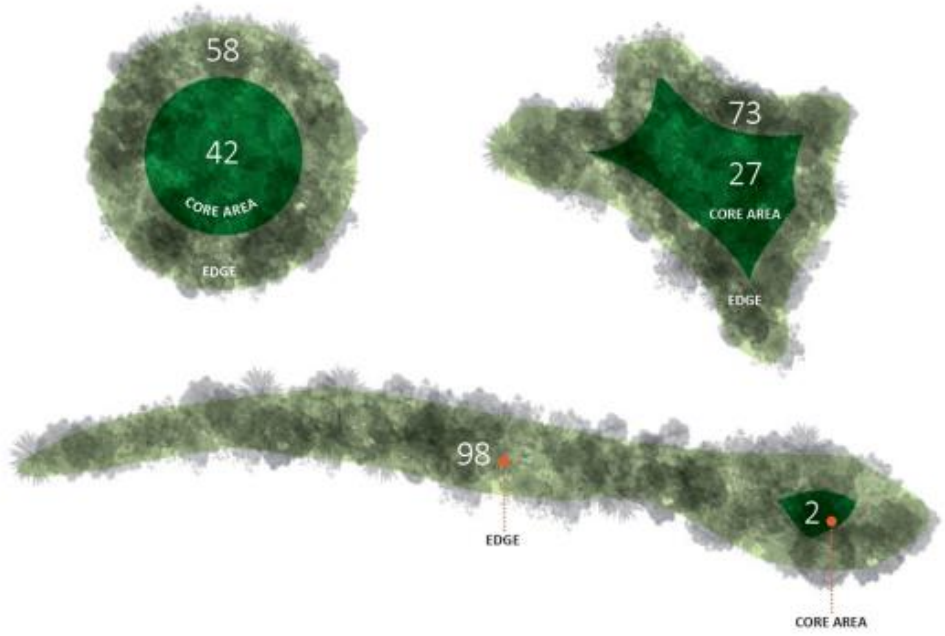


Figure 5: Core Area Analysis

Rapid Biodiversity Assessment

Some patches have been identified to follow a Rapid Biodiversity Assessment, in Behwan concession, Wetchoken bloc 1 and Gennoyah. This study is necessary as no HCV study has been conducted, and indication on potential biodiversity present in these patches is essential before making land use planning decisions. This could be conducted by locally available organisms such as the Flora and Fauna International, World Chimpanzee Foundation or the Sapo National Park biodiversity monitoring rangers. If SIFCA decides to go ahead with the land use planning without conducting a RBA, TFT recommends that these patches be conserved and that corridors try to be created between them and HCS conservation areas or stream buffers.

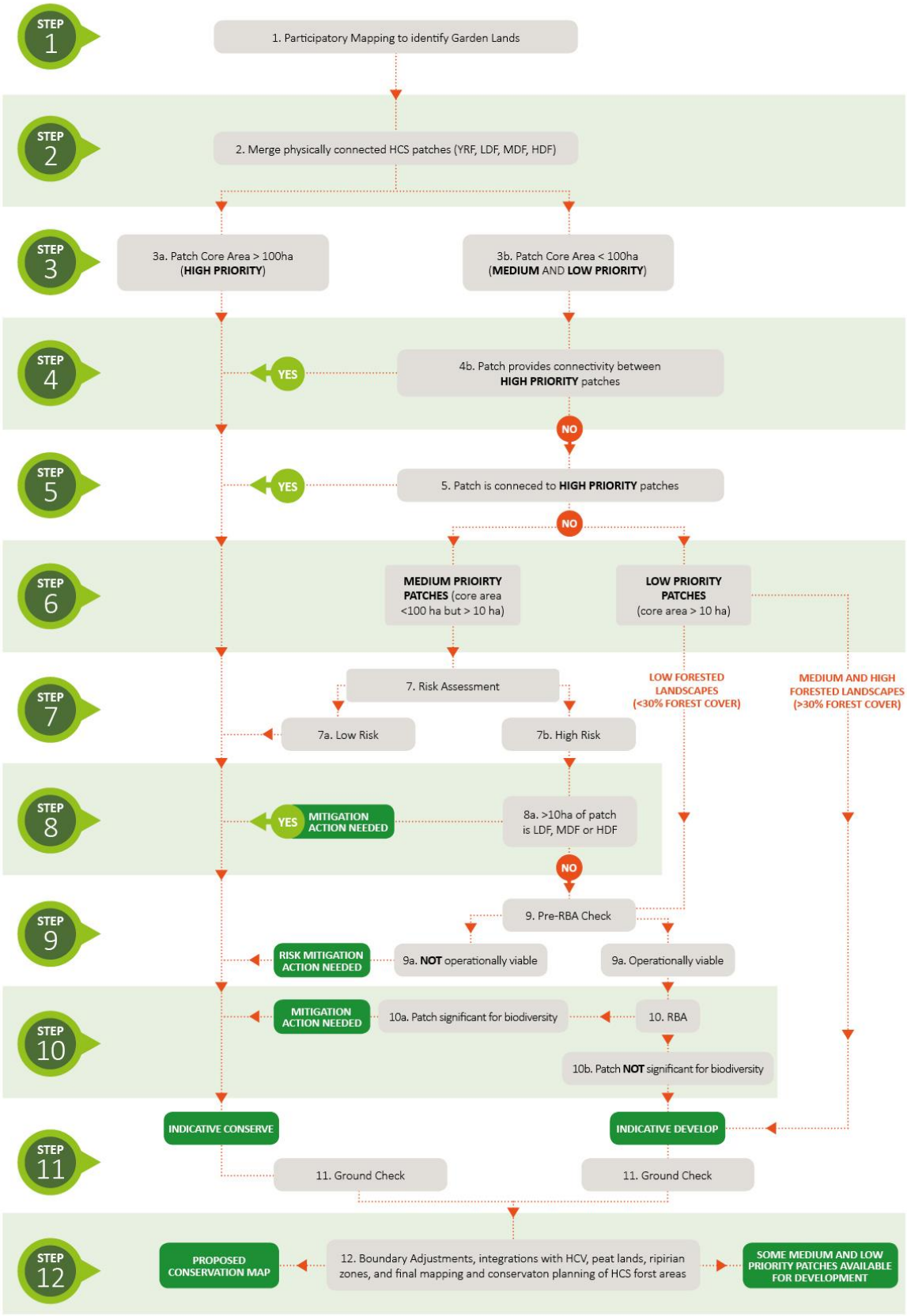


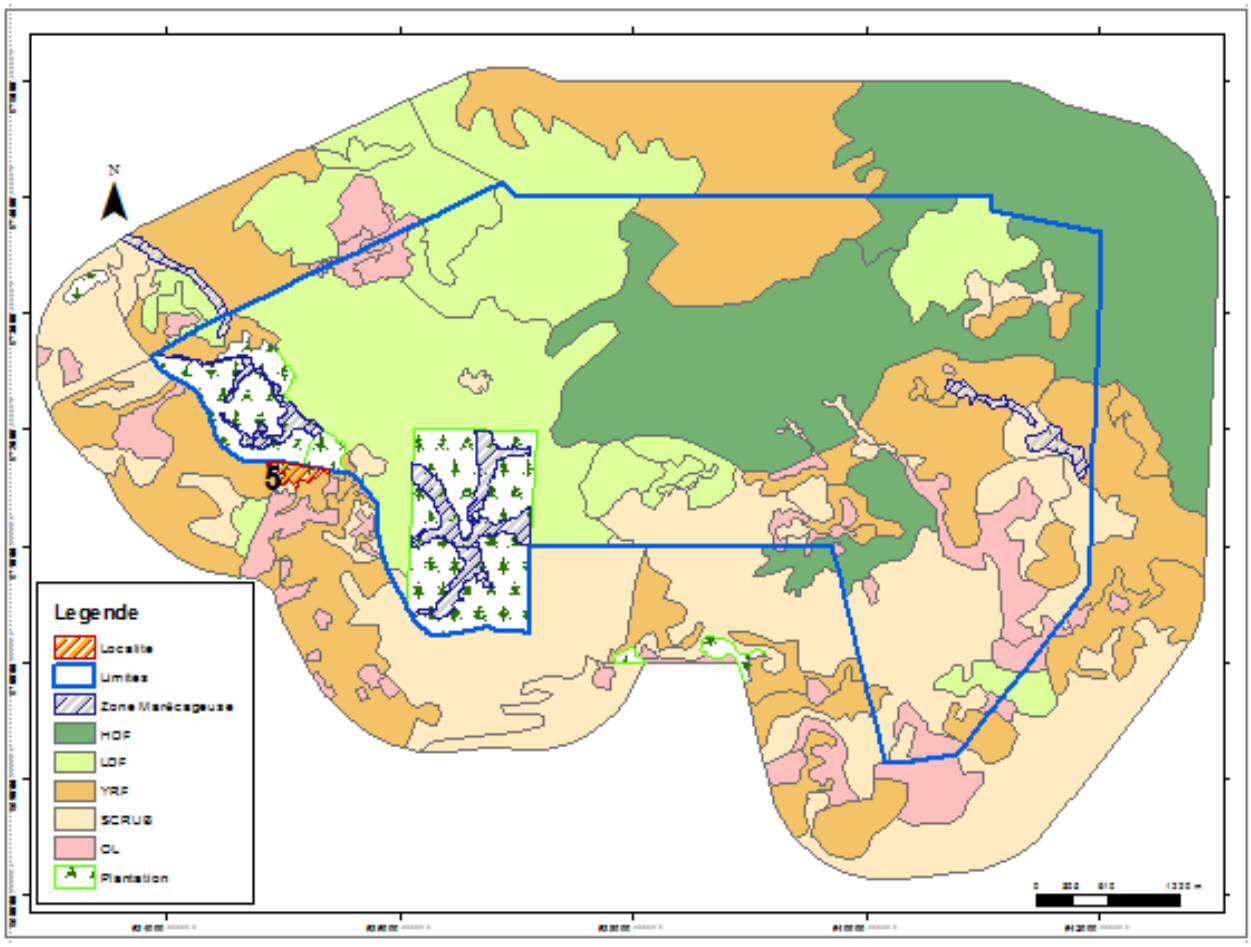
Figure 6: HCS Decision tree

Results of HCS assessment

Sarbo Concession

The Sarbo Concession is located in the densely forested River Gee county. It is the largest of the 6 concessions analysed, accounting for 2427 ha. To better integrate the ecological importance of the forests in the surrounding landscape we analysed a 1km buffer around the concession. 58 plots where sampled in this concession.

Below is the detail of the final HCS stratification for the Sarbo concession:



Map 4: Final HCS stratification for the Sarbo concession

The following table synthesizes the results of land use classes for the Sarbo Concession:

Table 4: Surface area per land cover type in Sarbo concession

Strata	Surface area (ha)	Percentage (%)
HDF	576	24
LDF	705	29
YRF	388	16
SCRUB	371	15
OL	114	5
Plantation	273	11
Total	2427	100

Carbon Summary Estimates By Land Cover Type

Concession: SAARBO

Inventory: CRC

Land Cover	*Average tonnes of Carbon / ha*	*Number of plots in strata*	*Standard Error*	*95% Confidence Limits*	
				Lower	*Upper*
HDF	254.5	7	99.9	10.0	498.9
LDF	199.7	16	43.7	106.6	292.9
YRF	73.3	5	28.3	-5.2	151.8
S	43.1	16	19.5	1.5	84.8
OL	15.8	12	14.1	-15.3	46.9

Tree Equation: Chave et al 2005 - Circonference

Tree Formula: C (t/ha) = Exp(-1.499+2.148*ln(DBH/3.14)+0.207*ln(DBH/3.14)^2-0.0281*ln(DBH/3.14)^3))/1000*(Wood Density)

Source: J. Chave, C. Andalo, S. Brown, M. A. Cairns, J. Q. Chambers, D. Eamus, H. Fölster, F. Fromard, N. Higuchi and T. Kira, et al, (2005). Tree allometry and improved estimation of carbon stocks and balance in tropical forests. OECOLOGIA, Volume 145, Number 1, 87-99, DOI: 10.1007/s00442-005-0100-x

Palm Equation: Cylinder- For palms, Unpublished

Palm Formula: C (t/ha) = (PI*([DBH])^2/40000)*[Tree_Ht])*(Palm Density)

Source: TFT Liberia, unpublished

Carbon Summary Estimates By Land Cover Type

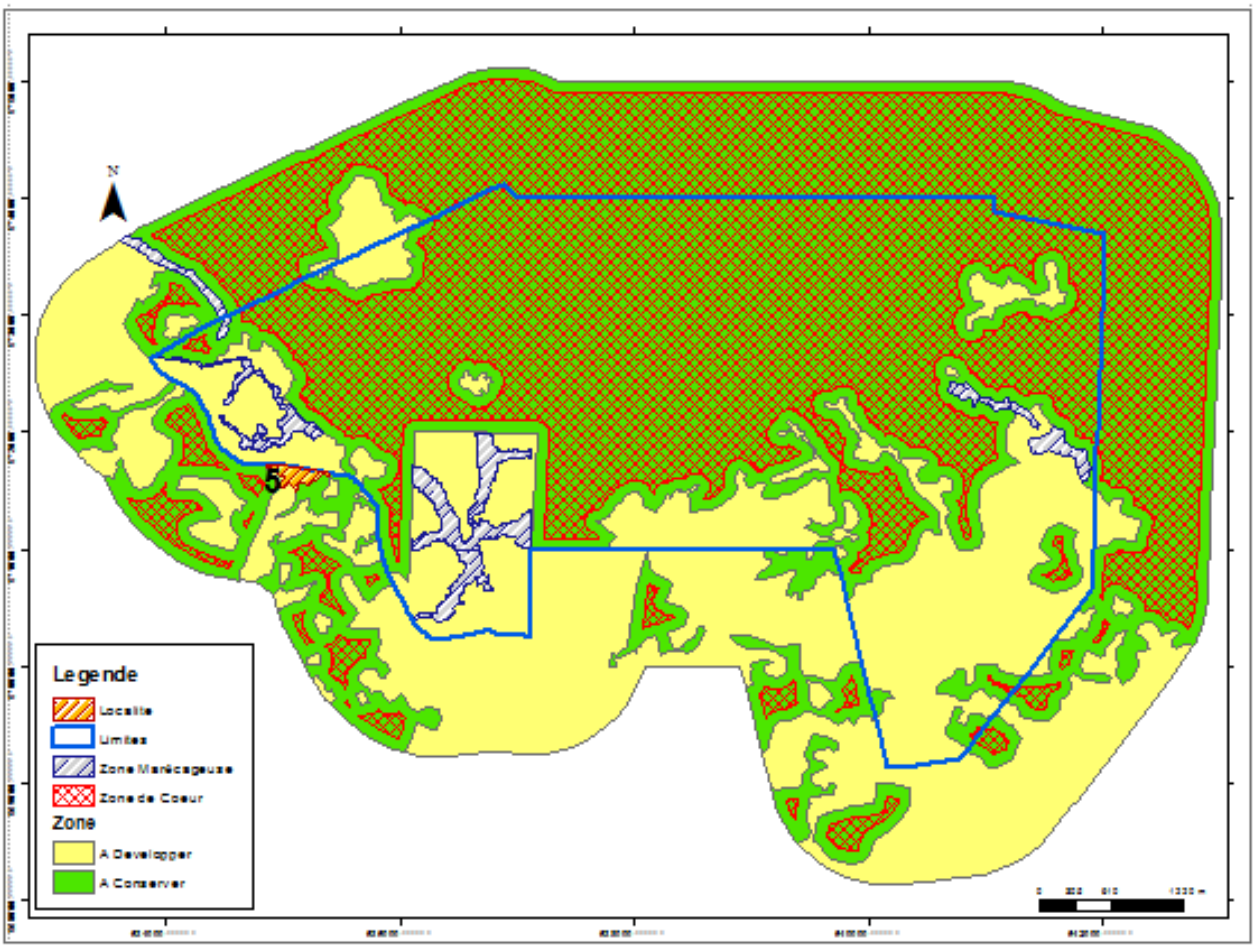
Concession: SARBO

Inventory: CRC

Land Cover	*Stems per ha by Circumference Classes*						*Carbon (tonnes per ha) by Circumference Classes*					
	Total	*5 - 10*	*10 - 20*	*20 - 30*	*30 - 50*	*> 50*	*Total*	*5 - 10*	*10 - 20*	*20 - 30*	*30 - 50*	*> 50*
HDF	**420**	0	129	83	40	169	254	0	1	1	1	252
MDF	**0**	0	0	0	0	0	0	0	0	0	0	0
LDF	**463**	0	175	73	61	154	200	0	1	1	2	196
YRF	**376**	0	180	24	52	120	73	0	1	0	2	70
SCRUB	**409**	0	244	68	36	61	43	0	1	1	1	40
OL	**150**	0	133	5	2	10	16	0	1	0	0	15
	0	0	0	0	0	0	0	0	0	0	0	0

Once the final stratification was completed, the HCS strata (HDF, LDF and YRF) were merged to identify where the important landscape forests are present. Areas that do not present interest of conservation from a HCS point of view are Scrub, Open Land and Plantation.

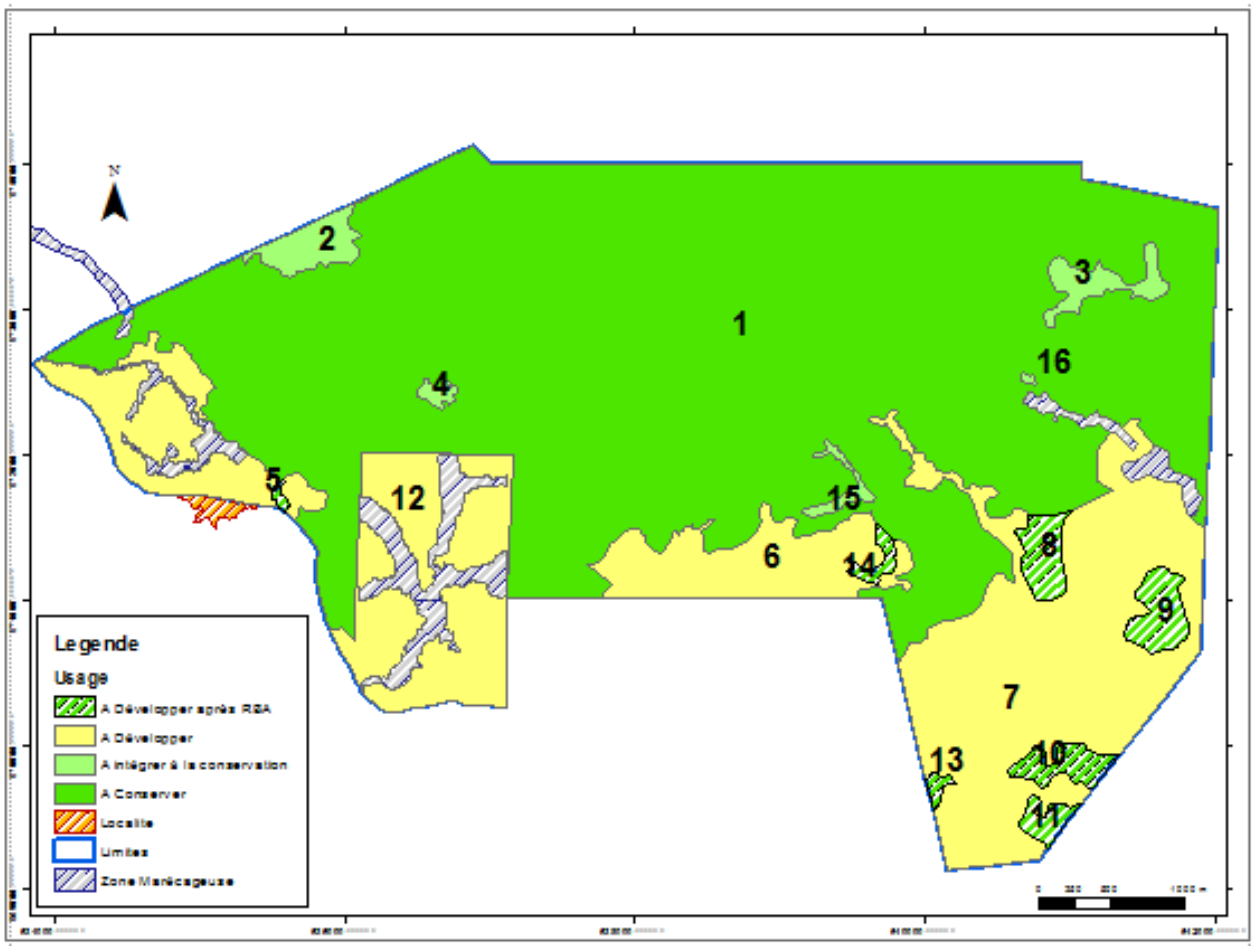
An analysis of the core of forest patches is then conducted to identify where potentially viable HCS forests are present in the area of interest. The results are presented in the following map



Map 5: HCS map for Sarbo concession

Once this result is obtained, each patch of HCS forest undergoes the Decision Tree process to obtain a proposed use in a final land use plan. In the case of Sarbo, almost all the HCS forest patches are linked and they create a coherent forest space with a very large core area. We propose a land use plan scenario that adapts to this landscape and allows for a balance between conservation and development.

TFT proposes a land use plan where there is a give and take of conservation areas to ensure coherent conservation areas and functional plantation development.



Map 6: SARBO proposed land use plan

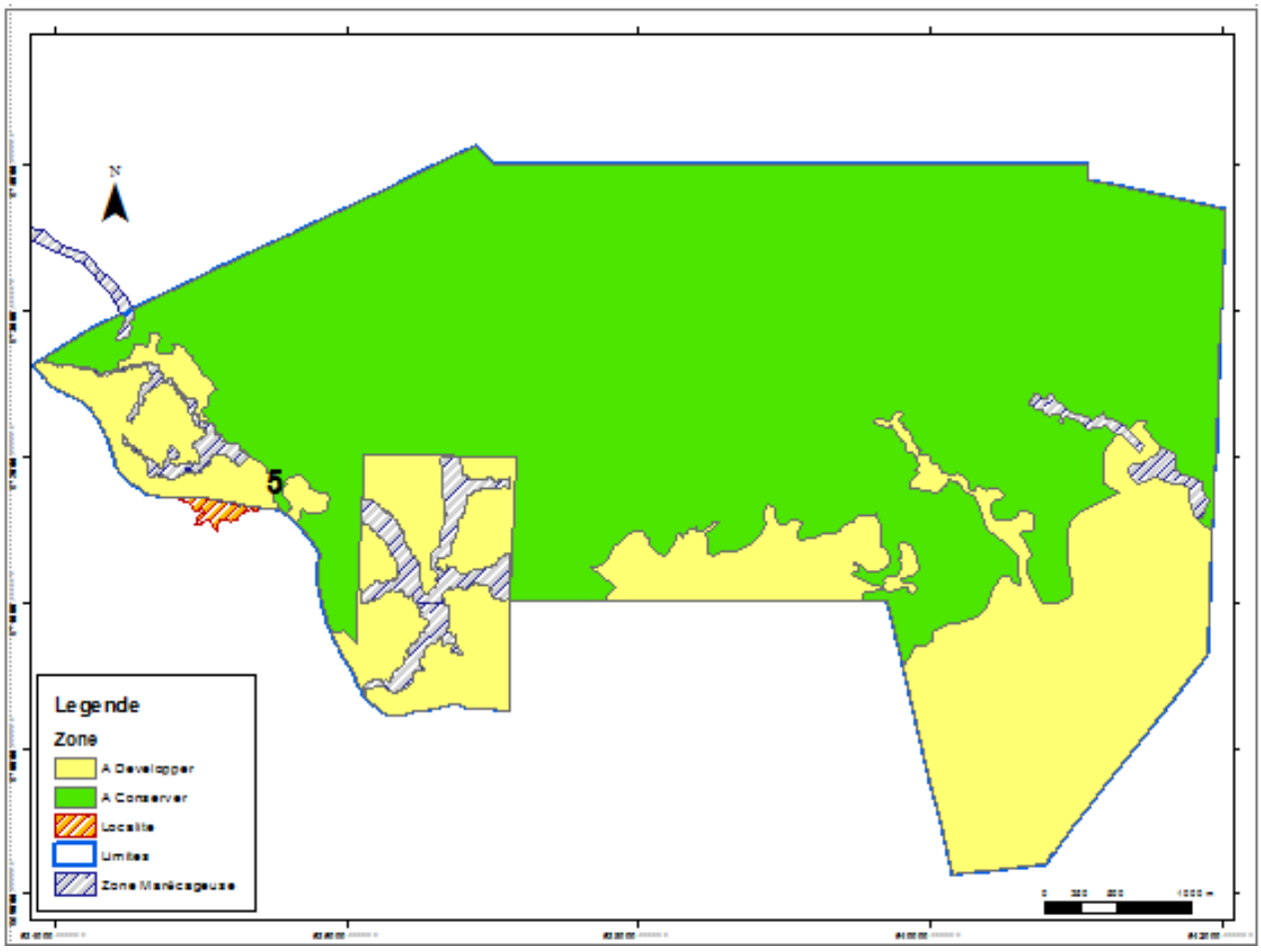
Detail of patch analysis:

Patches 2 – 3 – 4 – 15 and 16: They are small areas that could potentially be developed according to HCS criteria. However they are surrounded by forest and would not be a functional plantation area. TFT recommend their conservation, their total surface area is of 47 ha.

Patches 5 - 8 – 9 – 10 – 11 – 13 and 14: These patches all have a forest core of less than 3 ha. They are therefore considered low priority for conservation. Considering the high forest landscape in which the concession is situated, TFT recommends that these patches be developed. Their total surface are is of 44 ha.

Table 5: Potential conservation and development areas in Sarbo concession

Land use	Surface area (ha)	Percentage (%)
Conservation areas	1629	67
To add to conservation	47	2
To add to development	44	2
Potential development	632	26
Swamps	75	3
Total	2427	100



Map 7: SARBO proposed land use plan

Table 6: Proposal of surface areas for development for SARBO concession

Land use	Surface area (ha)	Percentage (%)
Conservation areas	1653	68
Swamps	75	3
Development area	699	29
Total	2427	100

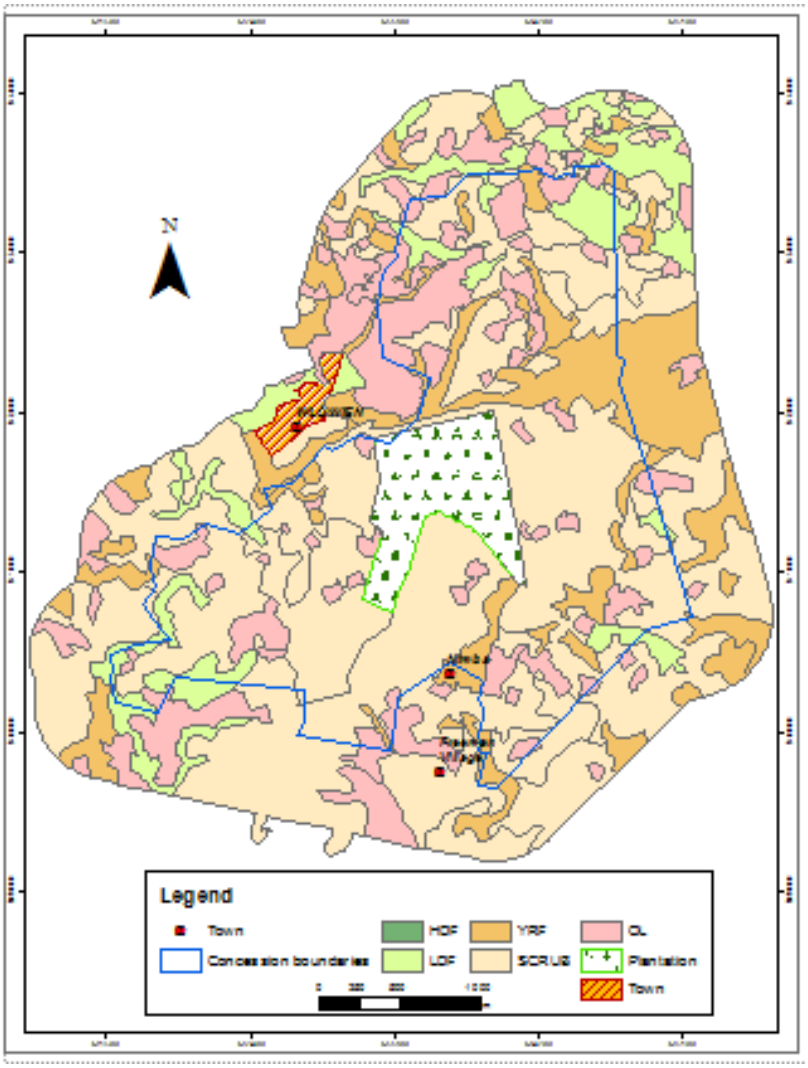
Recommendations:

Findings	**Recommendations**
During our field visit we were made aware of a land conflict between two neighbouring communities.	CRC should catalyse the resolution of this conflict.
Information about farms, plantations and community use areas within the concession area was not available during our visit.	This information should be obtained, it can be via a more detailed participatory mapping exercise with the local communities.
No HCV study was conducted on this concession,	A precise mapping of rivers and delimitation of their protection buffers should be conducted prior to development
68% of the concession is considered HCS Forest, however it is still under CRC management.	CRC should work with the local communities and governments to create a land management plan that ensures the conservation of this forest.

Wlowein Concession

The Wlowein Concession is located in Maryland County. The proposed boundaries of the concessions have changed over time, the surface area of the concession is 714 ha at the time of the assessment. To better integrate the ecological importance of the forests in the surrounding landscape we analysed a 1km buffer around the concession.

33 plots were randomly identified and measured in the concession. The following map illustrates the final HCS stratification of Wlowein concession.



Map 8: HCS stratification of Wlowein concession

Table 7: Surface area per land cover type in Wlowein concession

Strata	Surface area (ha)	Percentage (%)
HDF	0	0
LDF	44	6
YRF	84	12
SCRUB	409	57
OL	109	15
Plantation	68	10
Total	**714**	**100**

The following table is a compilation the results of the carbon analysis per strata for the Wlowein concession.

Carbon Summary Estimates By Land Cover Type

Concession: WLOWEIN

Inventory: MOPP

Land Cover	Average tonnes of Carbon / ha	Number of plots in strata	Standard Error	95% Confidence Limits Lower	Upper
LDF	230,7	3	88,9	-151,9	613,4
YRF	40,7	4	18,5	-18,3	99,7
S	31,3	12	12,9	2,8	59,8
	8,6	1			
OL	0,8	13	0,7	-0,7	2,3

Tree Equation: Chave et al 2005 - Circonference

Tree Formula: C (t/ha) = Exp(-1.499+2.148*ln(DBH/3.14)+0.207*ln(DBH/3.14)^2-0.0281*ln(DBH/3.14)^3))/1000*(Wood Density)

Source: J. Chave, C. Andalo, S. Brown, M. A. Cairns, J. Q. Chambers, D. Eamus, H. Fölster, F. Fromard, N. Higuchi and T. Kira, et al, (2005). Tree allometry and improved estimation of carbon stocks and balance in tropical forests. OECOLOGIA, Volume 145, Number 1, 87-99, DOI: 10.1007/s00442-005-0100-x

Palm Equation: Cylinder- For palms, Unpublished

Palm Formula: C (t/ha) = (PI*([DBH])^2/40000)*[Tree_Ht])*(Palm Density)

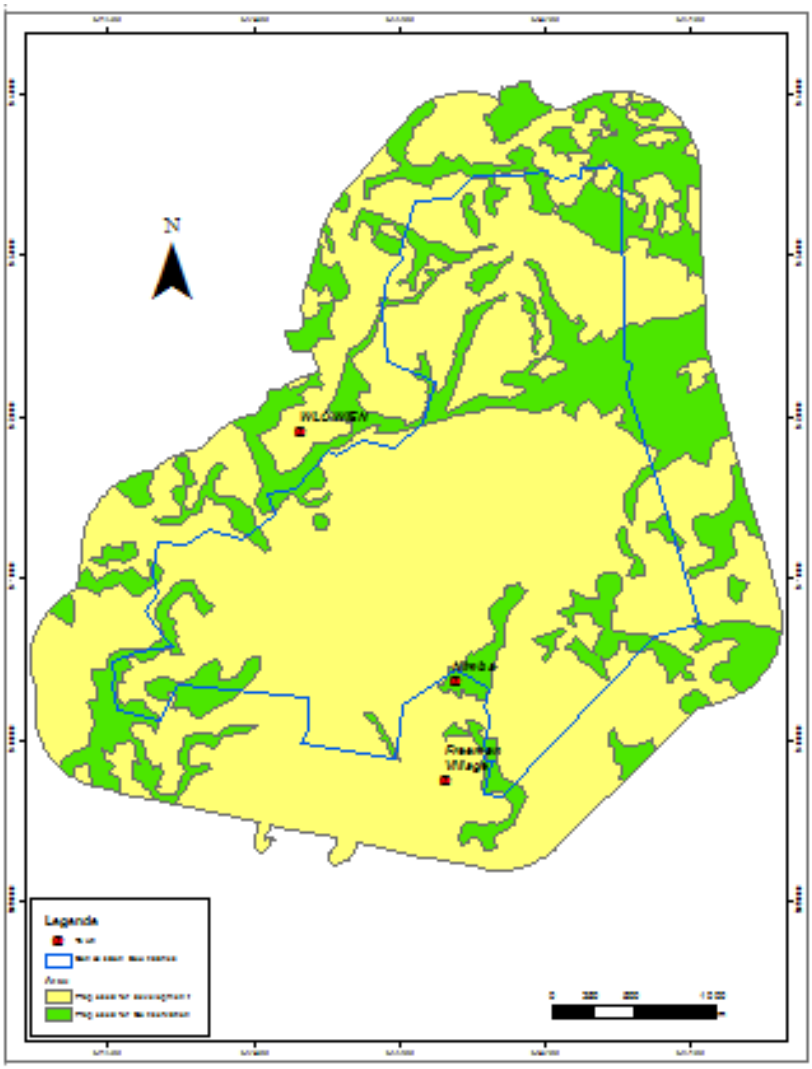
Source: TFT Liberia, unpublished

Concession: WLOWEIN

Inventory: MOPP

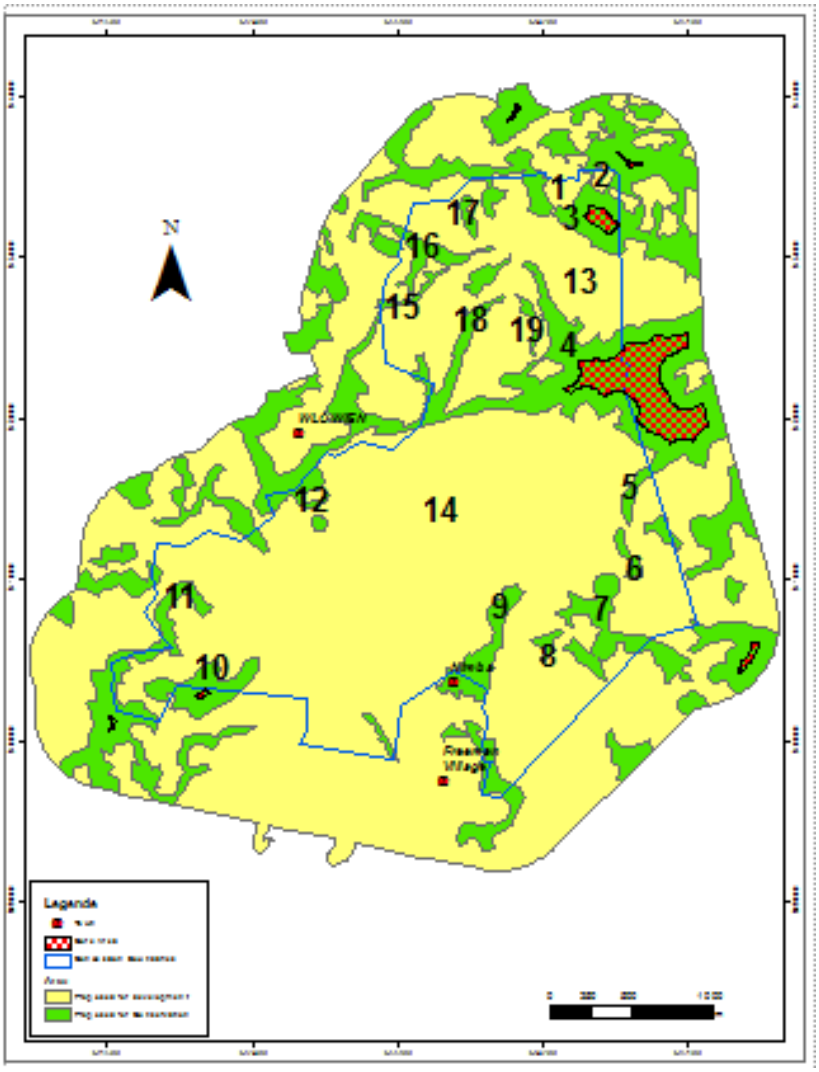
Land Cover	Stems per ha by circumference Classes						Carbon (tonnes per ha) by DBH Classes					
	Total	5 - 10	10 - 20	20 - 30	30 - 50	> 50	Total	5 - 10	10 - 20	20 - 30	30 - 50	> 50
HDF	**0**	0	0	0	0	0	**0**	0	0	0	0	0
LDF	**227**	0	33	47	33	113	**231**	0	0	0	1	229
YRF	**460**	0	200	70	65	125	**41**	0	1	1	2	38
SCRUB	**408**	0	233	77	23	75	**31**					29
OL	**38**	0	23	14	0	2	**1**	0	0	0	0	1
	440	0	400	0		40	**9**	0	1	0	0	7

The HCS classes were merged to create the HCS/non-HCS map below:



Map 9: Wlowein HCS/non-HCS map

Core areas of HCS forests were identified and a HCS patch analysis was conducted following the Decision tree rules. The map below illustrate the various core areas of the patches and certain patches are numbered.



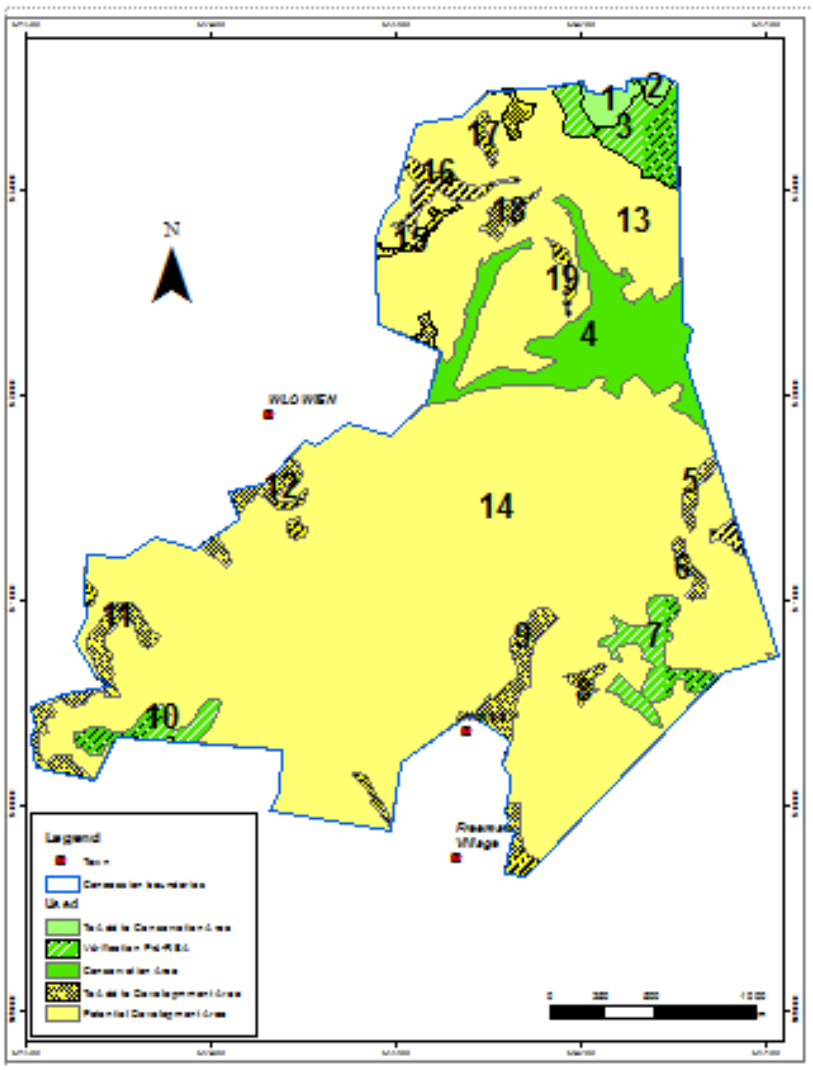
Map 10: Core HCS areas in and around Wlowein concession

In the analysis of this result, it appears that several forest patches do not have a core area. These patches are the ones numbered: 5 – 6 – 7 – 8 – 9 – 10 – 11 – 12 – 15 – 16 – 17 – 18 and 19 . Patch 10 and part of patch 7 are Low Density Forest (LDF), however they are not connected to any high priority patches. As we are in a Medium forested landscape, these patches are indicated for development without any prior field survey (Step 7 of Decision Tree), as well as patches 5 – 6 – 8 – 9 - 11 – 12 – 15 – 16 – 17 – 18 and 19 which are all Young Regenerating Forest (YRF).

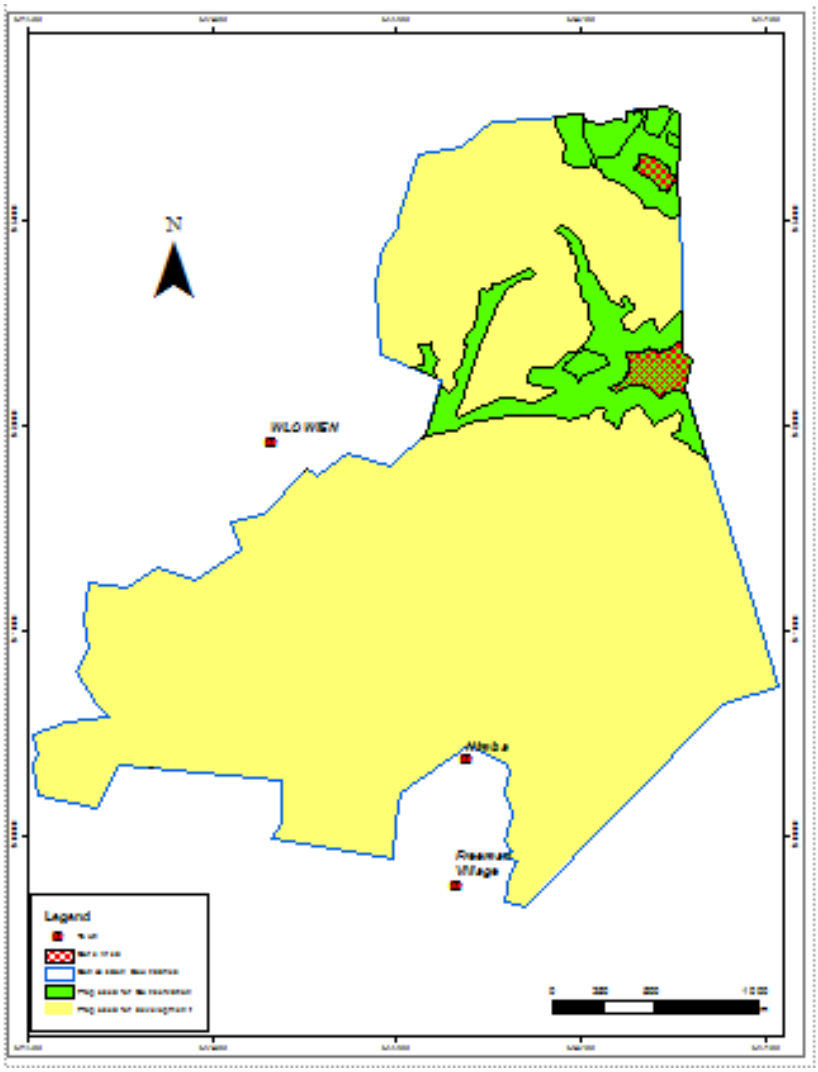
Only patches 4 and 3 have a core area. Patch 4 has a core area of 24 ha, and 6 ha of the core area are in the concession. It is solely YRF and is classified as medium priority for conservation (Step 7a of Decision Tree). The recommendation is to conserve this patch.

Patch 3 has a core area of 2 ha and is classified as LDF. It is connected to a large HCS area in the north part of the concession. As there is heavy agricultural activity in Wlowein concession, the forest cover represents approximately 25% of the landscape, it is considered a low forested landscape. A pre-RBA (pre-Rapid Biodiversity Assessment) is to be conducted on this area, according to step 9 of the decision tree. If the result of this pre-RBA indicates that this area is not viable for development, it should be conserved. However if the pre-RBA indicates that the area is viable for plantation development, a full RBA should be conducted to determine whether the area should be conserved or developed.

Patches 1 and 2 are small non HCS areas that are proposed to be included into conservation areas to guarantee a coherent and robust land use plan. These two patches, which totalise 7 ha surface area, should be integrated into conservation areas.



Map 11: Proposed patches to be conserved and developed in Wlowein concession



Map 12: First proposal of land use planning for Wlowein concession

From the below analysis, TFT suggest twos options:

Option 1:

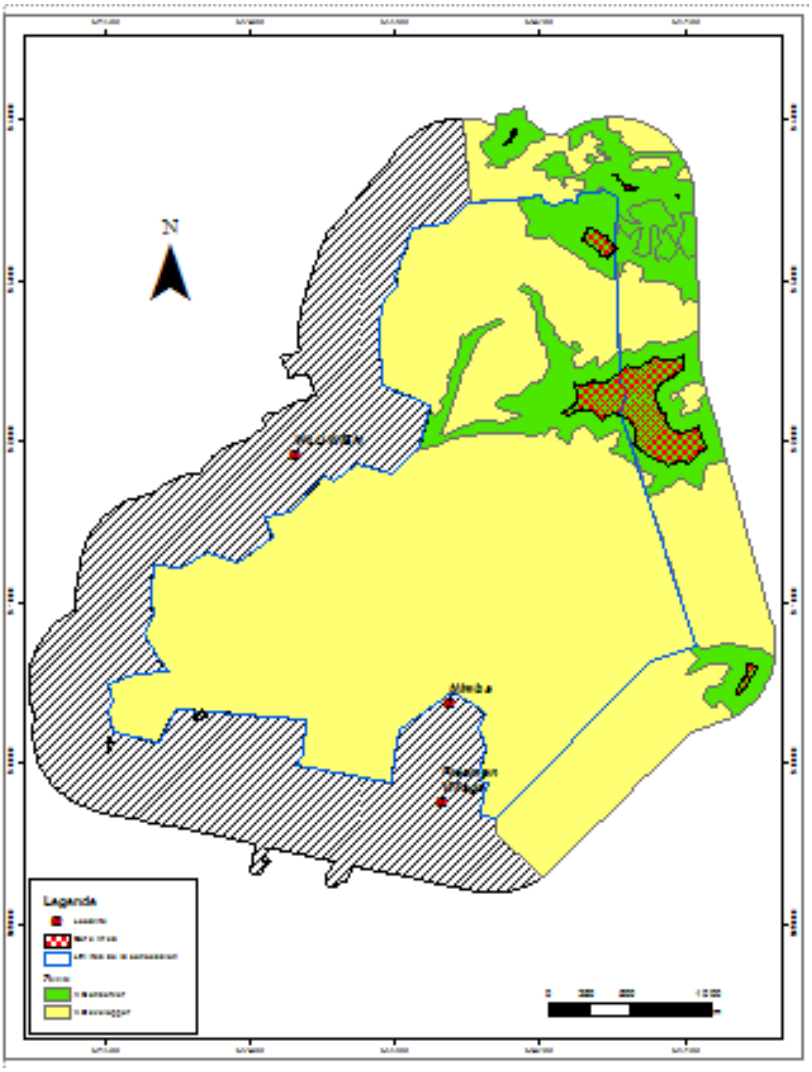
Table 8: Proposal of surface areas for development and conservation for option 1

Land use	Surface area (ha)	Percentage (%)
Conservation areas	65	9
Potential development	649	91
Total	714	100

Options 2

Another proposition would be for SIFCA to negotiate an extension of the Wlowein concession to the East, into the buffer area identified around the concession. The results of the HCS assessment in this 500m buffer around Wlowein concession shows that out of the 302 ha present, there is a potential plantation area of 200 ha and an additional 102 ha of HCS potential conservation area. If SIFCA attempts to expand the concession in this area, the total concession area would be 1016 ha out of which 177 ha would be considered for conservation (17,5%). In this land use plan proposition, the buffer area to the South and East of the concession would remain under community land tenure rights as their landbank for agricultural activity.

This expansion of the concession can only happen if a thorough consultation and FPIC process is conducted with the local communities. This should include rigorous participatory mapping with all involved communities, including identification of important cultural areas (sacred forests, shrines, grave sites etc.), agricultural areas etc. The following map and table illustrate this proposal.



Map 13: Second proposal of land use planning for Wlowein concession

Table 9: Proposal of surface areas for development and conservation for option 2

Land use	Surface area (ha)	Percentage (%)
Conservation areas	65	9
Proposed development	649	91
Total	714	100

Findings

The Wlowein concession is situated in an area of high agricultural activity. During the field visits within the concession we identified several rice plantations, sugar cane fields and perennial crops such as rubber plantations, palm oil plantations etc.

Recommendations:

- To elaborate a clear and solid land use plan, all these cropland areas within the concession need to be identified and mapped out. Appropriate discussions with the owners of these areas can take place following the FPIC process guidelines.
- Swamplands and rivers within the concession also need to be mapped out, identified and appropriate buffers determined for conservation around these water areas, this is a legal obligation within Liberian law.
- It is also essential to continue the process of community consultation and FPIC in the surrounding villages to ensure long term stability of the concession. Particularly with Nearby Village (close to Freeman village) who seemed concerned with the proximity of the concession boundary with their houses and farms. The consultation should also continue with Wlowein village and Freeman village.
- If the expansion scenario in proposition two is chosen, the FPIC process, community engagement and participatory mapping should be rigorously conducted with all concerned villages.
- Discussions concerning management of HCS areas to be conserved should be conducted. It is essential to ensure community buy in and monitoring of these areas to guarantee long term preservation of these forested areas. The results of this study should be socialised with the community and a management plan defined and implemented with the communities.

Behwan Concession

Behwan Concession is also located in Maryland County, is under MOPP management and covers a surface area of 1740 ha. 44 HCS sample plots were sampled in this concession. The data analysis related to the HCS work is presented in the following table.

Table 1 : Analysis of Carbon statistics in Behwan concession

Carbon Summary Estimates By Land Cover Type

Concession: BEHWAN

Inventory: MOPP

Land Cover	*Average tonnes of Carbon / ha*	*Number of plots in strata*	*Standard Error*	*95% Confidence Limits*	
				Lower	*Upper*
HDF	293,2	1			
LDF	126,6	7	20,0	77,7	175,5
YRF	76,9	7	29,7	4,1	149,7
S	32,9	21	9,8	12,4	53,4
OL	0,5	8	0,3	-0,2	1,2

Tree Equation: Chave et al 2005 - Circonference

Tree Formula: C (t/ha) = Exp(-1.499+2.148*ln(DBH/3.14)+0.207*ln(DBH/3.14)^2-0.0281*ln(DBH/3.14)^3))/1000*(Wood Density)

Source: J. Chave, C. Andalo, S. Brown, M. A. Cairns, J. Q. Chambers, D. Eamus, H. Fölster, F. Fromard, N. Higuchi and T. Kira, et al, (2005). Tree allometry and improved estimation of carbon stocks and balance in tropical forests. OECOLOGIA, Volume 145, Number 1, 87-99, DOI: 10.1007/s00442-005-0100-x

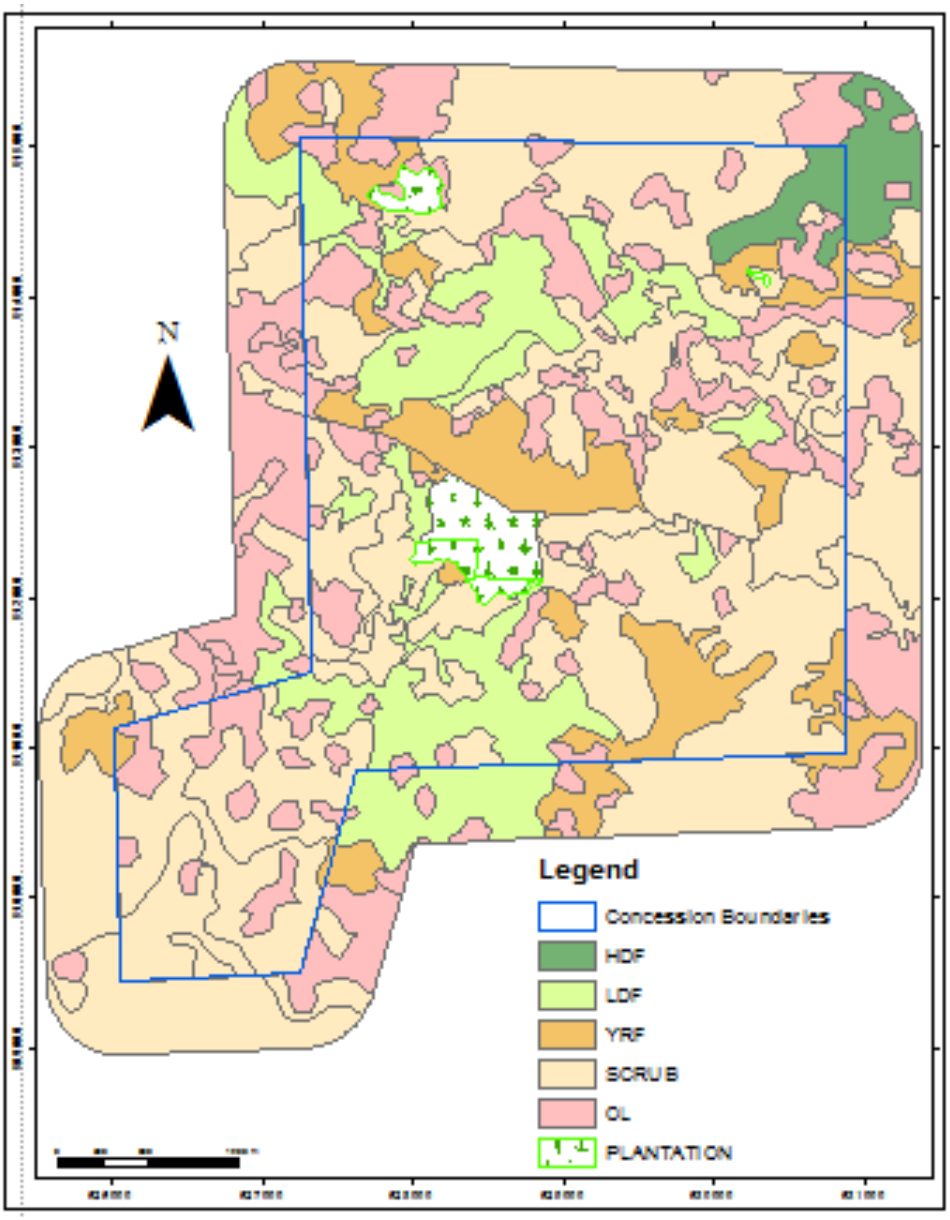
Table 2 : Carbon Summary Estimates By Land Cover Type

Concession: BEHWAN

Inventory: MOPP

Land Cover	*Stems per ha by DBH Classes*						*Carbon (tonnes per ha) by DBH Classes*					
	Total	*5 - 10*	*10 - 20*	*20 - 30*	*30 - 50*	*> 50*	*Total*	*5 - 10*	*10 - 20*	*20 - 30*	*30 - 50*	*> 50*
HDF	**300**	0	0	40	60	200	**293**	0	0	0	3	290
MDF	**0**	0	0	0	0	0	**0**	0	0	0	0	0
LDF	**620**	0	300	63	34	223	**127**	0	1	1	1	124
YRF	**540**	0	214	80	83	163	**77**	0	1	1	3	73
SCRUB	**449**	0	243	68	49	90	**33**	0	1	1	2	30
OL	**120**	0	113	8	0	0	**1**	0	0	0	0	0
	0	0	0	0	0	0	**0**	0	0	0	0	0

The final HCS land cover map was developed using the analysis of this data, incorporating other field information such as photos, GPS points, and botanical analysis:



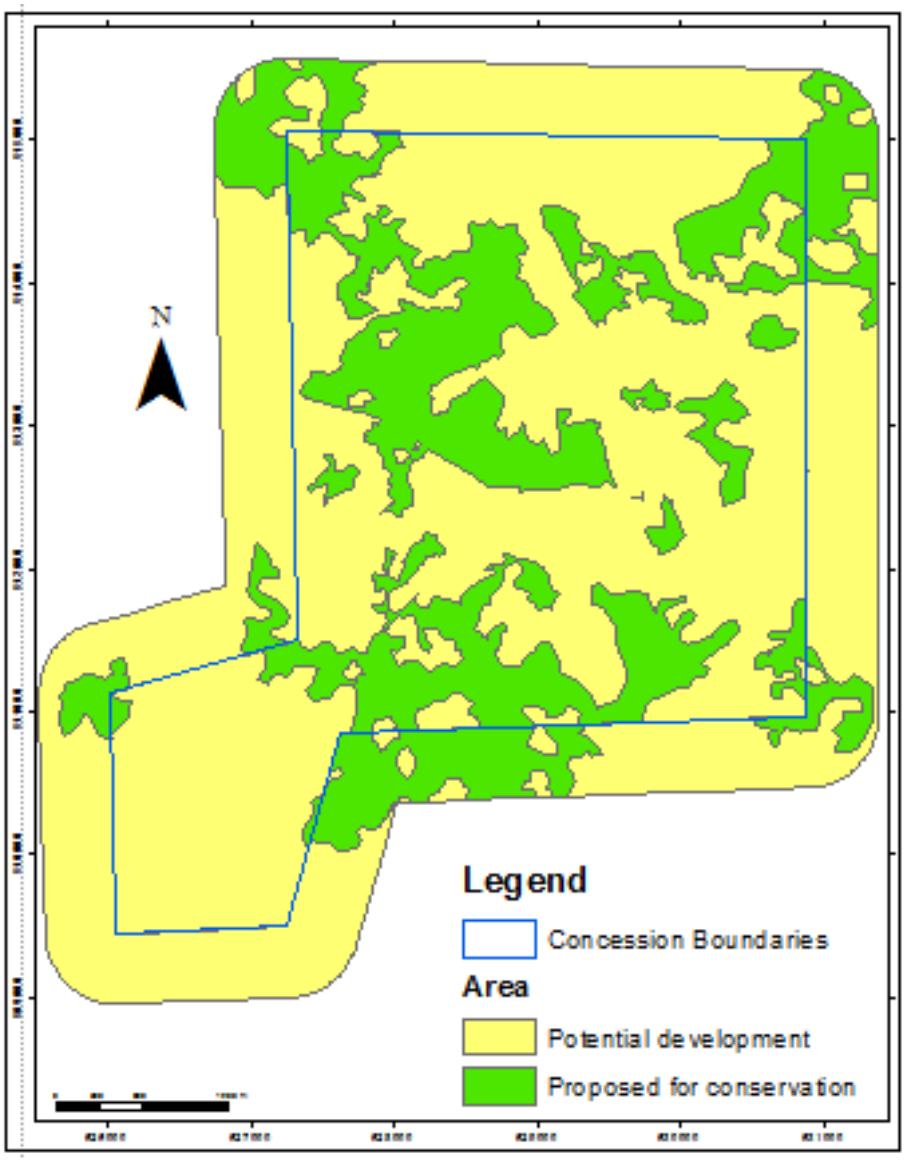
Map 14 : Final HCS stratification for Behwan Concession

Table 3 : Surface area per land cover type in Behwan concession

Strata	Surface area (ha)	Percentage (%)
HDF	32	2
LDF	275	16
YRF	217	12
SCRUB	871	50
OL	290	17

Plantation	55	3
Total	**1740**	**100**

The following map illustrates the untreated results after having merged all HCS classes together in Behwan concession and surrounding buffer area:



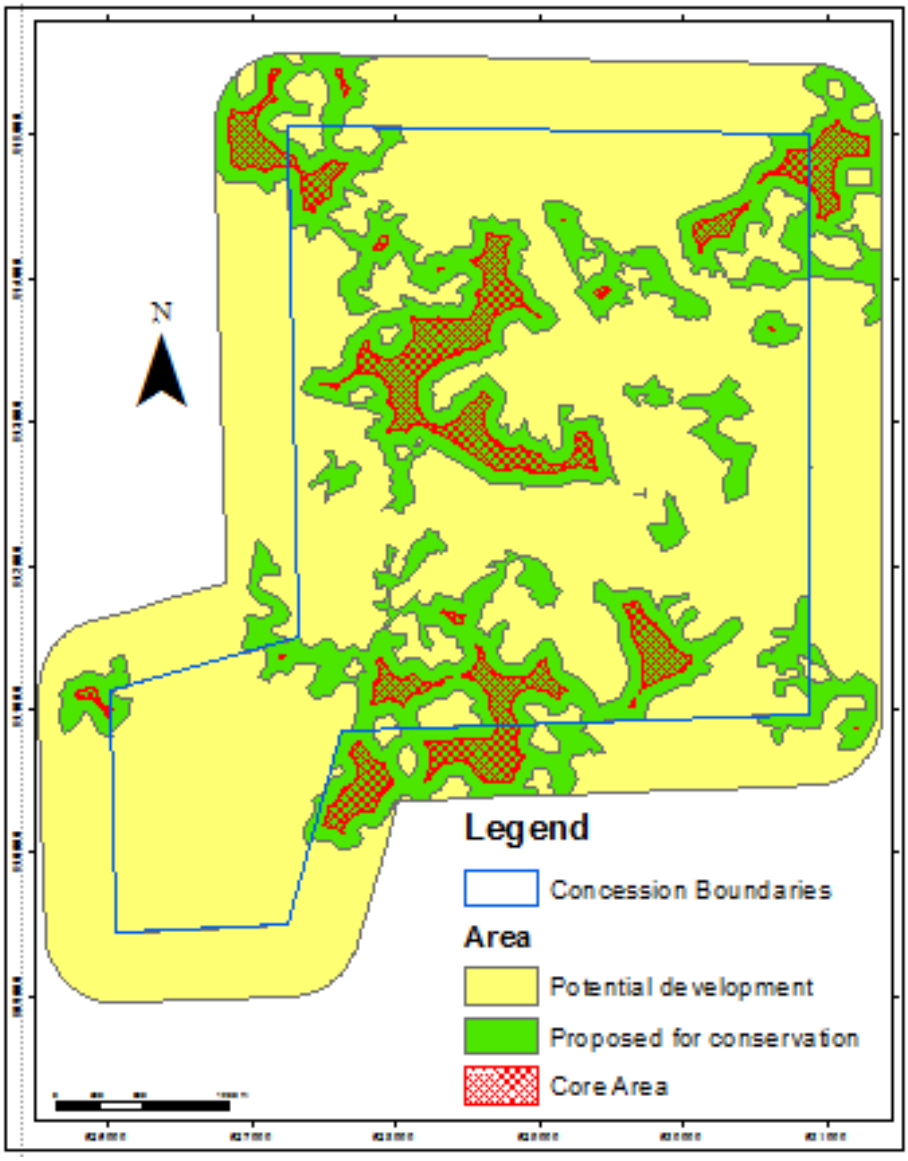
Map 15 : Preliminary results of HCS and non-HCS areas in Behwan concession

Table 4 : Surface areas of HCS areas and non-HCS areas in Behwan concession

Land classes	Surface area (ha)
HCS areas	525
Non-HCS areas	1215
Total	**1740**

These preliminary results show that 525 ha out of 1740 ha are considered as HCS. 1215 ha are considered as non-HCS in Behwan, however further analysis is conducted to define a workable land use plan and these results do not include buffer areas around water areas such as riparian buffers and swamps.

To refine the land use plan, an analysis of HCS forest core areas is conducted using a 100m buffer within all HCS areas. The results of this analysis are presented in the following map:



Map 16 : Core area analysis of HCS patches in Behwan concession

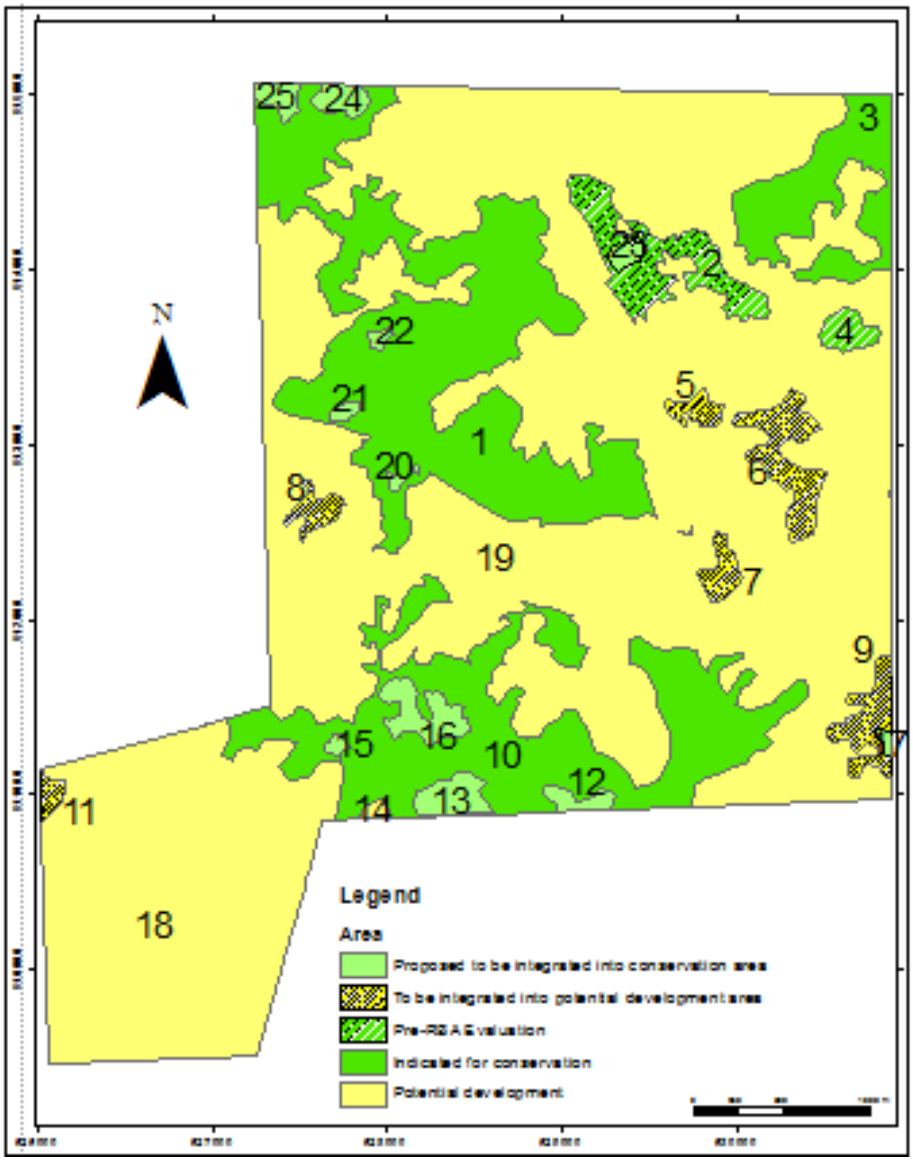
The analysis of core forested areas within Behwan concession allows us to refine the land use plan:

- Patches 5, 6, 7, 8 and 9 do not present any core forest area. Patches 6, 7 and 8 are Low Density Forest (LDF) whereas patches 5 and 9 are considered as Young Regenerating Forest (YRF). These patches do not present any connectivity to important HCS areas. In accordance with the HCS Decision Tree, these patches are considered low priority and, as we are in a medium forested landscape, are indicated for development. The total surface area of these patches is 39 ha.
- Patches 2 and 4 respectively present a core area of 0.4 ha and 0.34 ha. They consist of LDF and YRF HCS strata. According to step 9 in the HCS Decision Tree, a pre-RBA

verification is recommended to determine whether these patches are to be considered for development or conservation. The total surface area of these patches is of 37 ha.

- Patch 11 is isolated and has a small forest core area and is mostly outside the concession. Being YRF it is considered not suitable for conservation.
- Patch 1: A large patch that is mostly LDF, has a core area of 77 ha of which 60 ha is situated within the concession. This patch is therefore classified as medium priority for conservation and is indicated for conservation.
- Patch 3 is a High Density Forest area (HDF) with a core forest area of 21 ha. Even though a large part of the patch is within the buffer area around the concession, it is considered as medium priority for conservation and indicated for conservation.
- Patch 10 is considered as LDF and has a forest core area of 59 ha, of which 18 ha are within the concession. According to step 8a of the Decision Tree this patch is indicated for conservation.
- **The total surface are of these patches indicated for conservation is of 439 ha**
- Patches 12 to 24 or small non-HCS areas that are proposed to be included into the conservation areas to create a homogenous and connected conservation area.

The following map and table summarize the results of this patch analysis



Map 17 : Results of patch analysis according to Decision Tree

Table 5 : Categorisation of patches and surface area according to decision tree results in Behwan concession

Patches	Surface area (ha)
Indicated for conservation	439
Proposed to be integrated into conservation area	39
Pre-RBA Evaluation	37
To be integrated into potential development area	46
Potential development	1179
Total (ha)	**1740**

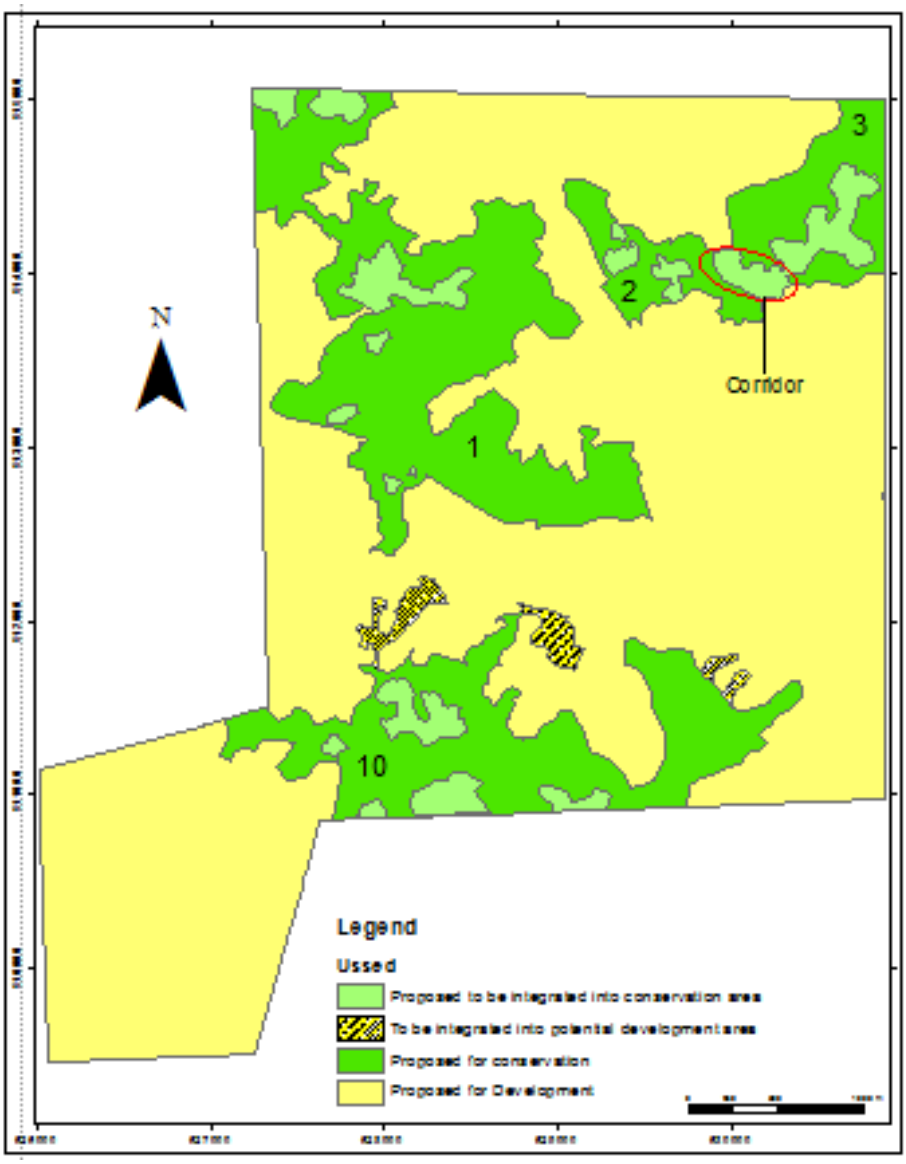
To transform these results into a coherent and pragmatic land use plan, the following proposition of a land use plan is proposed. This land use plan proposal does not include river buffers, swamps or results of FPIC participatory exercise which will need to be integrated.

Land use plan proposal

For this land use plan, we propose to create coherent conservation areas for conservation and integrate the smaller edges and complicated areas of HCS into development to facilitate development operations:

- A conservation corridor is proposed between blocs 2 and 3. This corridor consists of Scrub areas. The other small potential development areas situated with this large conservation area are integrated into the proposed conservation plan for cohesion.
- Certain areas of patch 10 are quite isolated and would be surrounded by plantations therefore potentially not viable for conservation. Even though these areas that are considered as YRF, they are proposed to be integrated into the development

The following map illustrates the land use plan proposal.

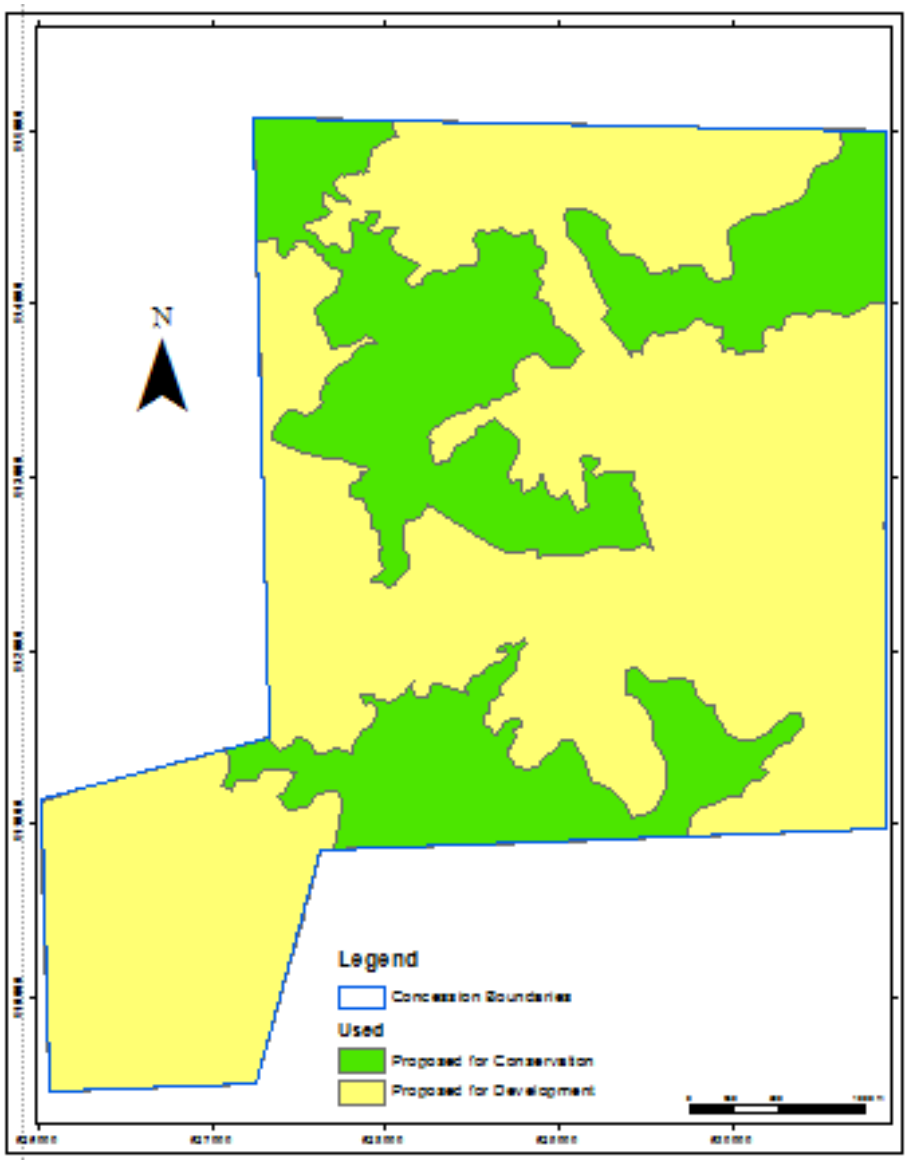


Map 18: Proposal of land use plan including give and take areas for Behwan concession

Table 6 : Surface area of final land use plan proposition

Patches	Surface areas (ha)	Subtotal (ha)
Non-HCS integrated into conservation	82	536
Proposed conservation	454	
Proposed development	1188	1204
HCS Integrated into proposed development	16	
Total	**1740**	**1740**

The final proposition of the land use plan is illustrated in the following map.

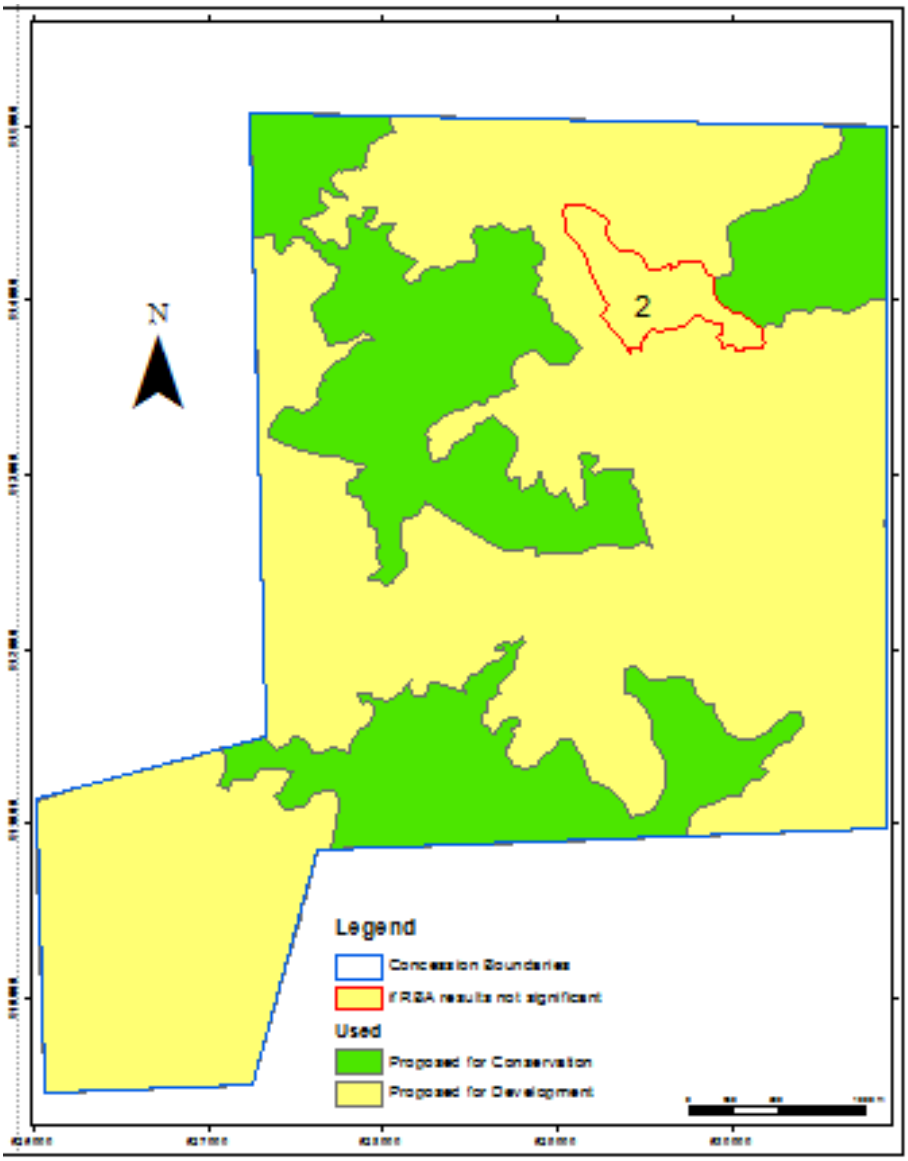


Map 19 : Final proposal of land use plan for Behwan

Table 10: Surface area of development and conservation area for Behwan concession

Patches	Surface area (ha)
Indicated conservation	536
Indicated development	1204
Total	**1740**

In the case where the RBA analysis of bloc 2 concludes that it is not of significance to conserve, 37 ha could be added to the development area. The following illustrates this scenario.



Map 20 : Proposal of land use plan for Behwan if RBA results not significant

Table 11: Surface areas to be developed in Behwan if RBA results not significant

Patches	Surface area (ha)
Indicated conservation	499
Indicated development	1241
Total	**1740**

These proposal need to be refined with the integration of riparian buffers and swamp areas.

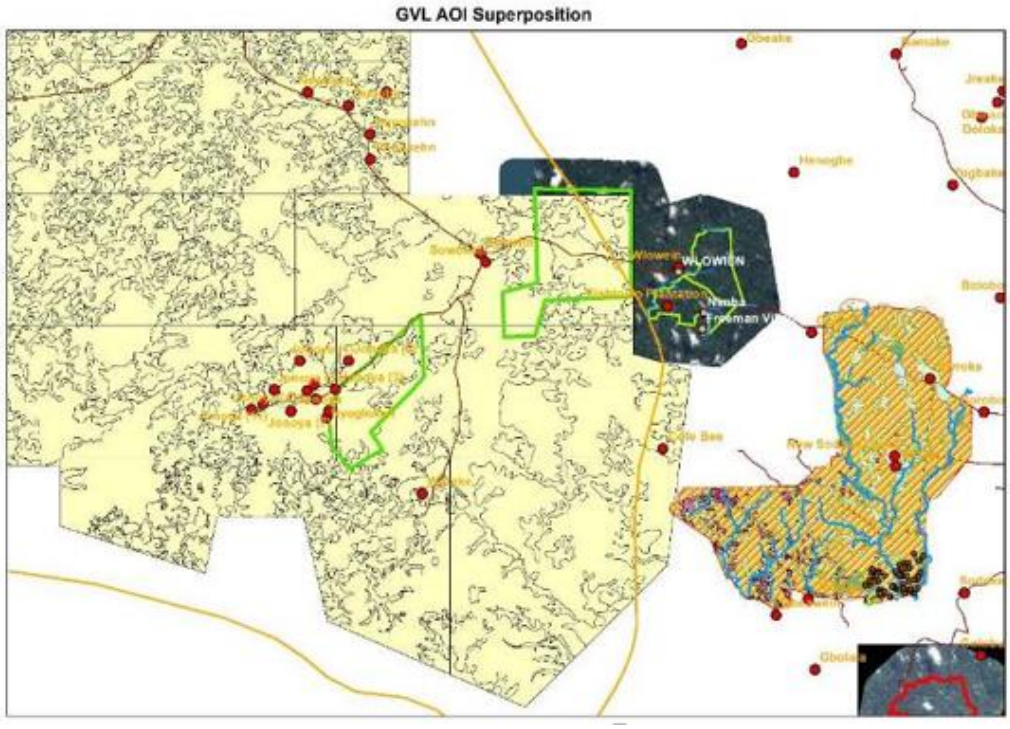
Recommendations

Behwan concession is situated in an area of high agricultural activity. To create the final land use plan it is essential to map out all rivers and swamp areas within the concession area. This will allow for the creation of river buffers in line with Liberian legislation.

- Bloc 2 on map 18 should follow a RBA assessment, this will give the final result on whether it should be considered as a development or conservation area
- As with the Wlowein concession, it is important to map out all the plantations, cropland areas and settlements within this concession following the FPIC principles of participatory mapping with local communities
- A better knowledge of community land use plans needs to be obtained to guarantee that the final land use plan and development has buy in from communities
- Discussions concerning management of HCS areas to be conserved should be conducted. It is essential to ensure community buy in and monitoring of these areas to guarantee long term preservation of these forested areas. The results of this study should be socialised with the community and a management plan defined and implemented with the communities.

Gennoyah Concession

The Gennoyah concession is situated in Grand Kru County and is approximately 1000 ha in surface area. Gennoyah concession is very close to GVL's new plantation activities in Grand Kru. It is also situated in the Area of Interest of GVL, as illustrated on the map below. This situation can complicate the land use planning, particularly on the community land use aspect. The risk being that communities indicate different areas for future farmlands to GVL and to SIFCA, and their livelihoods can be threatened if there is no coordination between the various actors in this landscape. It is therefore key that the FPIC process takes place in depth and that coordination with GVL is engaged regarding the land use planning. Another risk for SIFCA is the possibility that communities sell their production to GVL rather than to SIFCA. It is therefore recommended to have a strong MoU regarding the outgrower scheme.



Map 21*: Geographical location of Gennoyah concession*

27 HCS plots where sampled in the Gennoyah concession. The results and analysis of this data are presented in the following tables.

Table 12*: Carbon Summary Estimates By Land Cover Type (Gennoyah)*

Carbon Summary Estimates By Land Cover Type

Concession: GENNOYAH

Inventory: MOPP

Land Cover	*Average tonnes of Carbon / ha*	*Number of plots in strata*	*Standard Error*	*95% Confidence Limits*	
				Lower	*Upper*
LDF	114.8	4	32.1	12.5	217.1
YRF	80.7	1			
S	11.4	16	4.2	2.4	20.3
OL	0.0	3	0.0	0.0	0.0

Tree Equation: Chave et al 2005 - Circonference

Tree Formula: C (t/ha) = Exp(-1.499+2.148*ln(DBH/3.14)+0.207*ln(DBH/3.14)^2-0.0281*ln(DBH/3.14)^3))/1000*(Wood Density)

Source: J. Chave, C. Andalo, S. Brown, M. A. Cairns, J. Q. Chambers, D. Eamus, H. Fölster, F. Fromard, N. Higuchi and T. Kira, et al, (2005). Tree allometry and improved estimation of carbon stocks and balance in tropical forests. OECOLOGIA, Volume 145, Number 1, 87-99, DOI: 10.1007/s00442-005-0100-x

Palm Equation: Cylinder- For palms, Unpublished

Palm Formula: C (t/ha) = (PI*([DBH])^2/40000)*[Tree_Ht])*(Palm Density)

Source: TFT Liberia, unpublished

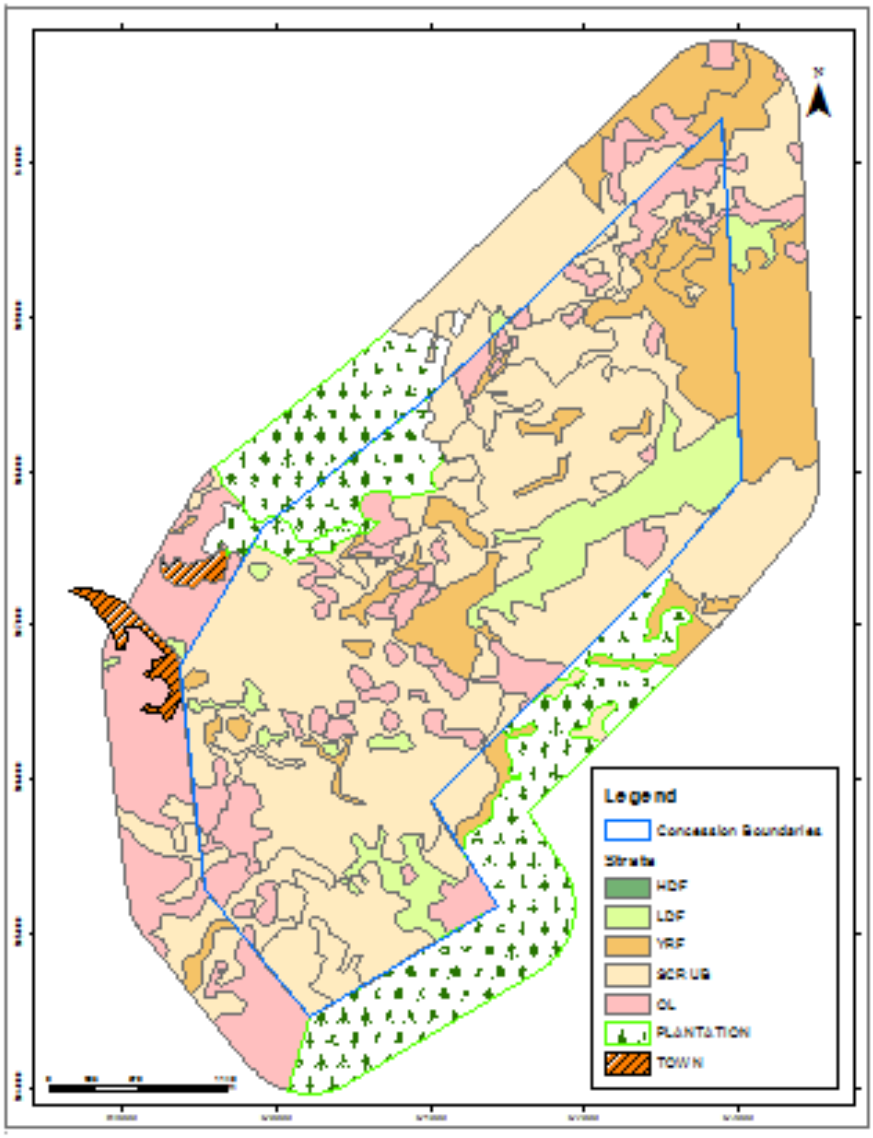
Carbon Summary Estimates By Land Cover Type

Concession: GENNOYAH

Inventory: MOPP

Land Cover	*Stems per ha by DBH Classes*						*Carbon (tonnes per ha) by DBH Classes*					
	Total	*5 - 10*	*10 - 20*	*20 - 30*	*30 - 50*	*> 50*	*Total*	*5 - 10*	*10 - 20*	*20 - 30*	*30 - 50*	*> 50*
HDF	**0**	0	0	40	60	200	**293**	0	0	0	3	290
MDF	**0**	0	0	0	0	0	**0**	0	0	0	0	0
LDF	**460**	0	225	55	55	125	**115**	0	1	1	2	111
YRF	**650**	0	150	60	90	350	**118**	0	1	1	3	113
SCRUB	**501**	0	300	98	59	90	**11**	0	1	1	2	7
OL	**0**	0	113	0	0	0	**0**	0	0	0	0	0
	0	0	0	0	0	0	**0**	0	0	0	0	0

A final HCS stratification map was drawn up using the combined analysis of this carbon data, combined with field information and satellite imagery treatment. This final stratification is illustrated in map 23 and table 18 presents the spatial coverage of each land use class.

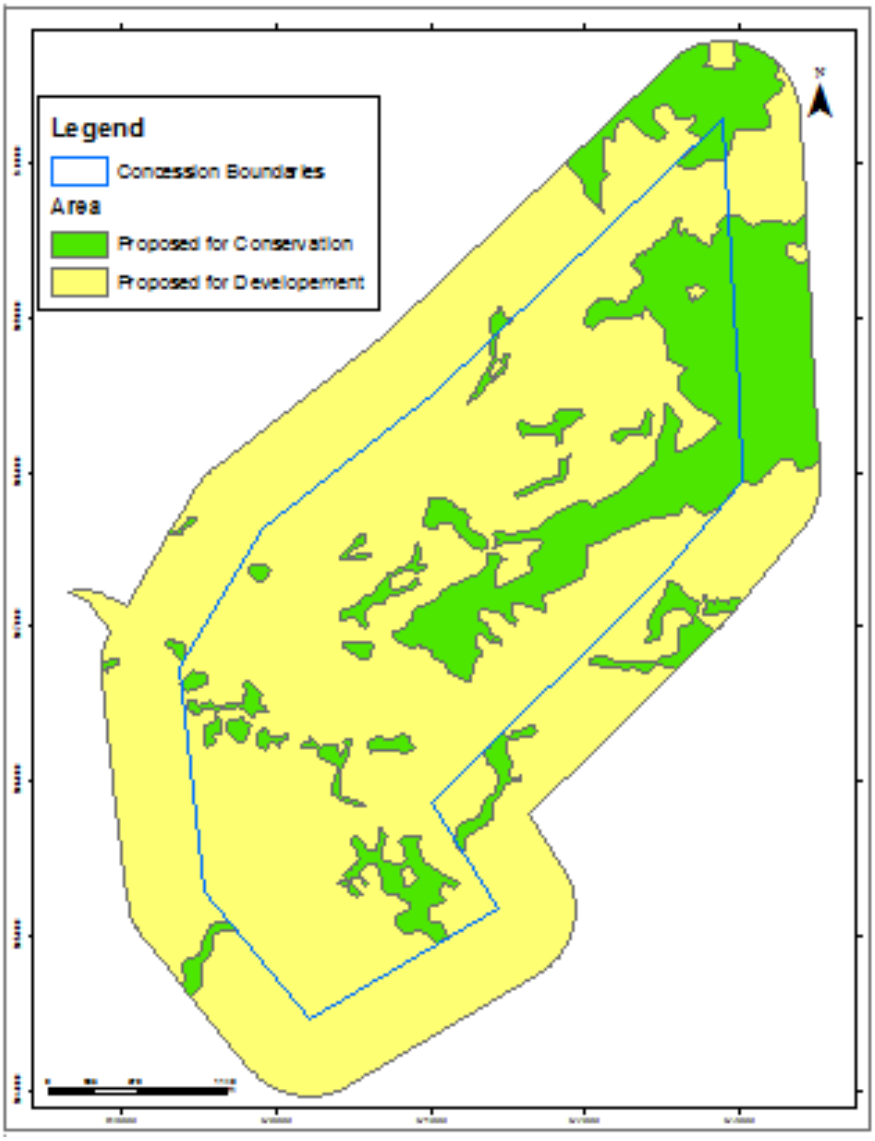


Map 22 *: HCS stratification map for Gennoyah concession*

Table 13 *:* Surface area per land cover type in Gennoyah concession

Strata	Surface area (ha)	Percentage (%)
HDF	0	0
LDF	96	10
YRF	123	12
SCRUB	595	59
OL	140	14
Plantation	49	5
Total	**1003**	**100**

The raw results of the merging of all HCS classes and non-HCS classes are presented below and in the summary of the surface area/strata in the following map and table:

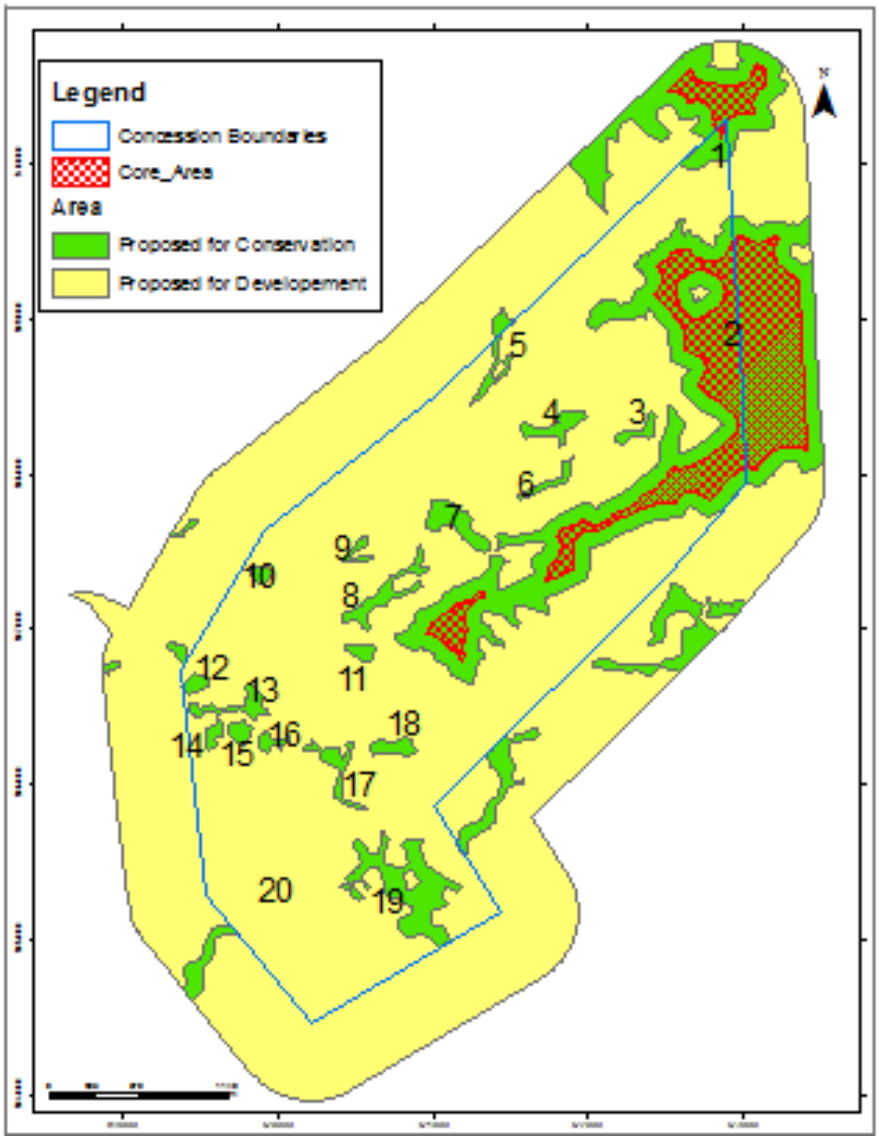


Map 23: Preliminary results of HCS study in Gennoyah concession

Table 14: Surface area of HCS and non-HCS land classes in Gennoyah concession

HCS status	Surface area (ha)
HCS land classes	218
Non-HCS land classes	782
Total (ha)	1000

This preliminary result indicates that approximately 218 ha of the total 1000 ha are considered as HCS. An analysis of core areas of forest patches then follows, to identify the priority for conservation of each individual HCS forest patch. The map of core forest areas is presented below in map 25.



Map 24: Individual analysis of core areas per HCS patch in Gennoyah concession

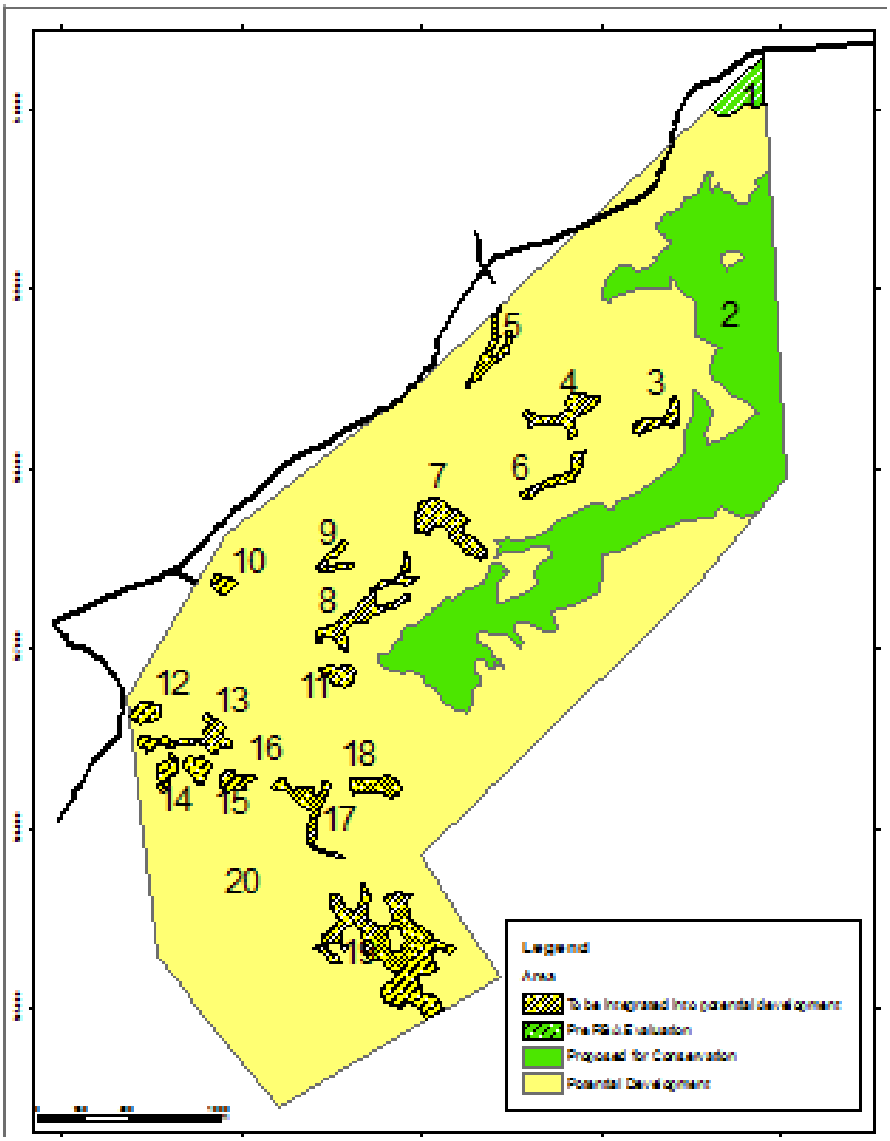
These patches each followed the Decision Tree process, here are the results:

- Only patches 1 and 2 have a core forest area, they are respectively of 11 ha and 105 ha. Almost all the core area of patch 1 is in the buffer area around the concession. The total surface area of these two patches is of 286 ha. Patch 1 is considered medium priority for conservation, a Rapid Biodiversity Assessment is recommended to be

conducted in this patch of YRF. Patch 2 is considered high priority for conservation and is indicated to be conserved.

- All the other patches (3 to 19) do not have any core area. They can be therefore considered as indicated for development.

The result if this analysis is presented in the map below:

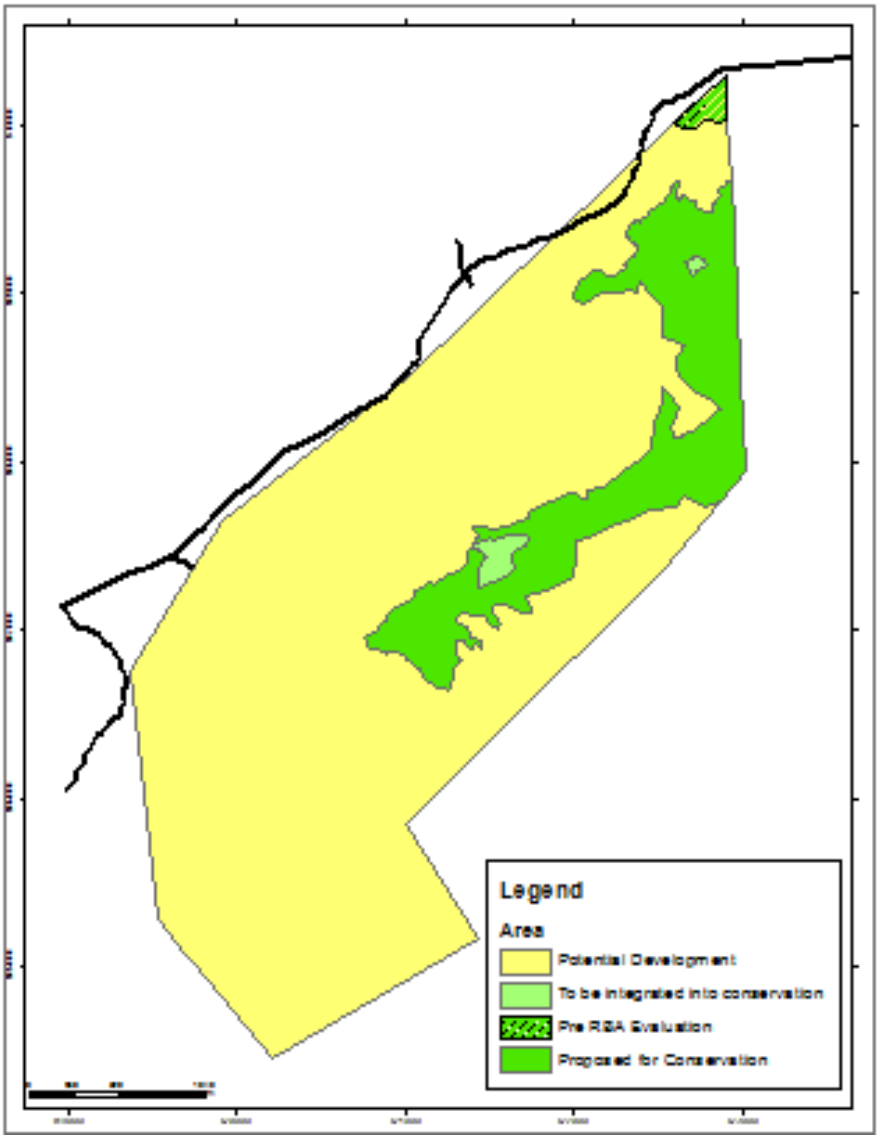


Map 25: Results of the HCS Decision Tree process for Gennoyah concession

To transform this raw analysis into a coherent land use plan, TFT has created a proposition of HCS conservation area within the Gennoyah concession.

Proposition

According to the analysis patch 2 presents the highest attributes for conservation. Two patches that would be considered potential for development are surrounded by conservation areas, these patches have therefore been integrated into the proposition of conservation area to guarantee a coherent forest area. An RBA needs to be conducted on Patch 1 before any decision can be made about its conservation or development.



Map 26: Proposition of conservation areas in Gennoyah concession

Figure 7: Surface areas of land use propositions for Gennoyah concession

Land use proposition	Surface area (ha)
To be integrated into conservation	6
Conservation	153
Indicated for development	841
Total	**1000**

Recommendation

The Gennoyah concession is a highly degraded one, it is situated in an area of dense agricultural activity. This will be a challenge when looking to conserve forests in this landscape. To better elaborate a land use plan, it is necessary to:

- Patch 1 should undergo a Rapid Biodiversity Assessment before a decision to conserve of develop is taken
- Map out all rivers and swampy areas in the concession, this will allow the identification of riparian buffer areas
- Intensify the social and FPIC work with communities, conduct participatory mapping to identify croplands and potential areas of importance. These activities should also take place in coordination with GVL, to ensure that community livelihoods and food security (future farmland areas) are preserved and taken into account.
- Discussions concerning management of HCS areas to be conserved should be conducted. It is essential to ensure community buy in and monitoring of these areas to guarantee long term preservation of these forested areas. The results of this study should be socialised with the community and a management plan defined and implemented with the communities.
- Old palm plantations are present in and around the concession, they seem to be managed by the communities. But they are under poor maintenance. Working with the communities to renew these plantations could be the opportunity to create for SIFCA to create a deeper partnership with the communities and develop productive smallholder plantations.

Wetchoken Concessions

Wetchocken concessions consists of 2 separate blocks in Maryland County. The village of Wetchocken is situated between these two blocks. The HCS analysis is presented separately for each block.

Wetchoken 1 or Bloc 1

A total of 19 HCS plots were sampled within the 424 ha of the Wetchoken bloc 1. The results of the carbon analysis for each HCS strata are presented in the following table:

Table 15 *:* Carbon summary estimates by landcover type for Wetchoken bloc 1

Carbon Summary Estimates By Land Cover Type

Concession: WETCHOKEN 1

Inventory: MOPP

Land Cover	*Average tonnes of Carbon / ha*	*Number of plots in strata*	*Standard Error*	*95% Confidence Limits*	
				Lower	*Upper*
HDF	108.2	1			
YRF	67.4	1			
S	10.6	7	3.0	3.4	17.9
OL	0.0	4	0.0	0.0	0.0

Tree Equation:	Chave et al 2005 - Circonference
Tree Formula:	C (t/ha) = Exp(-1.499+2.148*ln(DBH/3.14)+0.207*ln(DBH/3.14)^2-0.0281*ln(DBH/3.14)^3))/1000*(Wood Density)
Source:	J. Chave, C. Andalo, S. Brown, M. A. Cairns, J. Q. Chambers, D. Eamus, H. Fölster, F. Fromard, N. Higuchi and T. Kira, et al, (2005). Tree allometry and improved estimation of carbon stocks and balance in tropical forests. OECOLOGIA, Volume 145, Number 1, 87-99, DOI: 10.1007/s00442-005-0100-x
Palm Equation:	Cylinder- For palms, Unpublished
Palm Formula:	C (t/ha) = (PI*([DBH])^2/40000)*[Tree_Ht])*(Palm Density)
Source:	TFT Liberia, unpublished

Table 16 *:* Carbon summary Estimate by Land Cover Type Wetchoken bloc 1

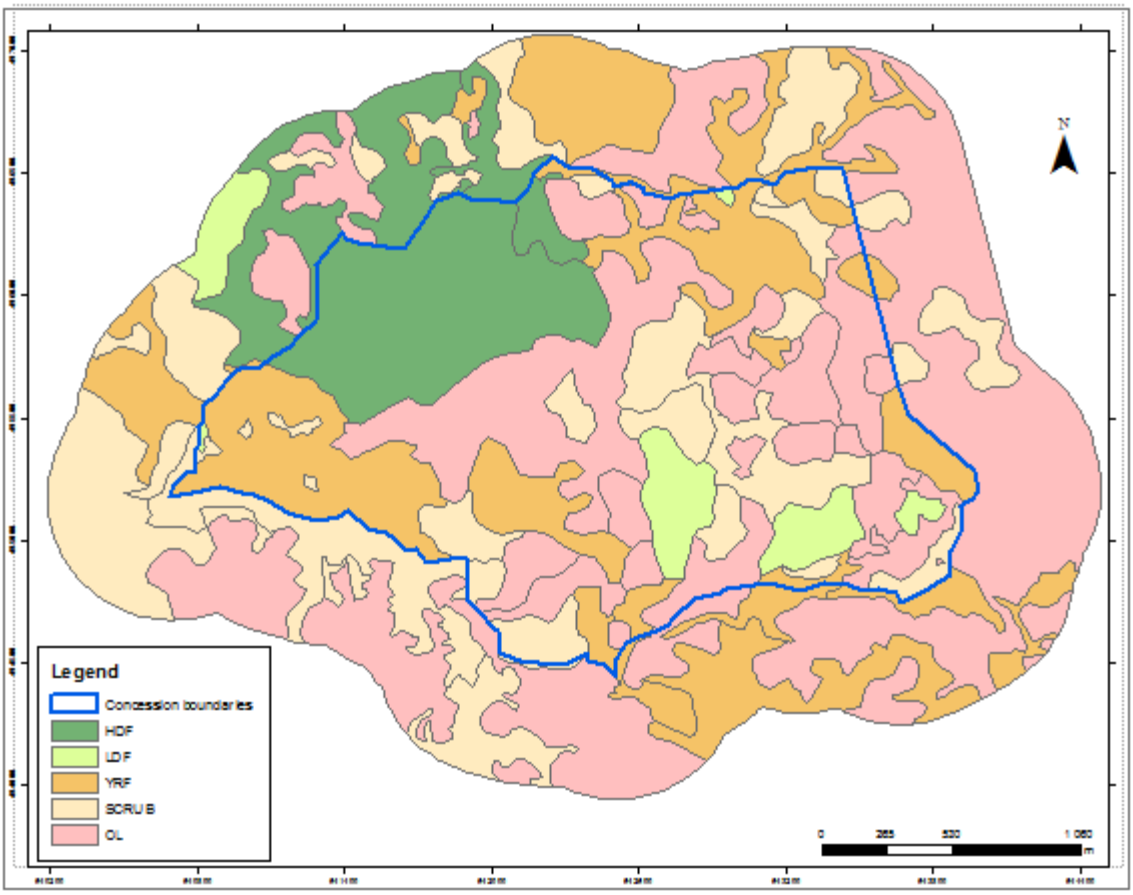
Carbon Summary Estimates By Land Cover Type

Concession: WETCHOKEN 1

Inventory: MOPP

Land Cover	Stems per ha by DBH Classes						Carbon (tonnes per ha) by DBH Classes					
	Total	5 - 10	10 - 20	20 - 30	30 - 50	> 50	Total	5 - 10	10 - 20	20 - 30	30 - 50	> 50
HDF	**800**	0	400	120	120	160	**108**	0	2	1	5	101
LDF	**160**	0	0	80	0	80	**48**	0	0	1	0	47
YRF	**487**	0	133	73	53	227	**173**	0	1	1	2	169
SCRUB	**703**	0	457	163	49	34	**11**	0	2	2	2	5
OL	**0**	0	113	0	0	0	**0**	0	0	0	0	0
	0	0	0	0	0	0	**0**	0	0	0	0	0

The final HCS stratification was obtained combining these results with satellite imagery analysis, photos and field information. It is presented in the following map:

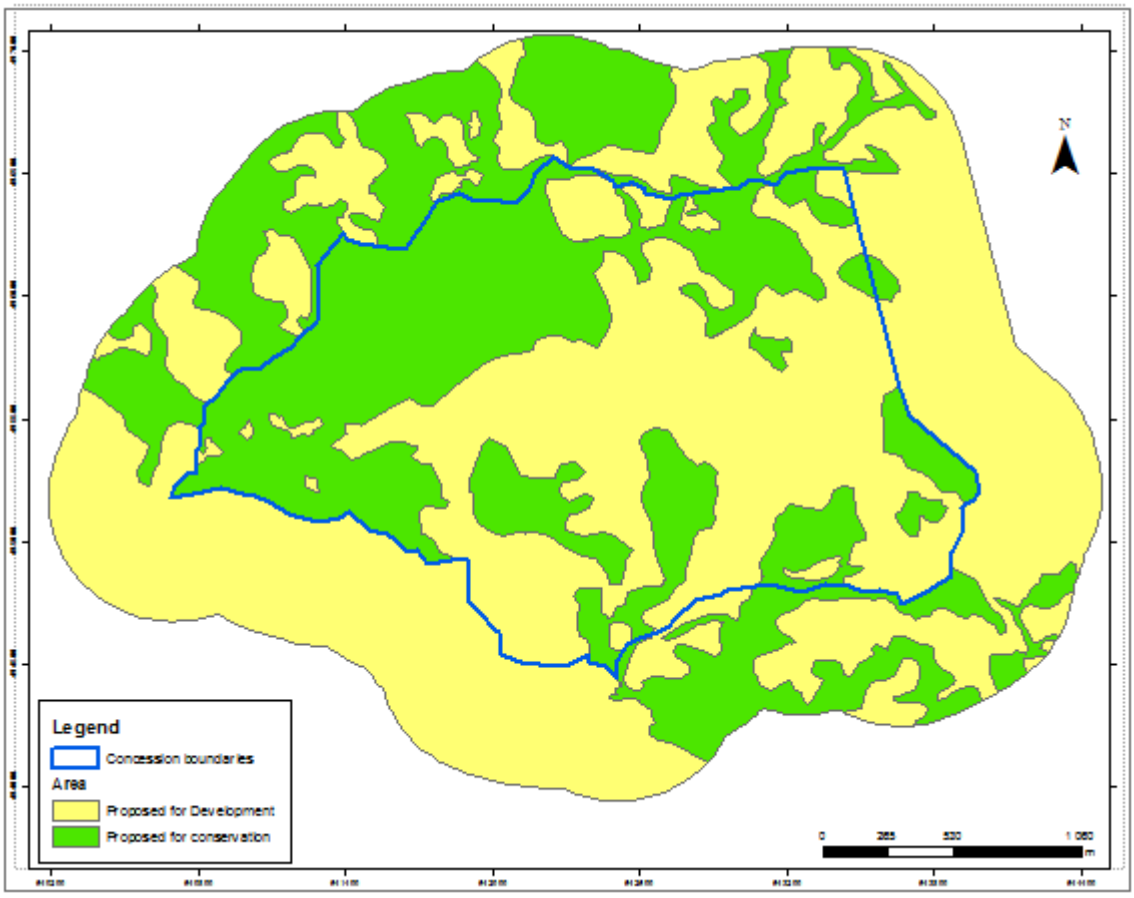


Map 27*:* Final HCS stratification map for Wetchoken bloc1

Table 17 : Surface area per land cover type in Wetchoken bloc 1

Strata	Surface area (ha)	Percentage (%)
HDF	76	18
LDF	24	5
YRF	104	25
SCRUB	70	17
OL	150	35
Total	**424**	**100**

The raw results after merging all HCS strata together is presented below:

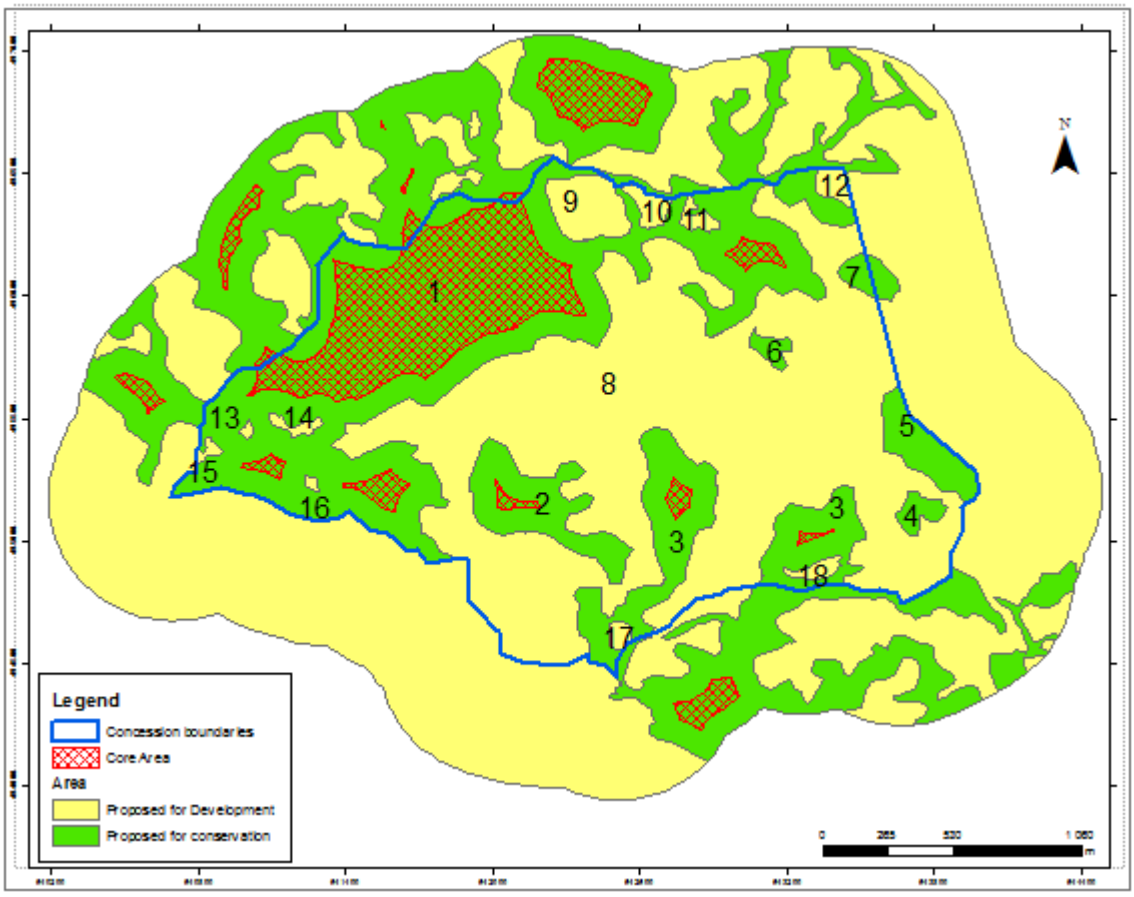


Map 28: HCS and non-HCS areas in Wetchoken bloc 1

Table 18 : Surface area according to HCS status of landcover in Wetchoken bloc 1

HCS status	Surface area (ha)
HCS land classes	204
Non-HCS land classes	220
Total (ha)	**424**

Below is the map of the core forest analysis:



Map 29 : Core forest analysis of HCS patches in Wetchoken bloc 1

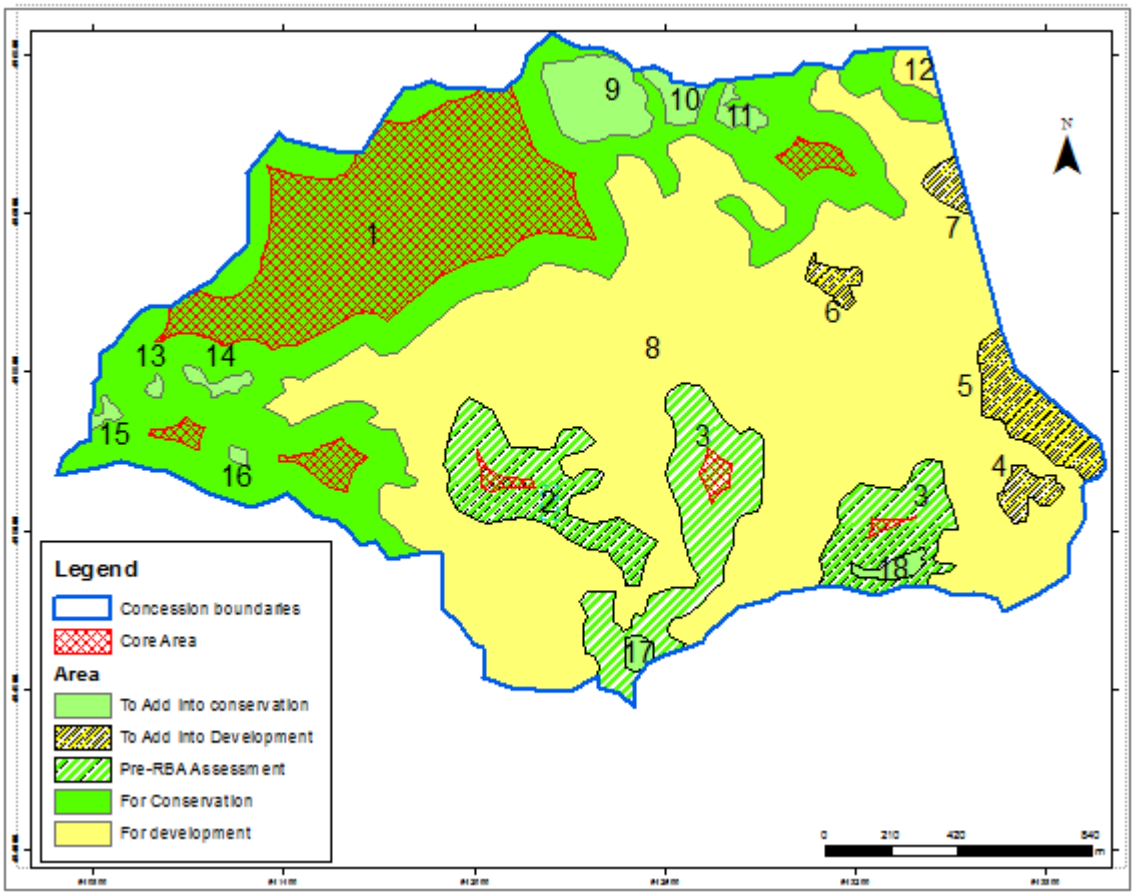
Here is the detail of the Decision Tree process for each patch:

- Patch 1 is 71 ha and consists mostly of High Density Forest (HDF). It covers a large area of the north of this bloc. The field visits allowed us to identify this area as mostly hilly and difficult to access. Patch 1 has a core area of 57 ha, according to the Decision Tree it is therefore classified as medium priority and is indicated for conservation.
- Patches 2 and 3 have core areas of 0.7 ha and 1.3 ha respectively. As Wetchoken bloc 1 is considered as a medium forested landscape, these patches could be considered

as indicative development areas. However as no biodiversity studies have been conducted, we recommend to conduct a Rapid biodiversity assessment within these areas.

- Patches 4 to 7 do not have any forest core. According to the decision tree they can be considered as indicative development areas.
- Patches 9 to 18 are small areas enclaved into the proposed areas for conservation. TFT proposes that these area be merged into the proposed conservation area to create a coherent land use plan.

The results of the analysis of the decision tree are shown in the map below:



Map 30 : Decision Tree results for Wetchoken bloc 1

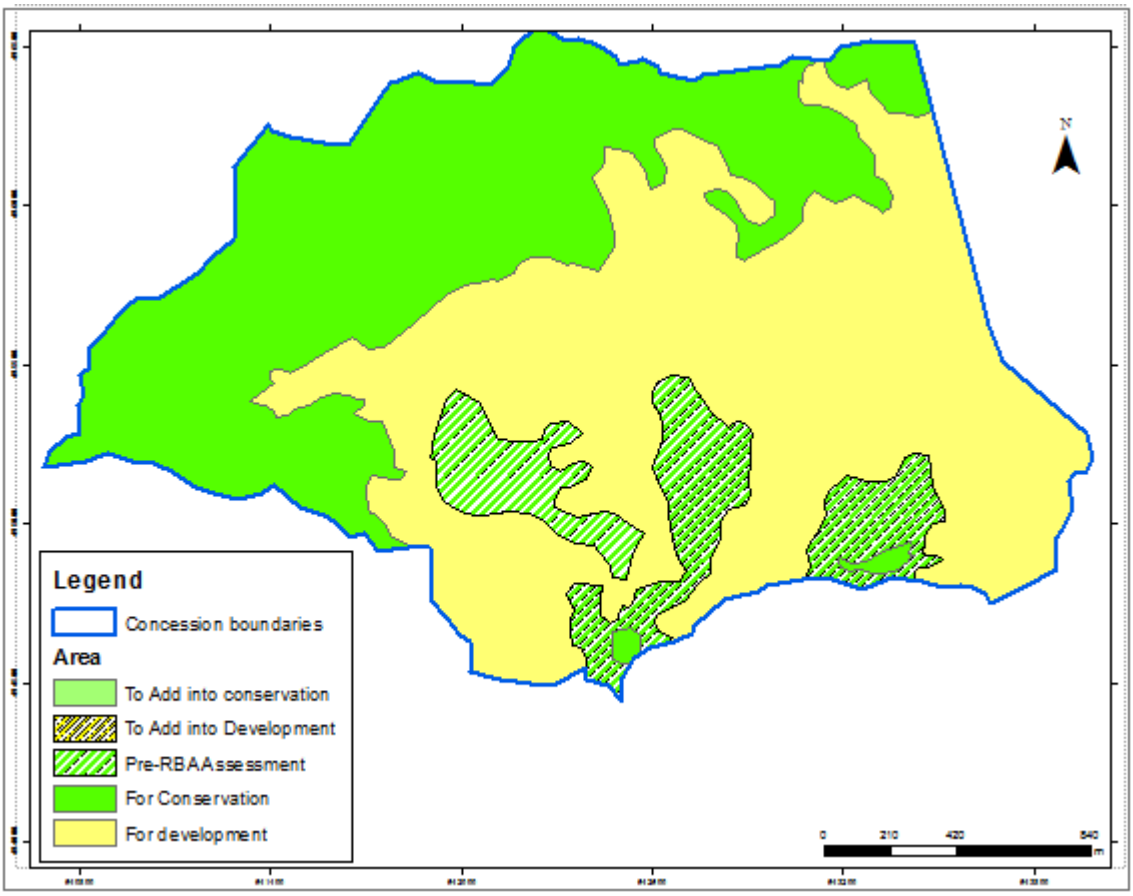
Table 19: Surface area per land use proposition for Wetchoken bloc 1

Patches	Surface area (ha)	Subtotal (ha)
RBA areas	45	201
Areas to integrate into conservation	14	

Indicative conserve	146	
Indicative develop	206	219
Areas to integrate into indicative develop	13	
Total (ha)	**424**	**424**

Proposition

Below is the map that illustrates the land use proposition.



Map 31 : Proposition of land use plan for Wetchoken bloc 1

Table 20: Surface areas of land use proposition for Wetchoken bloc 1

Patches	Superficies (ha)
For conservation	162
Pre RBA assessment	45
For development	217
Total (ha)	424

Recommendations

- TFT recommends that Rapid Biodiversity Assessments be conducted in patches 2 and 3. If the RBA results indicate that there is no significant biodiversity for conservation, then these areas can be considered for potential development. However if the RBA indicates that there are important species for conservation, then these patches should be integrated into the conservation plan.
- Map out all rivers and swampy areas in the concession, this will allow the identification of riparian buffer areas
- Intensify the social and FPIC work with communities, conduct participatory mapping to identify croplands and potential areas of importance.
- Discussions concerning management of HCS areas to be conserved should be conducted. It is essential to ensure community buy in and monitoring of these areas to guarantee long term preservation of these forested areas. The results of this study should be socialised with the community and a management plan defined and implemented with the communities.

Wetchoken 2 or Bloc 2

Wetchoken bloc 2 is situated to the east of the Wetchoken village. In this bloc, 20 HCS plots where sampled. The results of the carbon analysis for these plots are presented in the table below:

Table 21: Summary of Carbon analysis for Wetchoken bloc 2

Carbon Summary Estimates By Land Cover Type

Concession: WETCHOKEN 2

Inventory: MOPP

Land Cover	*Average tonnes of Carbon / ha*	*Number of plots in strata*	*Standard Error*	*95% Confidence Limits*	
				Lower	*Upper*
S	10.7	13	8.0	-6.8	28.2
OL	0.9	4	0.9	-1.9	3.7

Tree Equation: Chave et al 2005 - Circonference

Tree Formula: C (t/ha) = Exp(-1.499+2.148*ln(DBH/3.14)+0.207*ln(DBH/3.14)^2-0.0281*ln(DBH/3.14)^3))/1000*(Wood Density)

Source: J. Chave, C. Andalo, S. Brown, M. A. Cairns, J. Q. Chambers, D. Eamus, H. Fölster, F. Fromard, N. Higuchi and T. Kira, et al, (2005). Tree allometry and improved estimation of carbon stocks and balance in tropical forests. OECOLOGIA, Volume 145, Number 1, 87-99, DOI: 10.1007/s00442-005-0100-x

Palm Equation: Cylinder- For palms, Unpublished

Palm Formula: C (t/ha) = (PI*([DBH])^2/40000)*[Tree_Ht])*(Palm Density)

Source: TFT Liberia, unpublished

Table 22: Carbon summary Estimate by Land Cover Type Wetchoken bloc 2

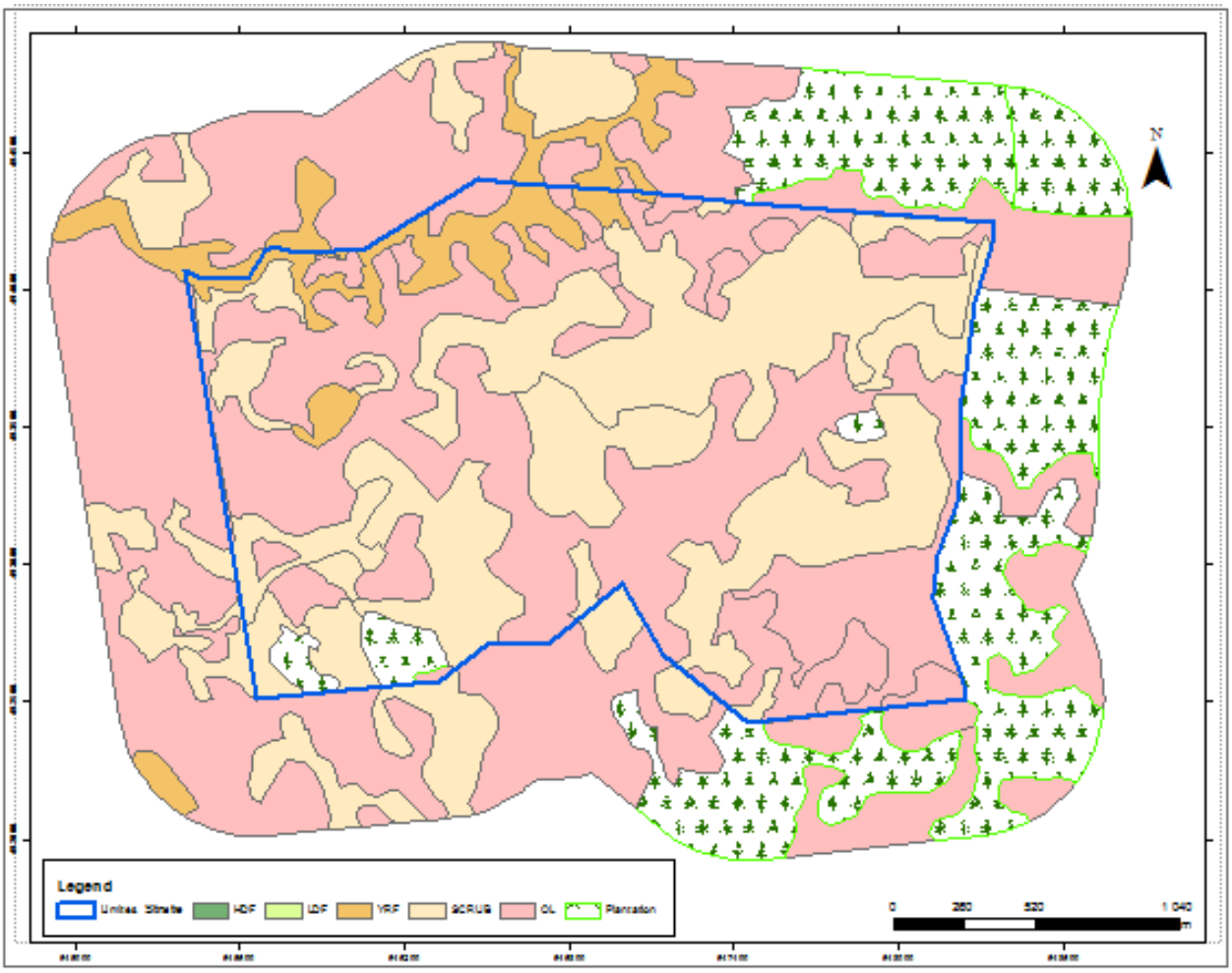
Carbon Summary Estimates By Land Cover Type

Concession: WETCHOKEN 2

Inventory: MOPP

Land Cover	*Stems per ha by DBH Classes*						*Carbon (tonnes per ha) by DBH Classes*					
	Total	*5 - 10*	*10 - 20*	*20 - 30*	*30 - 50*	*> 50*	*Total*	*5 - 10*	*10 - 20*	*20 - 30*	*30 - 50*	*> 50*
HDF	**0**	0	0	0	0	0	**0**	0	0	0	0	0
MDF	**0**	0	0	0	0	0	**0**	0	0	0	0	0
LDF	**0**	0	0	0	0	0	**0**	0	0	0	0	0
YRF	**640**	0	100	40	20	480	**338**	0	0	0	0	336
SCRUB	**317**	0	208	60	28	22	**11**	0	1	1	1	8
OL	**190**	0	175	15	0	0	**1**	0	1	0	0	0
	0	0	0	0	0	0	**0**	0	0	0	0	0

A final HCS stratification map was produced using the analysis of this carbon data in combination with satellite imagery and field information:

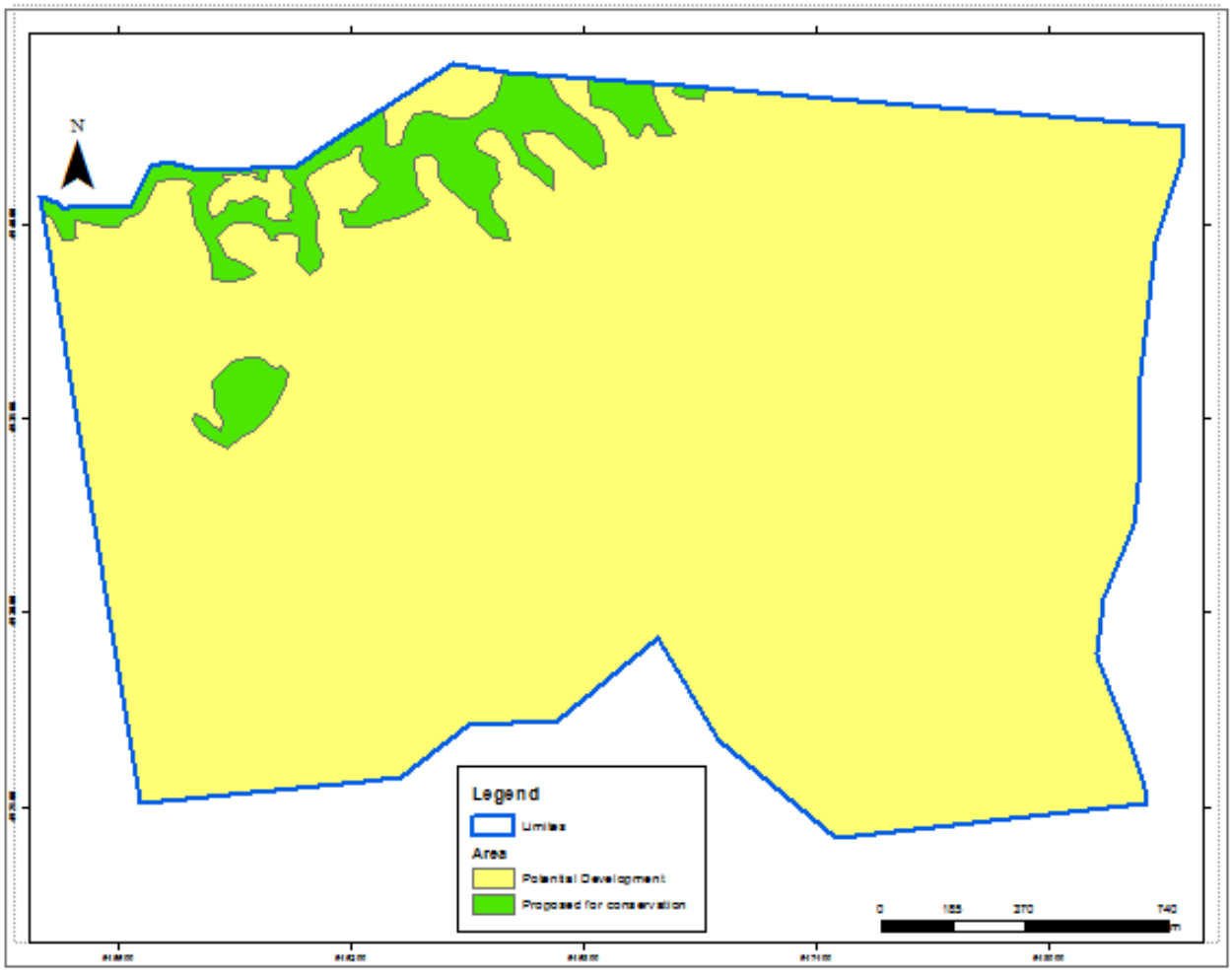


Map 32: Final HCS Stratification for Wetchoken bloc2

Table 23: Surface area per land cover type in Wetchoken bloc2

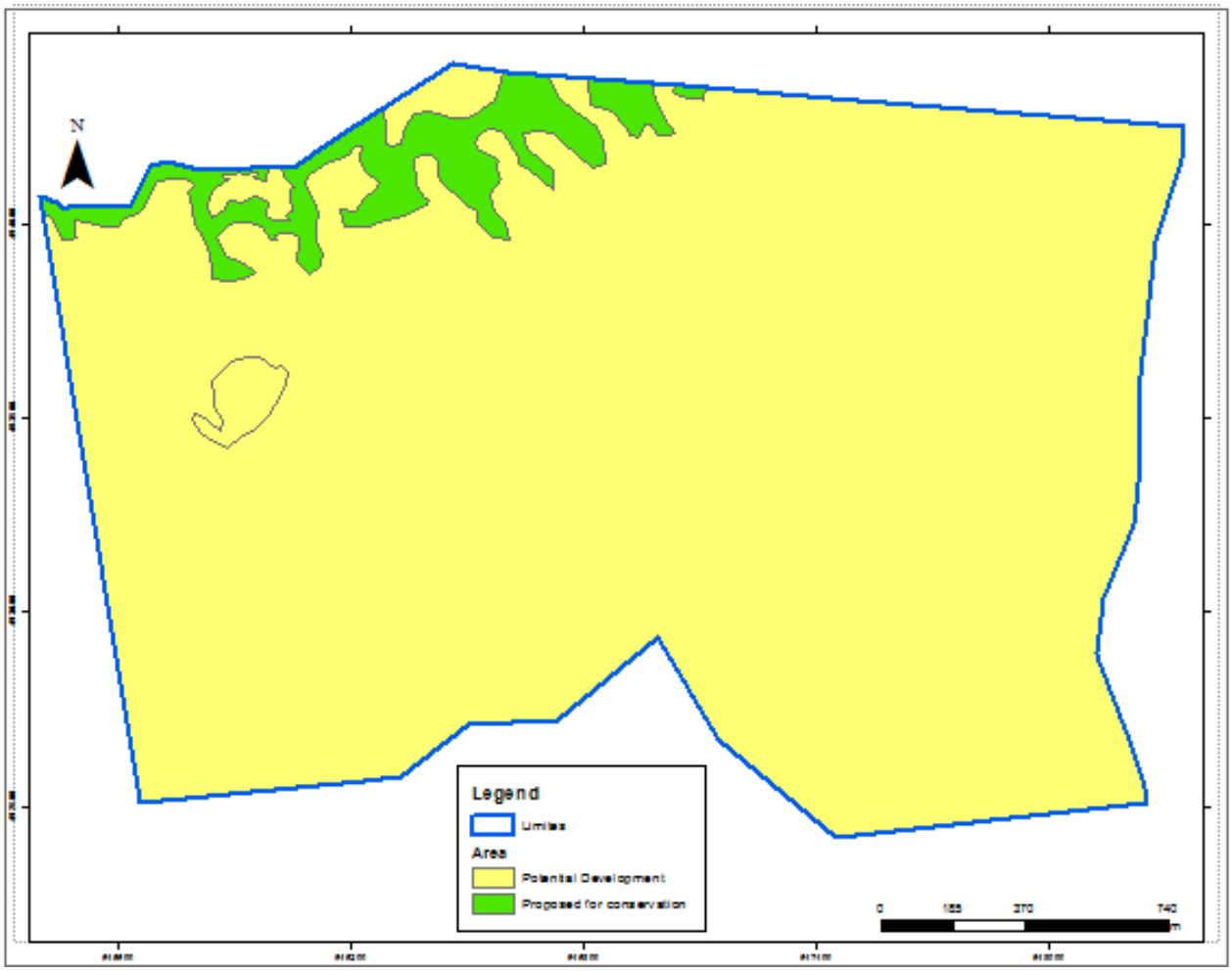
Strata	Surface area (ha)	Percentage (%)
HDF	0	0
LDF	0	0
YRF	24	5
SCRUB	203	44
OL	220	48
Plantation	11	3
Total	**458**	**100**

The raw result after merging HCS classes together is presented below:



Map 33: Preliminary results of HCS analysis for Wetchoken bloc 2

This bloc of the concession is very highly degraded. The only small areas of forest left are small patches of Young regenerating forest, which is present in the north east of the bloc. These patches represent 5.5% of the 434 ha that make up the bloc. These patches do not present any forest core, however it is alongside a river. It is therefore recommended to be conserved as a river buffer.



Map 34: Proposition of conservation areas in Wetchoken bloc2

Table 24: Surface area of proposed land use classes in Wetchoken bloc 2

Patches	Superficies (ha)
Indicative for conservation	25
Potential development	433
Total (ha)	**458**

Recommendations

Wetchocken bloc 2 is highly degraded, there is a high agricultural activity including presence of plantations (palm, rubber etc.).

- Map out all rivers and swampy areas in the concession, this will allow the identification of riparian buffer areas

- Intensify the social and FPIC work with communities, conduct participatory mapping to identify croplands and potential areas of importance. Identify possible villages or inhabited areas within the concession.
- Discussions concerning management of HCS areas to be conserved should be conducted. It is essential to ensure community buy in and monitoring of these areas to guarantee long term preservation of these forested areas. The results of this study should be socialised with the community and a management plan defined and implemented with the communities.
- Old palm plantations are present in and around the concession, they seem to be managed by the communities. Working with the communities to renew these plantations could be the opportunity to create for SIFCA to create a deeper partnership with the communities and develop productive smallholder plantations.

Annex 1: IUCN Red List vegetation species identified during HCS sampling

Table 25: Sarbo concession IUCN Species

Species	Number of individuals identified	IUCN Red List Status
Anopyxis klaineana	7	VU - Vulnerable
Anthonotha vignei	114	VU - Vulnerable
Copaifera salikounda	4	VU - Vulnerable
Didelotia idae	11	NT - Near Threatened
Drypetes afzelii	1	VU - Vulnerable
Garcinia kola	2	VU - Vulnerable
Guarea cedrata	1	VU - Vulnerable
Heritiera utilis	7	VU - Vulnerable
Lophira alata	10	VU - Vulnerable
Nauclea diderrichii	10	VU - Vulnerable
Nesogordonia papaverifera	1	VU - Vulnerable
Terminalia ivorensis	3	VU - Vulnerable