Roundtable on Sustainable Palm Oil

2021

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RSPO GHG Assessment Procedure for New Development

Version 4, July 2021

Document Title	:	RSPO GHG Assessment Procedure for New Development
Document Code	:	RSPO-PRO-T04-003 V3 ENG
Scope	:	New Planting
Document Type	:	Procedure
Approval	:	Standard Standing Committee, 8 July 2021
Contact	:	standard.development@rspo.org
Date Entry into Force	:	1st October 2021

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LIST OF ACRONYMS

AGB	Above Ground Biomass
AOI	Area of Interest
BGB	Below Ground Biomass
DBH	Diameter at Breast Height
DEM	Digital Elevation Model
DTM	Digital Terrain Model
GHG	Greenhouse Gas
GIS	Geographic Information Survey
HCSA	High Carbon Stock Approach
HCV	High Conservation Value
HCV-HCSA	High Conservation Value – High Carbon Stock Approach
IMP	Integrated Management Plan
IPCC	Intergovernmental Panel on Climate Change
LDF	Low Density Forest
LiDAR	Light Detection and Ranging
NI	National Interpretation
NPP	New Planting Procedure
OP	Oil Palm
P&C	Principles and Criteria
PDA	Proposed Development Area
POME	Palm Oil Mill Effluent
RSPO	Roundtable on Sustainable Palm Oil
SEIA	Social and Environmental Impact Assessment

FOREWORD

The RSPO Emission Reduction Working Group (ERWG), formed in November 2013, developed the RSPO Greenhouse Gas (GHG) Assessment Procedure for New Development as a procedure to identify and estimate the carbon stock and major potential emissions that may result directly from any new oil palm development.

This review has made changes mainly in Chapter 3: Carbon stock assessment to be in line with the latest 2018 Principles and Criteria (P&C), which has adopted the HCSA toolkit v2.0 for identification of HCS forests within any new oil palm development. Any of these areas identified through integrated HCV-HCSA assessments or standalone HCSA assessments (where permitted) are to be conserved and/or enhanced as per Criterion 7.12 of the 2018 P&C.

In order to streamline the GHG assessment procedure with the adoption of the HCSA toolkit, this version draws upon information readily available in the HCSA/HCV-HCSA assessments and adds on elements not covered under the toolkits scope, reducing duplication of processes.

This latest version of the RSPO GHG Assessment Procedure for New Development (Version 4, June 2021) will supersede all previous versions of the RSPO GHG Assessment Procedure. All GHG Assessments for new development submitted starting **1st March 2022** shall use this version of the RSPO GHG Assessment Procedure for New Development. Assessments submitted within this period may use this guidance on a voluntary basis.

ACKNOWLEDGEMENTS

RSPO would like to thank Faizal Parish (GEC) and Dr Gan Lian Tiong (Musim Mas), Co-chairs of the ERWG and all the ERWG members for their contribution to the revision of the RSPO GHG Assessment Procedure for New Development, as well as all RSPO member companies that have provided feedback on the use of the earlier drafts of the procedure.

Special thanks go to Olam Palm Gabon who contributed the original data which was used to develop hypothetical scenarios for optimum and sustainable new planting design. This data has been further expanded by Proforest and modified to include more land covers to represent common landscapes found in Southeast Asia (SEA).

Additional special thanks to Musim Mas who contributed example maps and tables (for illustration purposes) within this Procedure.

Revision Table

No	Revision	Version	Date
1	i. List of acronyms: Correction to DTM & DEM ii. Figure 3: Correction to decision tree for scenarios where no peat present iii. Figure 5: Correction to option 3.2.1.a.b & 3.2.1.b.a. iv. Section 4.2: Changed reference source to table 11 v. Annex 3 & 4: Revised figure numbers to A3-1 & A4-1	V 4.1	19 November 2021

SECTION 1: INTRODUCTION

The Roundtable on Sustainable Palm Oil (RSPO) is an international multi-stakeholder certification scheme for sustainable palm oil whose mission includes advancing the production, procurement, finance and use of sustainable palm oil products; and the development, implementation, verification, assurance and periodic review of credible global standards for the entire supply chain of sustainable palm oil.

Among many of the critical issues revolving around the production of sustainable palm oil is the expansion of oil palm (OP) plantations and related development, which may cause significant social, environmental and economic impact if not planned and executed with sustainability in mind.

Criteria 7.7, 7.10 and 7.12 of the 2018 RSPO Principles and Criteria (2018 P&C) have added several new requirements with respect to the sustainable development of OP related expansion, most importantly on the prohibition of any new planting on peat, the adoption of the High Carbon Stock Approach (HCSA) toolkit and HCV-HCSA manual, and the requirement to conduct an integrated HCV-HCSA assessment prior to any new development.

The RSPO GHG Assessment for New Development 2021, currently in its fourth version, aims to update the procedures of the previous version in line with the 2018 P&C. Among the significant revisions to this version is the integration of the HCSA toolkit and utilisation of the results from the HCV/standalone HCSA/HCV-HCSA[1] assessments in order to identify and estimate carbon stocks prior to and after new developments as well as major sources of emissions that may result directly from OP related development.

1.1 THE PURPOSE OF THIS PROCEDURE

The purpose of this procedure is to guide RSPO members planning on new development to identify and estimate carbon stocks prior to development as well as major sources of emissions that may result directly from OP related development. Selection of the most optimal scenario for development (refer to 4.4) shall be done taking into consideration social, environmental and economic impacts of the development. The output of this assessment shall be the final development plan specifying the proposed development and conservation/set asides (e.g. HCV, HCS, Peat, Social).

Emphasis has also been given to encourage the use of widely available guidance and practices, while adding on other information and calculations (e.g. Below Ground Biomass (BGB), soil carbon, scenario testing) to ease the application and reporting of this procedure. Utilisation of the results from existing assessments[2] as required by the New Planting Procedure (NPP) is found in Table 1.

[1] Standalone HCV and HCSA assessments are only valid for transition scenarios as detailed in the '*RSPO interpretation of indicator 7.12.2 and annex 5*' document

[2] Data from respective assessments may overlap each other as some assessments also utilise the results of other assessments (e.g. HCV-HCSA and Soil and Topography)

Table 1 – Assessments and data utilised

Assessment Type	Data utilised in GHG assessment

Integrated HCV-HCS
OR
Standalone HCSA
	• Forest cover stratification/classification
	• Details of HCS, HCV and social conservation areas
	• Maps from the assessment
	  ○ High Carbon Stock (HCS) forests
	  ○ High Conservation Value (HCV) areas
	  ○ Social conservation areas
	• Above ground biomass (AGB) values (t C/ha) for each stratification/classification

Soil and Topography	• Identification of peat (Histosols) and its characteristics • Carbon stock of peat (if available) • Map of identified peat areas
HCV assessment (if using standalone HCSA assessment)	• Maps of identified HCVs
SEIA/SIA/on-going FPIC process	• Social conservation areas

Note: The report summary from the result of this assessment is to be submitted as part of the NPP submission as required by the NPP 2021.

1.2 GHG ASSESSOR TEAM COMPETENCIES

As the bulk of the critical data and information used in the GHG assessment procedure draws upon other assessments which have been conducted by licenced assessors and undergone rigorous quality reviews by third party experts, much emphasis was given to minimising the resources that need to be mobilised in creating this procedure.

The GHG assessment can be conducted by the grower or by an independent consultant, with relevant competencies demonstrated (refer to Box 1); and must have been prepared based on carbon stock assessments and field verification conducted no more than three (3) years prior to the submission of the NPP. Assessments older than three (3) years at the time of NPP submission should be reviewed and updated to reflect changes on the ground.

Box 1: The assessment team should:

i. Have knowledge of carbon emission accounting methodologies for above and below ground carbon stocks including peat.

ii. Have experience in verifying land cover maps and/or conducting carbon stock assessment in agriculture and/or forestry sectors.

iii. Have experience and expertise in using remote sensing technology to estimate carbon stocks.

SECTION 2: OVERVIEW OF THE GHG ASSESSMENT FOR NEW DEVELOPMENT

This Procedure is not intended as a scientific review or a comprehensive assessment of methodologies for the estimation of carbon stocks; rather it has been developed to provide general guidance on key parameters and/or credible methodologies, which are widely available, for the estimation of GHG emissions associated with new development plans to minimise GHG emissions. In addition, it provides guidance on the selection of preferred development options and preparation of a plan to minimise GHG emissions from new developments.

In line with the adoption of the HCSA toolkit and HCV-HCSA manual, the initial step of land cover stratification and classification has been removed, as this has been accounted for in the standalone HCSA/ integrated HCV-HCSA assessment. As such, the GHG assessment shall draw upon the final land cover classification from the standalone HCSA/integrated HCV-HCSA assessment.

Guidance for the integration of other impacts and values (HCV and Social) are also available in this document. The process for the integration of these impacts/values would depend on the type of assessments used for the GHG assessment; whether standalone HCV & HCSA assessments or an Integrated HCV-HCSA assessment.

Figure 1 below shows the steps to be undertaken for this procedure while Table 2 provides a description for each respective step required for the GHG assessment procedure.

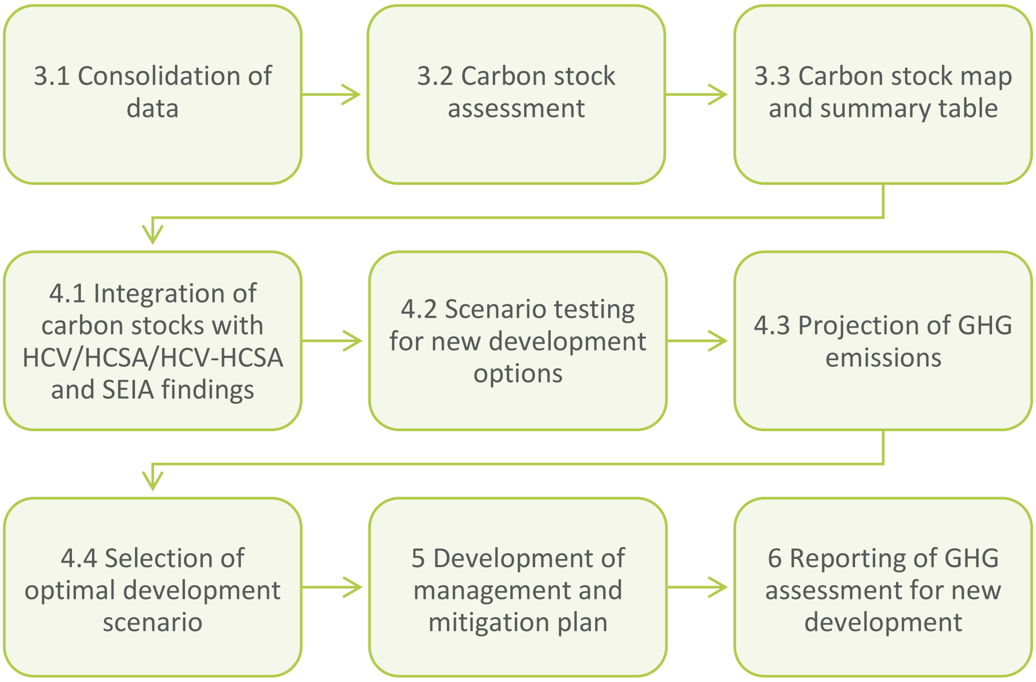

Figure 1: Required steps for GHG assessment procedure

Table 2 – Description of steps required for GHG assessment procedure

Step	Description
3.1 Consolidation of data	The first step in this GHG Assessment Procedure is to develop a carbon stock map and table for estimating the carbon stocks associated with stratified stratum (land cover stratification). A large portion of the required information can be drawn upon existing assessments (i.e. HCSA or HCV-HCSA, Soil and Topography) and thus should be used for the purpose of developing the carbon stock map. Additional information required such as Below Ground Biomass (BGB) and soil carbon (peat only, if identified) must be calculated respectively. Carbon stock map developed should include indicative presence of peat soil (if applicable) and estimated soil carbon.
3.2 Carbon stock assessment	
3.3 Carbon stock map and summary table	
4.1 Integration of carbon stocks with HCV/HCSA/HCV-HCSA and SEIA findings	The next step will be to integrate: i. Identified HCV areas ii. SEIA findings iii. Social findings from HCSA/HCV-HCSA assessments (i.e. participatory mapping, negotiations, agreements with communities etc.) into the carbon stock map developed. Integrated map serves to guide the exercise of projecting GHG emissions from different development options and eventually a summary of GHG emissions associated with the final development plan (a development map).
4.2 Scenario testing for new development options	
4.3 Projection of GHG emissions	
4.4 Selection of optimal development scenario	
5 Development of management and monitoring plans	This step will be to develop management and monitoring plans in order to ensure minimal emissions both during development of the chosen scenario in Section 4 and during operations once development has been completed.
6 Reporting of GHG assessment for new development	The final step for summarising the findings and emission calculations based on the selected scenario for New Planting Procedure (NPP) submission.

SECTION 3: CARBON STOCK ASSESSMENT

The carbon stock assessment is the first step of the GHG assessment procedure. The objective of this step is to quantify the existing carbon stock stored within the proposed development area (PDA), with the intent to identify the potential emissions that will be emitted from the development of the said area. The required carbon stock estimate must include carbon stored in:

1. Above Ground Biomass (AGB)
2. Below Ground Biomass (BGB)
3. Soil carbon (for peat only)

3.1 CONSOLIDATION OF DATA

With the adoption of the HCSA toolkit v2 in the 2018 P&C, it is acknowledged that the land cover maps and AGB carbon estimates have already been calculated through the standalone HCSA/ HCV-HCSA assessment, while soil maps (for identification of peat presence) are available through the soil and topography survey required for the NPP submission. Table 3 below provides some guidance to the existing source of information (if any) required in the carbon stock assessment.

Table 3 – Existing sources (If any) of data required for Carbon stock assessment

Information	Source
Location map and land cover map of PDA from satellite imagery	Standalone HCSA assessment; **OR** Integrated HCV- HCSA assessment
Soil map	Soil and topography survey
Above Ground Biomass (AGB)	Standalone HCSA assessment; **OR** Integrated HCV- HCSA assessment
Below Ground Biomass (BGB)	Not available. Must be calculated using AGB to BGB default value a.k.a. root:shoot ratio (refer 3.2.1)
Soil carbon (peat only)	Confirmation of presence of peat through Soil and Topography survey. If peat is present, confirm peat boundaries, average depth and bulk density through field sampling for calculation of peat soil carbon. (refer to 3.2.2)

This section explains how to produce the following specific outputs:

1. Location map and land cover map of the new development area derived from satellite imagery.
2. (if applicable) Map indicating the location and extent of peat soil.
3. (if applicable) Carbon stock estimated per ha for peat soil (tC/ha).
4. Table presenting carbon estimated per ha (tC/ha) per land cover class.
5. Map and a table summarising the total development areas (ha) and carbon stock estimated per land cover class.
6. Carbon stock map of the proposed development area.

It should be noted that this document is not intended to reproduce in detail information that is already contained in existing manuals and other guidance documents, including other RSPO guidance documents. Detailed descriptions for designing and establishing sample plots and calculating biomass, for example, is available in Module 4 of the HCSA toolkit V2.0. However, this tool provides references to the recommended online or published resources wherever possible. Growers may also use any other published references relevant to the steps described in this procedure.

3.1.1 LOCATION AND LAND COVER MAP

The 2018 P&C criteria 7.12.2 (b) requires that the identification of HCV, HCS and other conservation areas are identified through an HCV-HCSA assessment, using the HCSA toolkit and the HCV-HCSA assessment manual prior to any new development. As the HCV-HCSA assessment already includes the requirement for location and land cover maps derived from satellite imagery, these existing maps found in the HCV-HCSA assessment shall be used for the purpose of the carbon stock assessment.

For transition cases as described in the "*RSPO Interpretation of Indicator 7.12.2 and Annex 5*", the information shall be drawn from the standalone HCSA assessment prescribed by the document. The validity requirements of the standalone HCSA assessment described in the interpretation document apply. Table 4 indicates the sections of the standalone HCSA/HCV-HCSA assessment in which the required maps can be extracted for the use of the carbon stock assessment.

Table 4 – Source of maps from HCSA/HCV-HCSA assessments report sections

Map	Standalone HCSA	Integrated HCV-HCSA
Location map	Section 1.2: Overview of proposed plantation development	Section 6.1: Boundaries of the AOI
Land cover map	Section 8.3: Final Draft ICLUP	Section 8.2.3: Forest classification and carbon assessment

A table specifying the land cover classification/vegetation types and the hectarage of each respective classification is also required. Examples of both can be found in Figure 2 and Table 5.

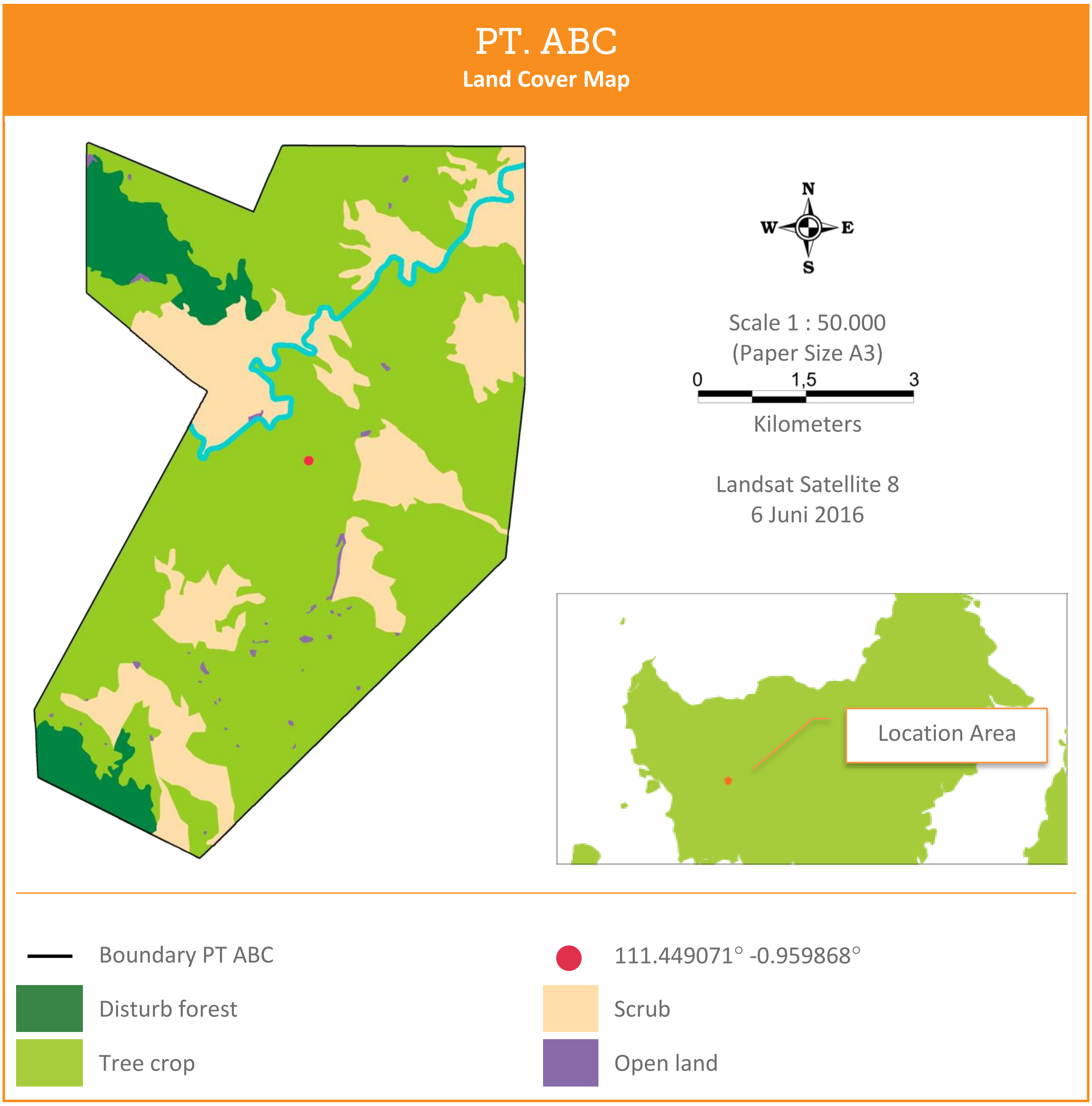

Figure 2: Sample land cover map of PT ABC

Table 5 – Land cover types of PT ABC

Land cover/vegetation type	**Area (Ha)**
Disturbed forest	877
Scrub land	1,620
Tree crop	4,515
Open land	36
Total	**7,048**

3.1.2 IDENTIFICATION AND VERIFICATION OF THE PRESENCE OF PEAT SOIL

Soils are carbon pools that can be influenced by land-use and management activities. The soil carbon stock in mineral soil is relatively low. Therefore, conversion to oil palm on mineral soils does not significantly alter soil carbon stock levels or significantly increase soil GHG emissions.

The soil carbon stock in peat soils is high and the peatland soil carbon stock can change significantly upon conversion to palm cultivation. Peat soils will readily decompose when conditions become aerobic such as following soil drainage for preparation of new development and on-going cultivation. Indicator 7.7.1 of the 2018 P&C prohibits new planting on peat regardless of depth after 15 November 2018 in existing and new development areas.

The generic definition of peat soils is defined in the "*RSPO Organic & Peat Soil Classification*" as:

Box 2: RSPO generic organic and peat soil definition

Histosols (organic soils) are soils with cumulative organic layer(s) comprising more than half of the upper 80 cm or 100 cm of the soil surface containing 35% or more of organic matter (35% or more Loss on Ignition) or 18% or more organic carbon (FAO 1998, 2006/7; USDA 2014; IUSS 1930).

The RSPO also allows nationally accepted definitions of peat, which may be proposed through the National Interpretation (NI) process for the RSPO P&C which may be applied in this assessment for the purpose of identifying peat presence in the PDA.

For the purpose of the RSPO GHG assessment procedure, the carbon stock of the peat soils in the proposed new development area and the potential emission upon development are considered. Carbon stocks of mineral soils are not considered.

The purpose of estimating the (peat) carbon stock and estimated GHG emissions from development of these areas within the proposed development area is to quantify peat areas where development should be avoided during the land use planning process and to identify potential savings for avoidance of peat areas. These scenarios are considered further in Chapter 4 and by using the New Development GHG Calculator.

In order to estimate the carbon stock for peat soils for a PDA, the following steps are required:

1. Identify areas of potential peat soils in the PDA (covered in this section),
2. Verification of peat distribution maps for the PDA (this section),
3. Determine average peat depth for the peat area (section 3.2.2),
4. Determine average carbon content and bulk density and determine total peat carbon stock for the peat area (section 3.2.2).

Step 1 above is done remotely by referring to existing data and maps, whereas steps 2-4 require field work. In order to estimate the potential sources of peat emissions, the New Development GHG Calculator is used.

Identification of potential peat soils

The first step in estimating potential carbon emissions from peat is to determine whether there are any peat soils in the PDA. The best place to start is to refer to existing soil maps and remote sensing data to assess whether there may be peat soils occurring in the area, and to delineate peat soils versus non-peat soils. This should be done in line with the decision tree in Figure 3.

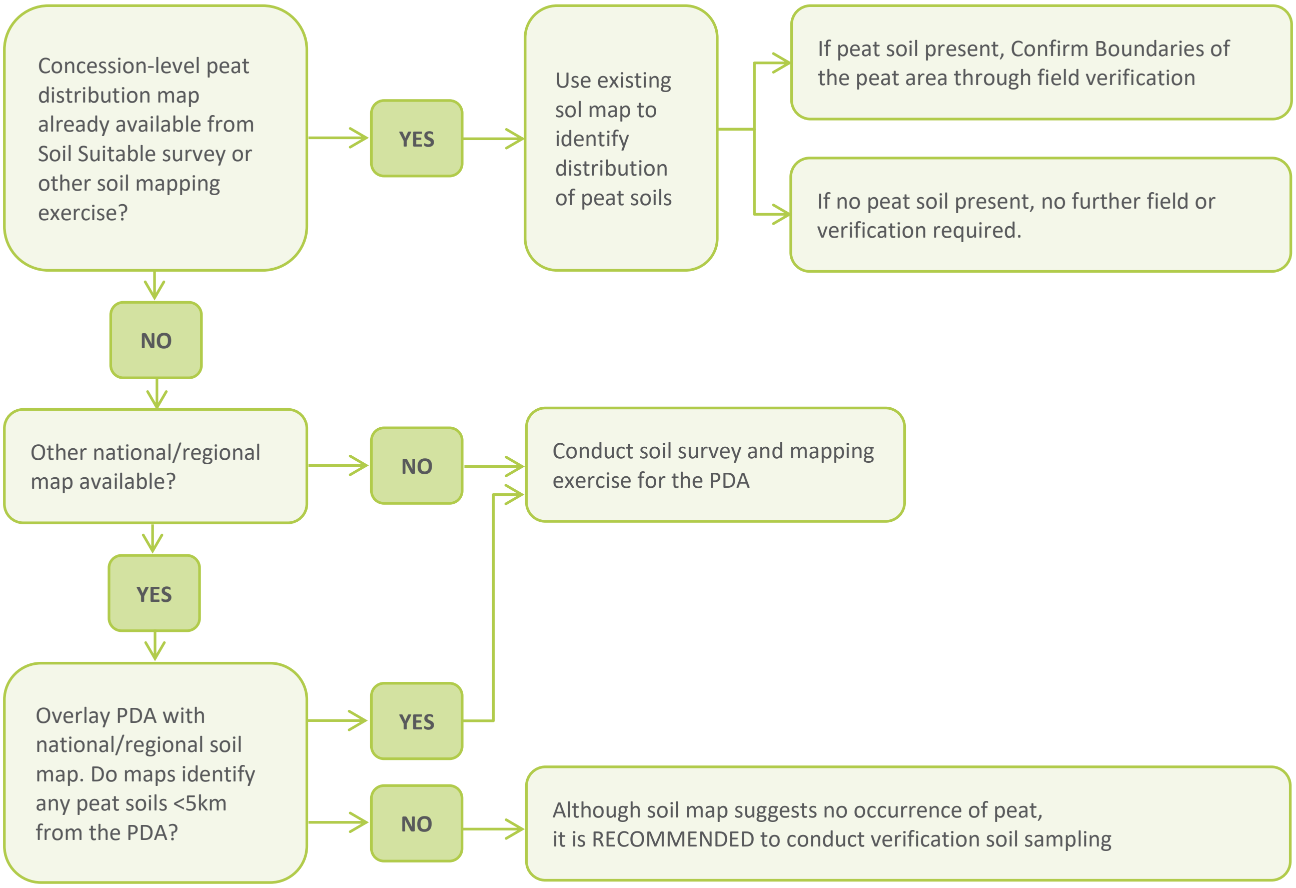

Figure 3: Decision tree for identifying potential peat areas

In many cases the company may have already developed peat/soil maps as part of a Soil Suitability mapping exercise, as also required for the NPP submission. Alternatively, national/regional (or sometimes global) maps may be available. The decision tree in Figure 3 explains how to use any existing maps.

Soil maps developed specifically for the PDA will typically be most accurate and so should be used as a priority. If soil maps developed for the PDA identify peat but have not been verified through field verification, then field verification of the peat distribution will be required as part of this GHG assessment. National/regional maps can be used as a second choice but will require additional field verification.

Most national soil/peat maps are developed at a low resolution and at a national scale and so are rarely accurate at a concession level. Therefore, national maps should be used only in the absence of more accurate soil maps for the PDA and in a precautionary manner to assess potential peat presence in the PDA. In most countries, soil maps can be procured from relevant government agencies, but there are also publicly available maps that give a useful indication of peat distribution (see Appendix 2). The most recently available and high resolution (peat) maps shall be used. It is recommended to conduct a soil mapping exercise for the PDA if any national soil/peat maps suggest that peat soils are found inside or within 5 km of the PDA.

There are three outcomes of the decision tree in Figure 3:

1. Peat soils not present in the PDA: no further peat verification or sampling required
2. Peat is definitely present and its distribution is mapped: proceed to peat carbon estimation (3.2.2)
3. Peat is potentially present: conduct a soil mapping exercise (guidance in this section)

Peat landscape mapping can be done through soil surveys or a combination of high spatial and spectral resolution remote sensing data and soil surveys in the PDA. Remote sensing data can be used as a first step to map topography of the PDA. Tropical peat typically occurs in domes[3] and so understanding topography can inform the potential presence/distribution of peat. Topography can be mapped using either existing Digital Elevation Models (DEMs) or new DEMs can be developed[4]. The resolution of any DEM should be sufficiently high (less than 1 m vertical resolution and 30 m horizontal resolution) to identify potential peat domes. One new technique for mapping peat distribution combines LiDAR with lower resolution contour maps to develop high resolution Digital Terrain Models (DTMs)[5]. Given the high-water content of peat soils, DEMs can also be combined with indices of soil wetness to refine maps of potential peatlands (see for example, Gumbricht 2012[6]).

Verification of peat distribution maps for the PDA

Having conducted remote topography mapping or reviewed Peat soil maps, the next step is to conduct field sampling to verify the distribution of peat soils on the ground. If field soil sampling is required then it should be combined, for the sake of efficiency, with peat carbon stock sampling as required under 3.2:

Field sampling should also measure:
1. Peat depth, and
2. Bulk density and carbon content (if growers choose to use real estimates rather than RSPO defaults)

It is recommended that soil samples and peat depth measurements are taken in transects or sampling grids perpendicular to the (estimated or expected) peat boundary as defined by maps/remote sensing data/ground surveys. Accurate peat boundary needs to be determined through sampling along a transect between the mineral soil and the peat. The results of the plot samples may then be used to refine the boundaries on the peat distribution maps, using manual drawing or GIS modelling to map the peat boundaries. Growers should also state the accuracy of the model used (if any), and ≥60% accuracy is recommended. Further guidance on peat sampling techniques can be found in (Agus et al., 2011; Schrier-Uijl & Anshari, 2013[7]; Barthelmes et al., 2015[8]).

The output of step 3.1.2 will be the map indicating the presence of peat soil as shown in Figure 4.

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[3] Note, in some regions, peat may also occur in depressions or river of lake basin and these systems may have concave rather than domed surfaces

[4] It should be noted that Digital Elevation Models (DEMs) mapped the surface of the vegetation, rather than the land and so DEMs need to be adjusted through ground-truthing as appropriate to produce Digital Terrain Models (DTMs)

[5] Deltares. Exploration of efficient and cost-effective use of LiDAR data in lowland/peatland landscape mapping and management in Indonesia. Status update April 2016. https://www.deltares.nl/app/uploads/2015/03/Overview-LiDAR-use-in-peat-management-Indonesia-Deltares-April-2016.pdf

[6] Gumbricht, T. 2012 Mapping global tropical wetlands from earth observing satellite imagery. Working Paper 103. CIFOR, Bogor, Indonesia.

[7] http://www.rspo.org/key-documents/supplementary-materials

[8] Barthelmes et al., December 2015. Consulting Study 5: Practical guidance on locating and delineating peatlands and other organic soils in the tropics. Carbon Stock Study.

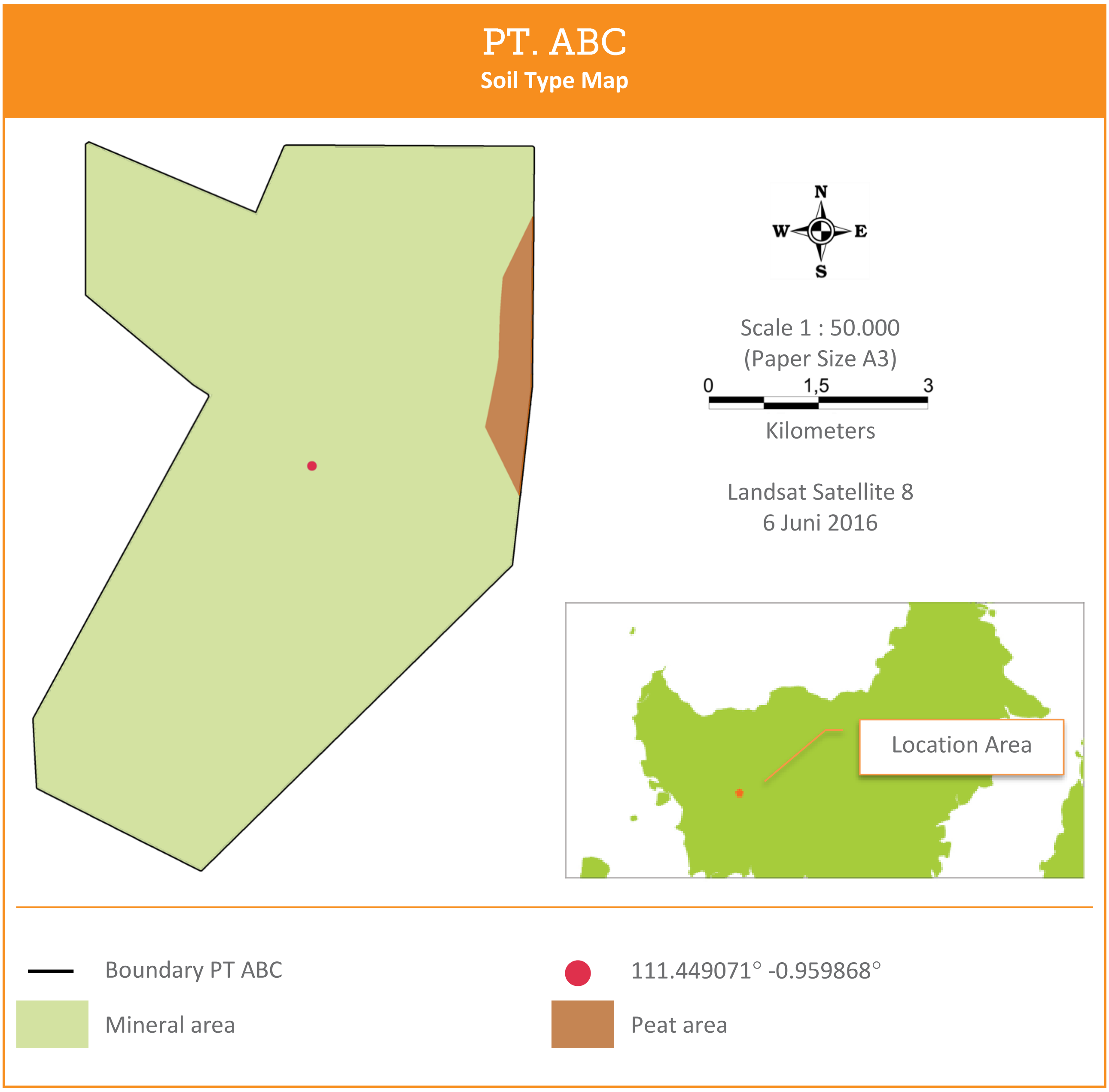

Figure 4: Sample map indicating presence of peat in PT ABC

3.2 CARBON STOCK ESTIMATION

With the land cover map and hectarage from the HCSA/HCV-HCSA assessment available, and the presence of peat ascertained, the next step is to estimate the carbon stock, expressed in tonnes of carbon per hectare (tC/ha) in the PDA. Of the five carbon pools (Above round Biomass, Below Ground Biomass, dead wood, litter and soil organic matter) as defined by the IPCC, this assessment only needs to consider Above round Biomass (AGB), Below round Biomass (BGB) and soil organic matter. As explained in Figure 3, soil organic matter only needs to be estimated when peat soils are present.

3.2.1 ABOVE GROUND BIOMASS (AGB) AND BELOW GROUND BIOMASS (BGB)

As mentioned in Table 1, the above ground biomass (AGB) for each land cover classification is calculated in the standalone HCSA/HCV-HCSA assessment. Table 6 shows the specific sections in which the AGB for each land cover class can be found in both the standalone HCSA and integrated HCV-HCSA assessments.

Table 6 – AGB from HCSA/HCV-HCSA assessments report sections

Item	Standalone HCSA	Integrated HCV-HCSA
Above Ground Biomass (AGB)	Section 7.7: Summary of statistical analysis of carbon stock results per vegetation class	Section 8.2.3: HCS forest classification and carbon assessment

For the purpose of GHG assessments, it is also important to include Below Ground Biomass (BGB); the estimated carbon content of all live root biomass found in the PDA. As it is not practical to measure BGB (root biomass) directly and the preferred approach is to use a default ratio of BGB to AGB (commonly referred to as root:shoot ratio).

The root:shoot ratio varies depending on the vegetation type and local circumstances (Mokany et al., 2006) and for the purpose of this GHG Assessment Procedure it is recommended that a value of 0.18 be used for Southeast Asian tropical rainforests (Germer & Saeurborn, 2008; Niiyama et al., 2010; and Saner et al., 2012), while a more generalised value of 0.20 (Houghton et al., 2001; Achard et al. 2002; Mokany et al., 2006; Ramankutty et al. 2007) is used for tropical rainforests elsewhere in the world, as well as for subtropical moist forest/plantation. Additional root:shoot ratios are available in the "List of Allometric Equations for Different Vegetation Types and regions", downloadable through the RSPO website[9].

In order to convert AGB and BGB to carbon stock (expressed in tC/ha), the carbon content of the biomass must be estimated. The default value for the carbon content of above- and below-ground biomass used in the PalmGHG and the New Development GHG calculator is 0.5 (derived from IPCC, 2006).

Once carbon stock estimates per land cover class have been obtained, it is possible to estimate total carbon stocks per land cover class in the PDA by simply multiplying the area of each land cover class (ha) by the carbon stock estimate (tC/ha). The area of each land cover class can easily be calculated in GIS software.

Note: In scenarios where standalone HCSA or Integrated HCV-HCSA are not applicable (refer to RSPO Interpretation of Indicator 7.12.2 and Annex 5 document), growers may estimate the AGB using either RSPO default values (as per the GHG calculator for New Development), Regional/National specific values (if any) or local values through field assessment (refer to Appendix 3 and 4 for details).

3.2.2 PEAT CARBON STOCK

Once the boundaries of the peat area are determined, the total area of peat (ha), the carbon stock of the total area of peat (ton C/ha) and the expected GHG emissions (ton CO2-eq/ha) in the proposed new planting area can be calculated. There are three options for estimating the carbon stock of peat soil: (a) using field assessments (b) using defaults and (c) a combination of a and b.

[9] https://www.rspo.org/resources/greenhouse-gas/rspo-ghg-assessment-procedure-for-new-development

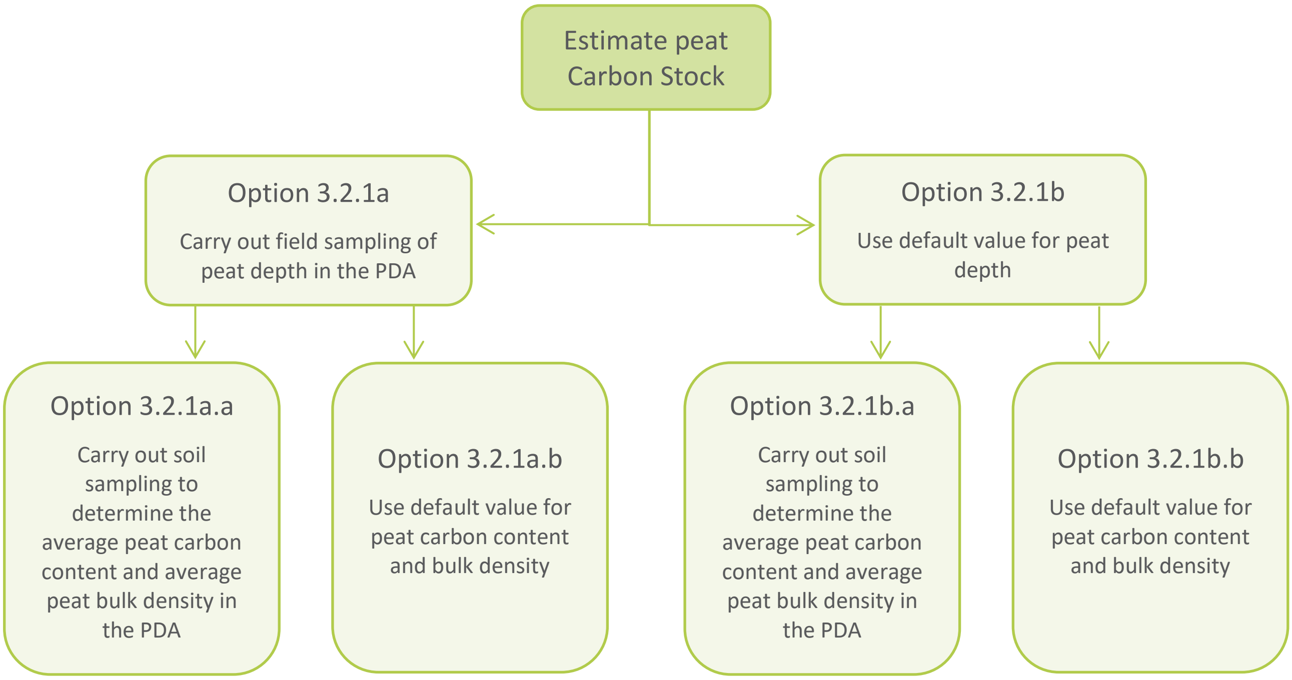

Figure 5: Options for peat carbon stock estimation

In the New Development GHG Calculator, GHG emissions from the drainage of peatlands are calculated using an equation that relies on drainage depth of peatland (in cm) as the main variable. This does not require the estimation of soil carbon stock prior to the calculation of GHG emissions.

Soil sampling conducted as part of the new plantation development should include measurements of the following parameters for calculating soil carbon stock in peatlands:

- Bulk density (g/cm3 or kg/dm3 or t/m3)
- Organic carbon content (% by weight or g/g or kg/kg)
- Peat depth or thickness (cm or m)
- Area of land in which the carbon stock is to be estimated (ha or km2)

For the assessment of average peat depth based on field measurements, a strategic and representative sample design shall be used referring to appropriate guidance such as Winrock Sampling Calculator[10]. The location of samples shall be shown on the peat map.

As stated in Figure 5, field assessment of peat depth can also be combined with field sampling used to map the distribution of peat soils, and (if chosen) for the assessment of the peat carbon content and peat bulk density based on field samples. The number of sample plots required for estimating carbon content and bulk density may be lower than that required for estimating peat distribution and depth.

It is recommended that once the plantation is under development; it is important that companies place permanent monitoring points in each peat block and conservation area with a piezometer (to measure water table depth) and a subsidence pole (to measure peat subsidence over time) or a combined piezometer/subsidence pole).

For growers deciding to use default values, RSPO provides default values for peat depth, bulk density and peat carbon content in Table 7.

[10] https://www.winrock.org/document/winrock-sample-plot-calculator-spreadsheet-tool/

Table 7 – Default values for estimating peat carbon stock

Parameter	Default value	Notes	References
Peat depth (D)	3 m	The use of the default value of 3 m is only applicable if there are valid reasons for not obtaining own measurements. It is strongly encouraged to perform own measurements.	
Bulk density (BD)	0.15 (range 0.05 – 0.25) t per m^3	Depending on compaction and peat type. Own data is preferred	Schrier-Uijl & Anshari, 2013
Peat Carbon Content (C)	47% (range 45 – 65) of total dry weight	Depending on peat type	IPCC 2006

The total peat carbon stock in the proposed new area of development can then be calculated as:

$$C_{peat}\ (tC) = A\ (ha) \times 10{,}000\ m^2/ha \times D\ (m) \times BD\ (t/m^3) \times C\ (\%)$$

Where:
A is the total area of peat in hectares
D is the average peat depth in metres
BD is peat bulk density in tonnes per cubic metre
C is the carbon content of the peat in percentages of dry weight.

Using the default values, the carbon stock per ha of peatland would be:

$$C_{peat}\ (t\ C) = 1 \times 10{,}000 \times 3 \times 0.15 \times 0.47 = 2{,}115\ tC$$

Details on measuring the above parameters are provided by Agus et al. (2011) and in a scientific review commissioned by the RSPO's Peatlands Working Group (Schrier-Uijl & Anshari, 2013).

3.3 PREPARATION OF THE CARBON STOCK MAP AND TABLE

With the conclusion of the activities outlined in Section 3.1 and 3.2, a map showing the different land cover strata and estimated carbon stock (above, below and soil carbon) shall be prepared. The values of the estimated carbon stock in each stratum shall also be indicated in a table (See Table 8, Table 9 and Figure 6).

Table 8 – Carbon stock (AGB and BGB) estimation for PT ABC

Vegetation type	Area (Ha)	Carbon Stock (tC/ha)	Total Carbon Stock (tC)
Disturbed forest	664	128	84,992
Scrub	1,800	46	82,800
Tree crop	4,548	75	341,100
Open land	36	0	0
Total concession	7,048 ha		508,892

Table 9 – Estimated peat soil carbon stock of PT ABC

	Area (ha)	Carbon Stock (tC/ha)	Total Carbon Stock (tC)
Peat soil	213	2,115	450,495

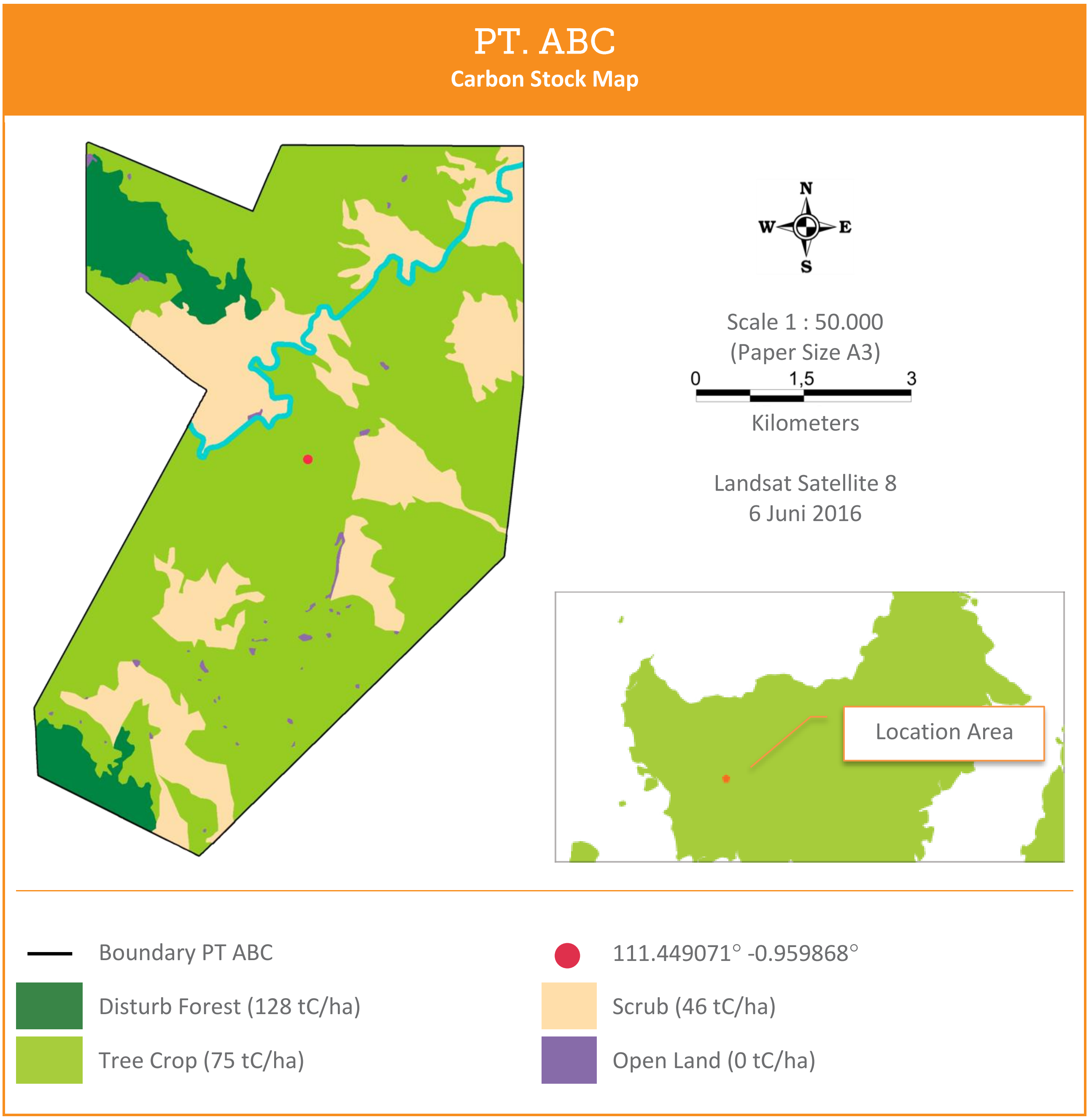

Figure 6: Carbon stock map of PT ABC

SECTION 4: ASSESSMENT OF GHG EMISSIONS FROM NEW DEVELOPMENT

This chapter serves to provide brief guidance and an example on:

1. Development of an integrated (carbon stock-HCV-social) map in the proposed new development area
2. New development scenarios
3. Conducting projection of GHG emissions associated with respective scenarios; and
4. The selection of an optimal development scenario considering environmental, economic, and practical considerations and resulting in a minimisation of GHG

4.1 INTEGRATION OF CARBON STOCKS WITH HCV AND SOCIAL FINDINGS

The results of the carbon stock assessment from Chapter 3 shall be combined with HCV and social findings (see Figure 7 and Table 10 for example). This shall be done by overlaying of the HCV areas and/or any other environmental and/or socially sensitive or important areas as identified through SEIA assessment and FPIC process (inclusive of participatory mapping) required in the HCSA/HCV-HCSA assessments, with the carbon stocks map developed.

Map created from overlaying HCV and/or other environmental and/or socially sensitive or important areas would then serve to create a map determining areas to be avoided or conserved and potential areas for new development (see Figure 7 for example).

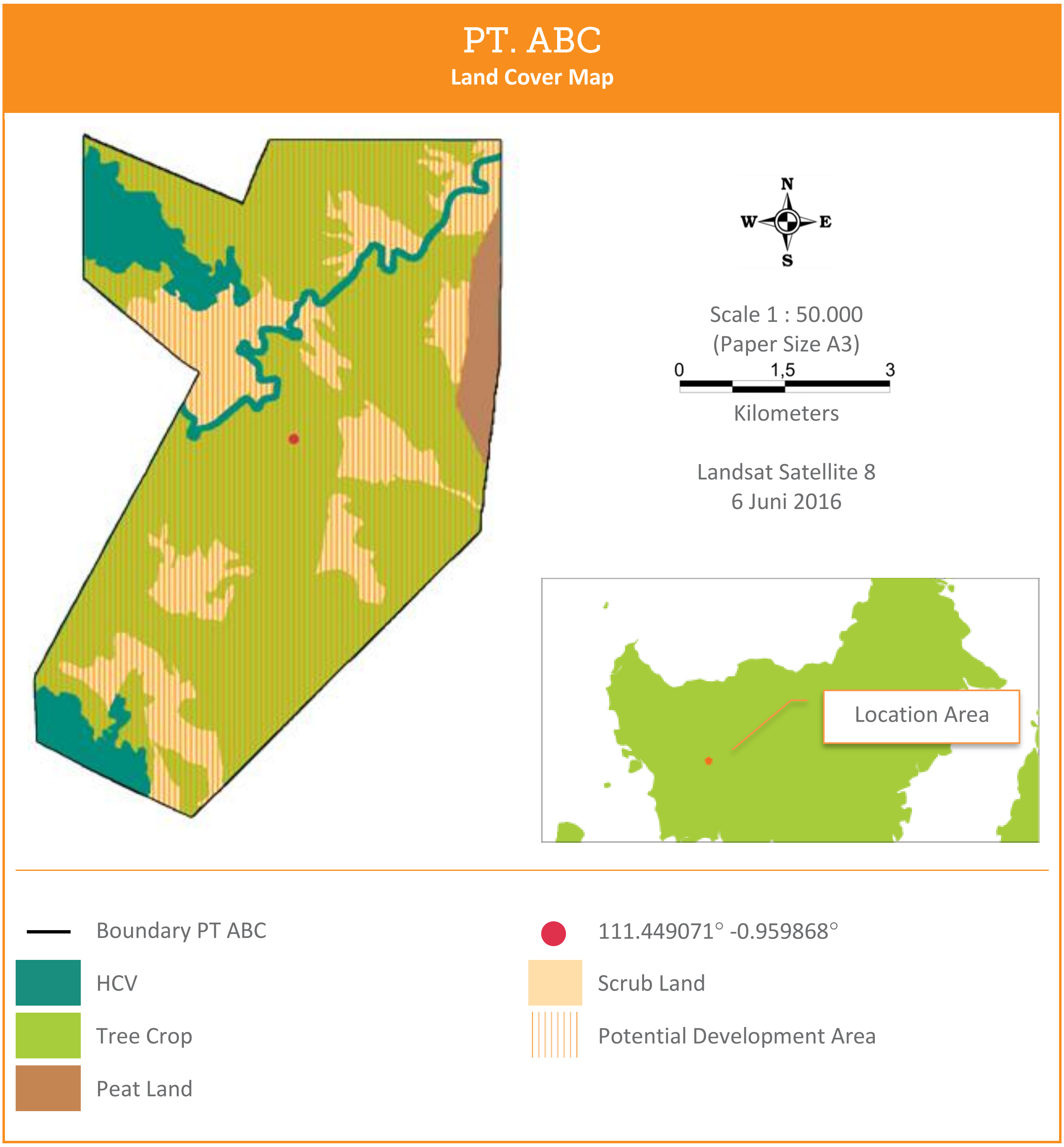

Figure 7: Integrated map with potential development area identified of PT ABC

Table 10 – Conservation areas of PT ABC

	Area (Ha)
HCV Area	564.8
Other Conservation set-aside	113 ha
Scrub (Peat soil)	100 ha
Disturbed forest	99 ha

4.2 SCENARIO TESTING FOR NEW DEVELOPMENT OPTIONS

Key steps:

STEP 1

Develop alternative scenarios based on spatial map developed (see Section 4.1)

→

STEP 2

Enter the carbon stock values, and (if applicable) planned depth of water table for peat areas into New Development GHG Calculator

Enter other projected agronomic and mill data as required in the New Development GHG Calculator and estimate the net GHG balance for one palm oil production cycle

→

STEP 3

Based on results of step 2, select optimal development scenario (see Section 4.3).

Based on both maps developed from Chapter 4.1, the company shall develop new development scenarios to guide the selection of the optimal development plan taking into consideration the areas that need to be avoided in the development and the operational practices that minimise GHG emissions.

Scenarios are projections of hypothetical land use options and mill design that enable potential GHG emissions to be estimated. The company needs to create two (2) or more scenarios for testing. This could be done through reconsidering if there are identified key emission sources or sinks within potential areas for new planting that could be set aside for conservation; and operational practices options that could be adopted for GHG emissions reduction.

It must be highlighted that scenario testing is hypothetical only, and as such allows creation of scenarios that may or may not fully comply with the 2018 P&C requirements, e.g. development of all areas of low-density forests (LDF) identified, etc. This is allowed to highlight the differences of emissions between the optimum scenario selected (which **must comply** with the 2018 P&C requirements) and other scenarios created (see note under table 11). Options created should be documented in a table (see Table 11 as an example).

Table 11 – Description of new development scenarios in PT ABC

Scenario 1	All potential areas for new development cleared for oil palm, except peat and disturbed forest. All peatlands and disturbed forests are to be conserved. No methane capture facilities planned for mill. Additional 100 m buffer for disturbed forests No clearing on HCV areas identified.
Scenario 2	All potential areas for new development cleared for oil palm, except peat and disturbed forest. All peatlands and disturbed forests are to be conserved. Methane capture facilities planned for mill. Additional 100 m buffer for disturbed forests No clearing on HCV areas identified.
Scenario 3	All potential areas for new development cleared for oil palm, except peat and disturbed forest. All peatlands and disturbed forests are to be conserved. No methane capture facilities planned for mill. No clearing on HCV areas identified.
Scenario 4	All potential areas for new development cleared for oil palm, except peat and disturbed forest. All peatlands and disturbed forests are to be conserved. Methane capture facilities planned for mill. No clearing on HCV areas identified.

		S1	S2	S3	S4
Area avoided for development	HCV area	565 ha	565 ha	565 ha	565 ha
	Other conservation set aside	243 ha	243 ha	212 ha	212 ha
	Scrub (Peat soil)	100 ha	100 ha	100 ha	100 ha
Potential areas for new development	Disturbed forest	0 ha	0 ha	0	0
	Scrub	1,620 ha	1,620 ha	1,620 ha	1,620 ha
	Tree crop	4,484 ha	4,484 ha	4,515 ha	4,515 ha
	Open land	36 ha	36 ha	36 ha	36 ha
POME Treatment	Conventional treatment	Y	-	Y	-
	Methane capture	-	Y	-	Y

*Note: Table 11 serves as an example only. There is no maximum limit for the number of scenarios to be developed. The examples shown have been simplified and in reality, the scenarios may be more complex and may include other set asides, e.g. social set asides, HCS areas etc. The selected optimal scenario **<u>must comply with the 2018 P&C requirements</u>**.*

4.3 PROJECTION OF GHG EMISSIONS

For each scenario, the estimated GHG emission should be calculated using the RSPO New Development GHG Calculator[11] (see Figure 8 and Table 12 for example). Follow the instructions provided within the New Development GHG Calculator to estimate GHG emissions associated with the development options of the respective scenarios. Flexibility is given to use either absolute emissions (tCO_{2e}) or emission intensity (tCO_{2e}/tCPO or tCO_{2e}/tFFB) for both projection table (Table 12) and projection graph (Figure 8). Where emission intensity (tCO_{2e}/tCPO or tCO_{2e}/tFFB) is used, the Oil Extraction Rate (OER) and Kernel Extraction Rate (KER) used to calculate the intensity (refer to New Development GHG calculator under 'Allocation to crop products tab') must be included in the assessment report.

Table 12 – Projection of GHG Emissions associated with different development scenarios (tCO_{2e}/tCPO)

Emission Source	S1	S2	S3	S4
Land conversion	1.96	1.96	1.96	1.96
Crop sequestration	-1.87	-1.87	-1.87	-1.87
Peat oxidation	0	0	0	0
Conservation sequestration	-0.21	-0.21	-0.20	-0.20
Fertiliser (mineral soil; manufacture & transport)	0.1	0.1	0.10	0.10
N_2O Emissions	0.09	0.09	0.09	0.09
Estate fuel consumption	0.004	0.004	0.004	0.004
Net estate emission	0.07	0.07	0.08	0.08
POME	0.78	0.15	0.78	0.15
Mill fuel consumption	0.04	0.04	0.04	0.04
Purchased electricity	0	0	0	0
Credit	0	0	0	0
Net mill emission	0.82	0.19	0.82	0.19
Net GHG emission	0.89	0.26	0.90	0.27

[11] RSPO New Development GHG Calculator can be downloaded from the RSPO Website, https://www.rspo.org/resources/greenhouse-gas/rspo-ghg-assessment-procedure-for-new-development

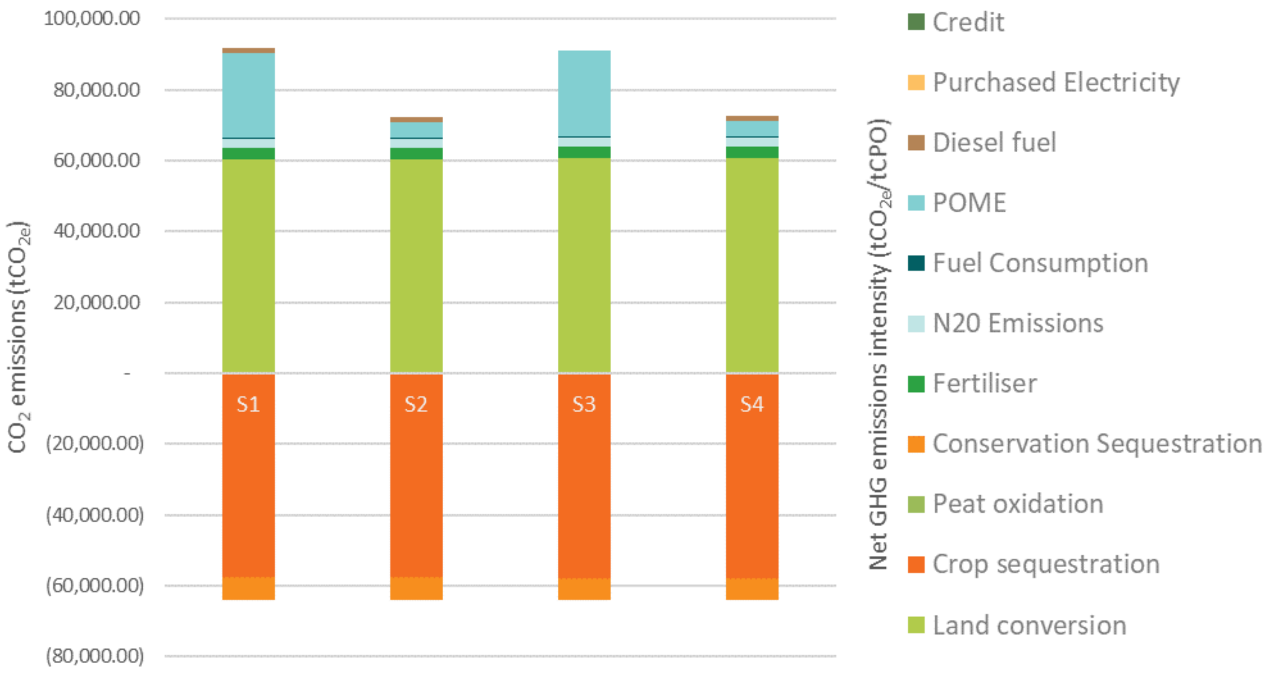

Figure 8: Projection of GHG Emissions (tCO_{2e}) associated with different development scenarios.

4.4 SELECTION OF OPTIMAL DEVELOPMENT SCENARIO

Analysis shall be conducted based on results from Chapter 4.3 presenting GHG emissions associated with respective development scenarios. Review the pros and cons of the various scenarios, considering:

1. Avoidance of land areas with high carbon stock[12] as determined in the HCSA/HCV-HCSA assessment and any areas containing peat.
2. Avoidance of HCV areas as determined in HCV assessment.
3. Options to increase the sequestration of carbon (conservation areas, river buffer zones, etc.)
4. Options to reduce operational emissions once development has been completed and plantation/mill is operational e.g. POME, fertiliser and fuel emissions etc.
5. Practical management issues such as access and connectivity, socio-economic concerns, participatory mapping, agreements with communities etc.

Select optimal development option, provide justification for the selection in the aspect of associated GHG emission and management and mitigation approaches for identified GHG emission hotspots. Present final selected new development plan and associated GHG emissions using map and table form. In the example shown here, Scenario 4 was selected as the optimal scenario (see Figures 9 and 10 as an example).

[12] Development of existing cultivated land with crop with higher carbon stock than oil palm e.g. rubber is permitted

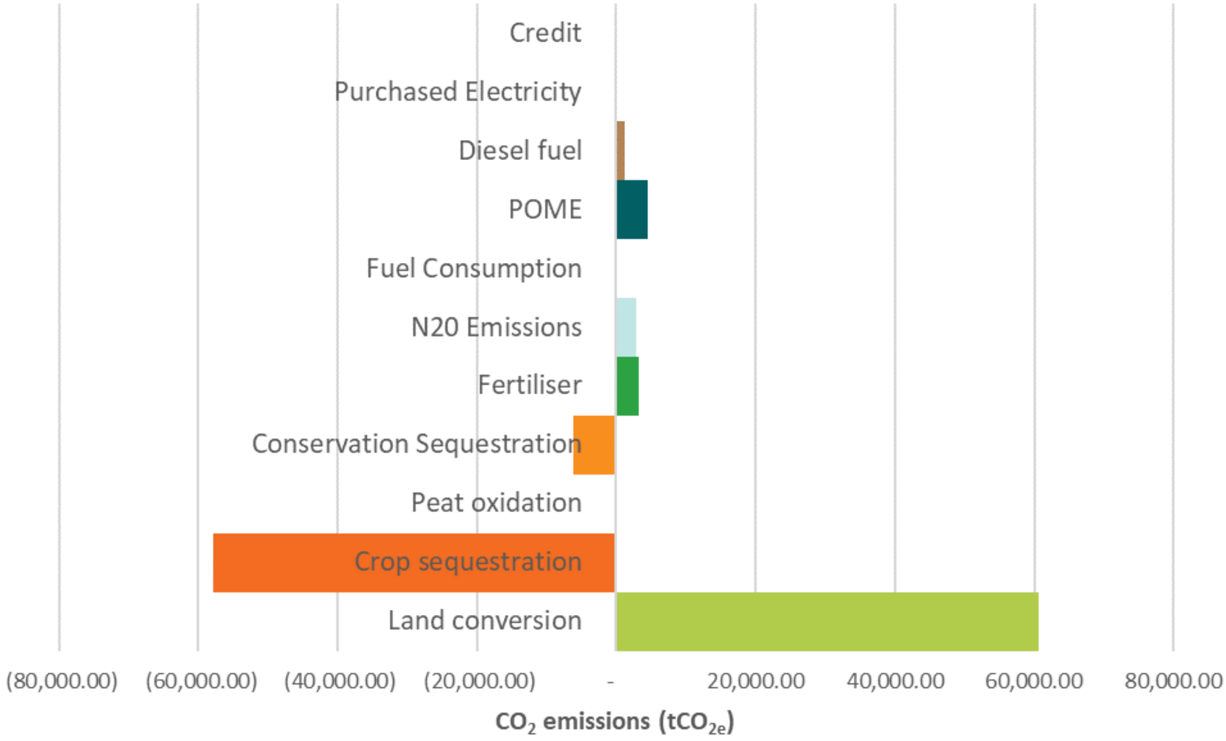

Figure 9: Summary of GHG emissions (Scenario 4) for new development plan of PT ABC (tCO_{2e})[13]

[13] Figures 8 and 9 serve as an example only. Presentation of data depends on user preferences

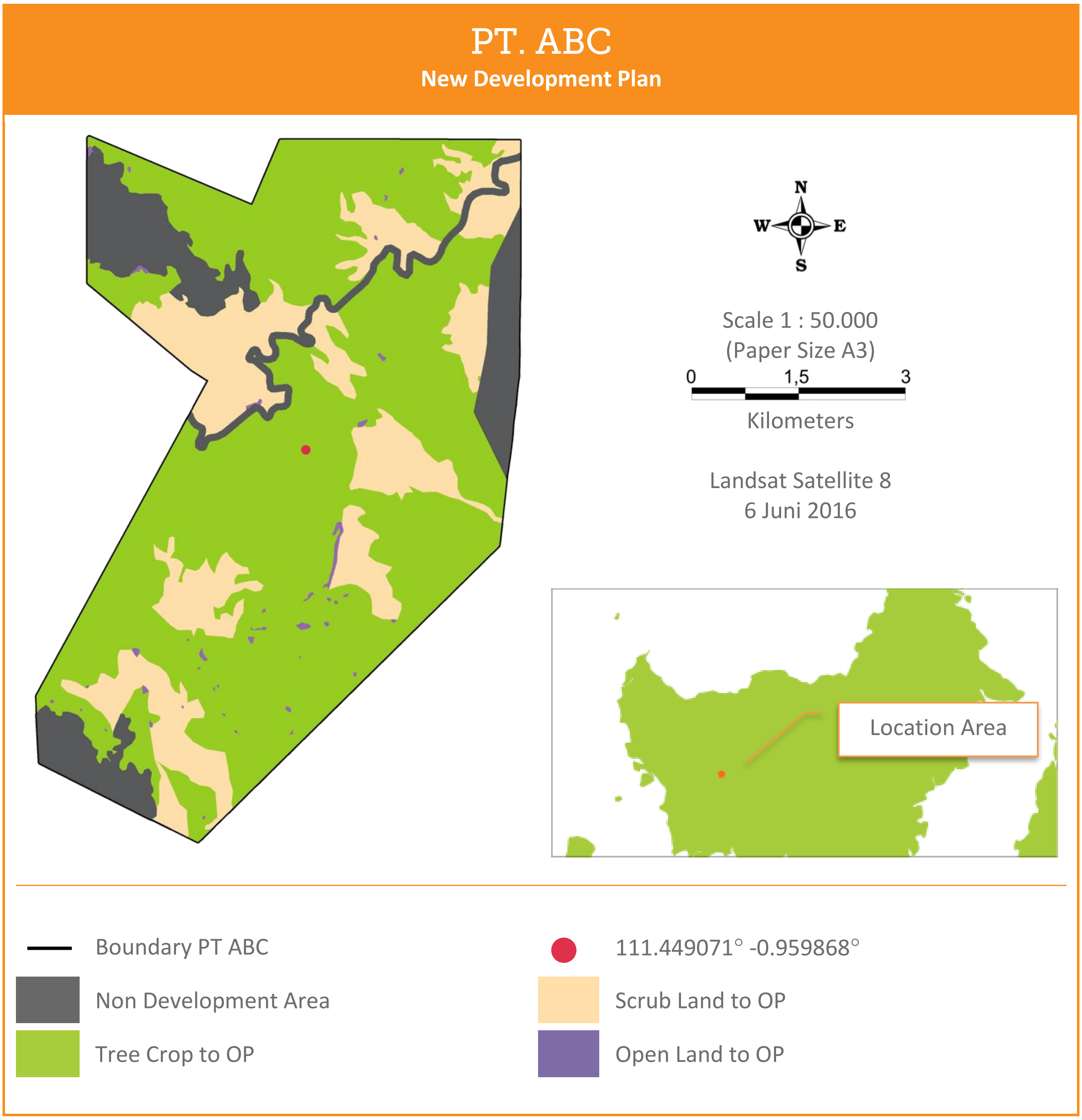

Figure 10: New development plan of PT ABC[14]

[14] Example given for assumption of the selected scenario 4

SECTION 5: DEVELOPING A GHG EMISSION MANAGEMENT AND MITIGATION PLAN

This chapter focuses on providing brief guidance on the development of the management and mitigation plan based on the projected GHG emissions of the new development plan (refer to GHG emissions associated with the development scenario selected from Chapter 4). The management and mitigation plan developed shall focus on minimising net carbon losses and GHG emissions and shall be a part of the Integrated Management Plan (IMP). The plan should describe the specific measures proposed to reduce or offset emissions for example:

1. Increasing sequestration (i.e. conservation areas, river buffer zones, etc.)
2. Management of the peat conservation areas to avoid impacts on ground water level (avoiding emissions from peat oxidation) within these areas due to development of adjacent areas.
3. Adoption of low GHG emissions management practices such as efficient use of fossil fuels, fertiliser regimes, etc.
4. Alternative mill technologies such as POME management, Biogas, etc.

The management and mitigation plan shall also include a process for monitoring the implementation of the plan and periodic review and refinement.

SECTION 6: REPORTING OF GHG ASSESSMENT FOR NEW DEVELOPMENT

The results of the GHG assessment procedure should be reported using the template shown in Box 3 below:

Box 3: GHG assessment report template

Assessment process and procedures

- Assessors and their credentials
- Methods and procedures used for conducting carbon stock and GHG assessments
- Team responsible for developing mitigation plan

Carbon Stock Assessment

- Location maps indicating area of new development at landscape level and property level
- Land cover map of the new development area (include verification process)
- (if applicable) Map indicating the location of peat soil
- Table presenting carbon stock estimated per ha (tC/ha) per land cover class
- (if applicable) Carbon stock estimated per ha for peat soil
- Table summarising the total development areas (ha) and carbon stock estimated per land cover class
- Carbon stock map
- List of references used in the assessment

GHG Emissions Assessment for New Development

- Summary table and map indicates carbon stock estimated with extent of HCV and presence of peat soil
- Map indicates areas to be avoided and potential areas for new development
- Table and chart summarising GHG emissions associated with development scenarios created
- Provide explanation for the selection of optimal scenario
- Development map and GHG emissions projection chart (final)

GHG Emissions Management and Mitigation Plans

- Explain measures taken to maintain and enhance carbon stocks within the new development areas.
- Explain measures that will be taken to mitigate net GHG emissions associated with oil palm cultivation and processing in the new development (e.g. methane capture at the palm oil mill, local sourcing of fertilisers, reducing usage of inorganic fertilisers, reducing fuel consumption, rehabilitation of HCS and HCV areas etc.)
- Plan for monitoring the implementation of selected scenario for new development including measures for enhancing carbon stock and minimising GHG emissions

Internal responsibility

- Formal sign off by assessors and company
- Statement of acceptance of responsibility for assessments
- Organisational information and contact persons
- Formal signoff of management and mitigation plans

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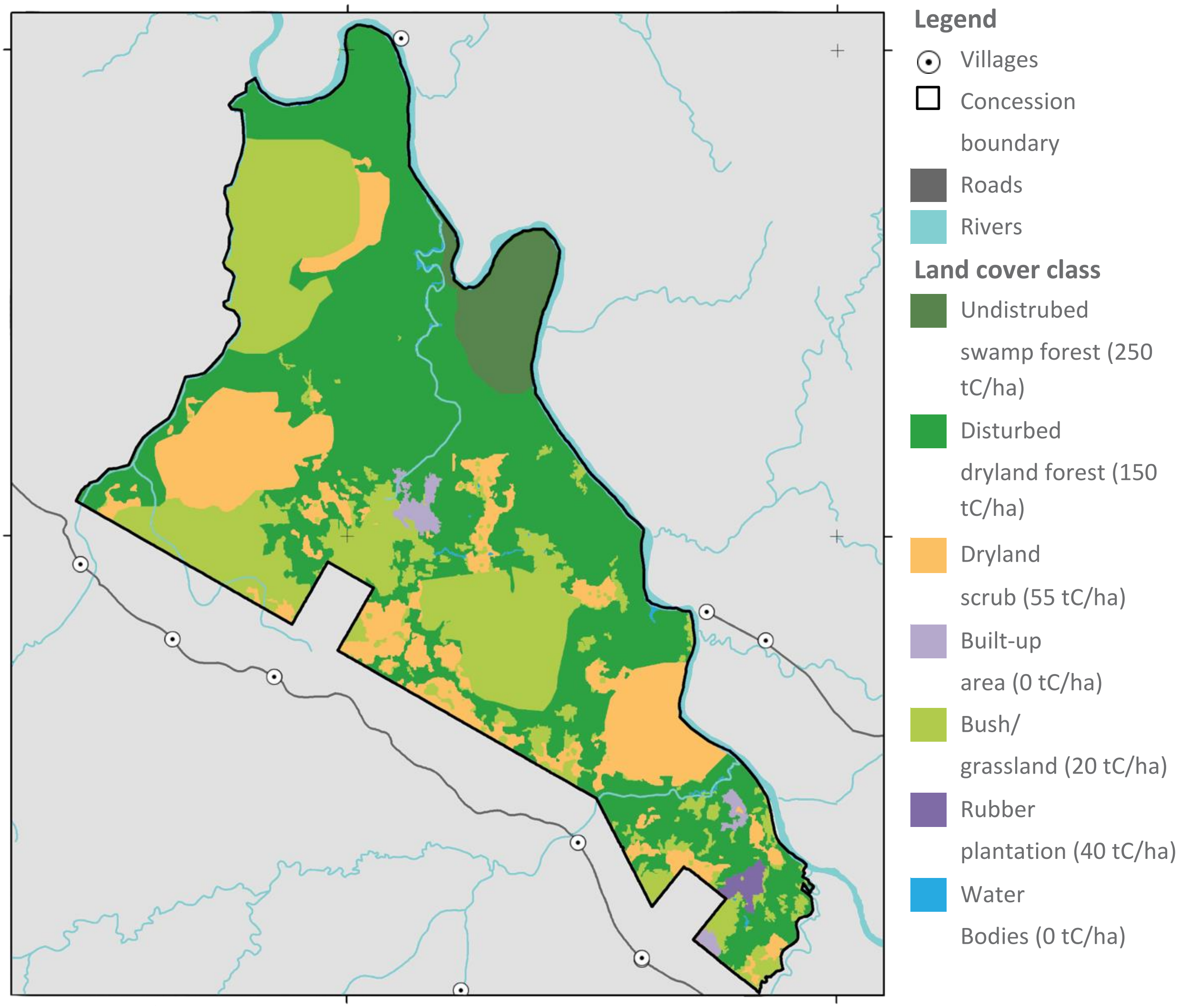
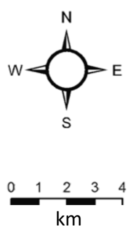
APPENDIX 1: EXAMPLE MAPS, TABLES AND CHARTS

Note that the concession boundary is based on a real concession, but all land cover, peat areas, local carbon stock estimates and HCV areas are entirely fictional. They are provided to illustrate the use of local-specific land cover classes.

Case Study: Land cover map





Coordinate system: GCS WGS 1984
Prepared for: GHG assesment procedure
Prepared by: ERWG
Date: 2016

Figure A1-1: Land cover map of Case Study

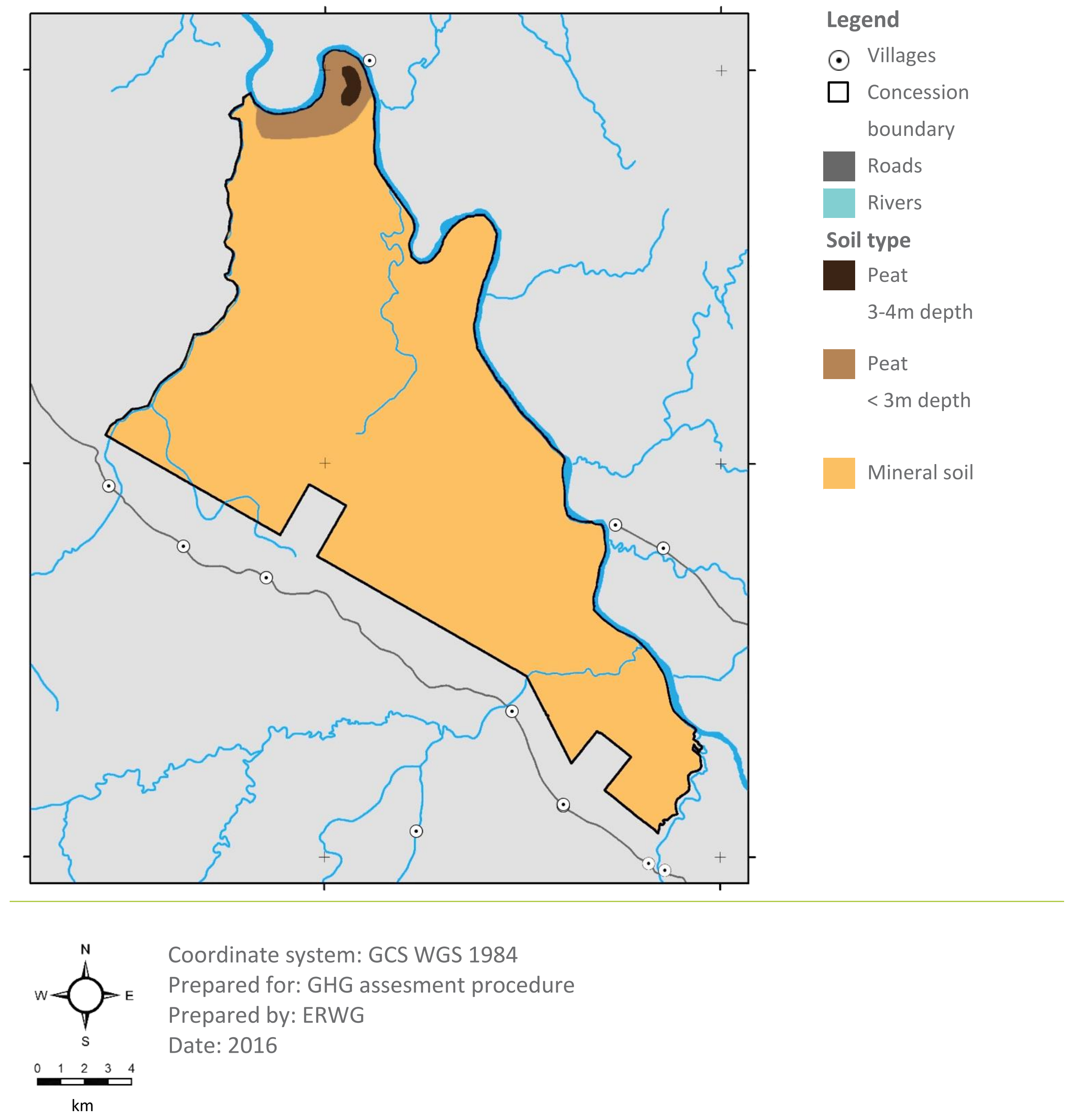
Table A1-1 – Land cover types of Case Study

Land cover/vegetation type	Area (Ha)
Undisturbed swamp forest	1,721
Disturbed dryland forest	17,566
Dryland shrub	9,386
Built-up area	147
Bush/grassland	6,215
Rubber plantation	360
Water	103
Total	**35,498**

Table A1-2 – Carbon stock (AGB and BGB) estimation for Case Study

Vegetation type	Area (Ha)	Carbon Stock (tC/ha)	Total Carbon Stock (tC)
Undisturbed swamp forest	1,721	250	430,250
Disturbed dryland forest	17,566	150	2,634,900
Dryland shrub	9,386	55	516,230
Built-up area	147	0	0
Bush/grassland	6,215	20	124,300
Rubber plantation	360	40	14,400
Water	103	0	0
Total concession	**35,498 ha**		**3,720,080**

Case Study: Peat Map



Coordinate system: GCS WGS 1984
Prepared for: GHG assesment procedure
Prepared by: ERWG
Date: 2016

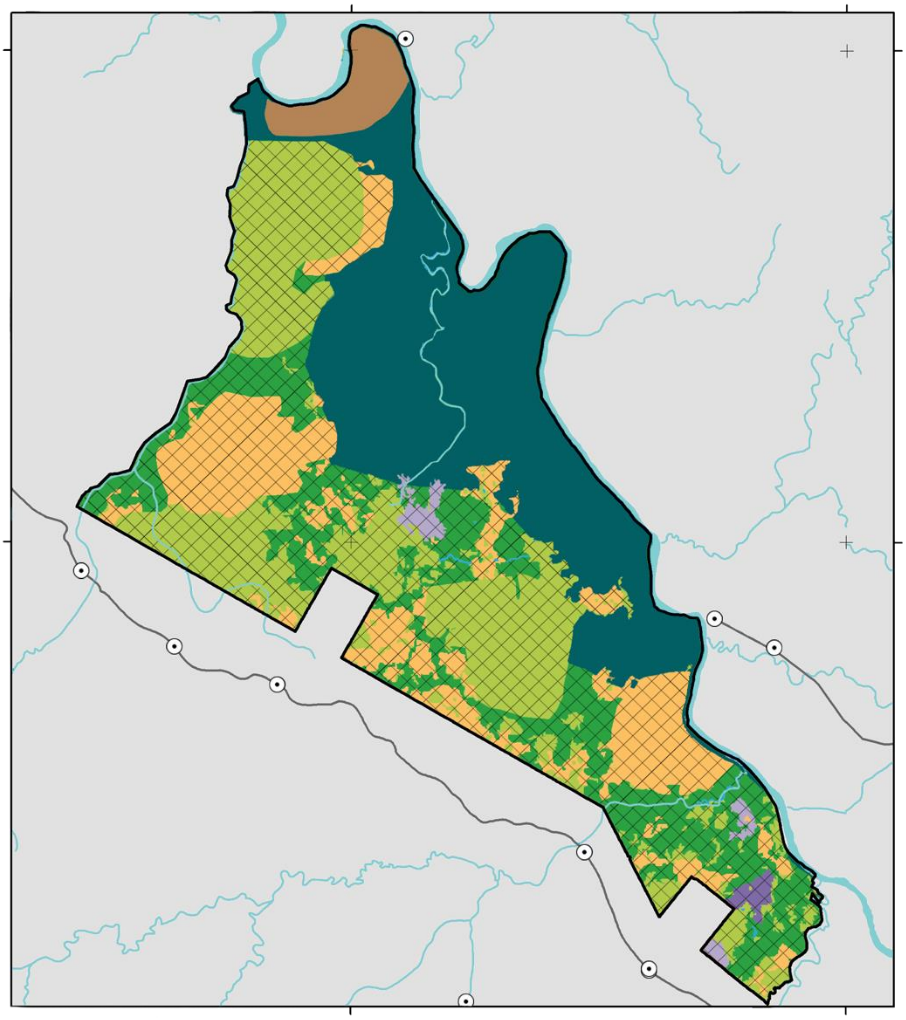
Figure A1-2: Peat map of case study

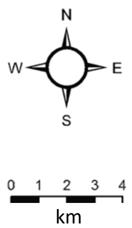
Table A1-3 – Estimated peat soil carbon stock of Case Study

Peat area	Area (ha)	Carbon Stock (tC/ha)	Total Carbon Stock (tC)
Peat < 3m depth[15]	932.0	1,057.5	985,590
Peat 3-4m depth[16]	136.9	2,467.5	337,800.75

[15] Carbon stock assuming average depth of 1.5m
[16] Carbon stock assuming average depth of 3.5m

Case Study: Integrated Map





Coordinate system: GCS WGS 1984
Prepared for: GHG assesment procedure
Prepared by: ERWG
Date: 2016

Figure A1-3: Integrated map with potential development area identified of Case Study

Table A1-4 – HCV areas of Case study

	Area (Ha)
HCV Area	6,783

Table A1-5 – Description of new development scenarios in Case study

Scenario 1	All potential areas for new development cleared for oil palm. No clearing on HCV areas identified. All peat soils are included within HCV areas. No methane capture facilities planned for mill.
Scenario 2	All potential areas for new development cleared for oil palm. No clearing on HCV areas identified. All peat soils are included within HCV areas. Methane capture facilities planned for mill.
Scenario 3	All potential areas for new development cleared for oil palm, except 5,500 ha of disturbed dryland forest with high carbon stocks. No clearing on HCV areas identified. All peat soils are included within HCV areas. No methane capture facilities planned for mill.
Scenario 4	All potential areas for new development cleared for oil palm, except 5,500 ha of disturbed dryland forest with high carbon stocks. No clearing on HCV areas identified. All peat soils are included within HCV areas. Methane capture facilities planned for mill.

		S1	**S2**	**S3**	**S4**
Area avoided for development	HCV area	6,783 ha	6,783 ha	6,783 ha	6,783 ha
	Other forested conservation set aside	0	0	5,500 ha	5,500ha
	Other non-forested set aside	424 ha	424 ha	424 ha	424 ha
Potential areas for new development	Disturbed dryland forest	12,404 ha	12,404 ha	6,904 ha	6,904 ha
	Rubber	355 ha	355 ha	355 ha	355 ha
	Bush/ Grassland	6,145 ha	6,145 ha	6,145 ha	6,145 ha
	Dryland shrub	9,140 ha	9,140 ha	9,140 ha	9,140 ha
	Built-up area	147 ha	147 ha	147 ha	147 ha
POME Treatment	Conventional treatment	Y	-	Y	-
	Methane capture	-	Y	-	Y

Table A1 – 6 – Projection of GHG Emissions ($tCO_{2e}/tCPO$)

Emission Source	S1	S2	S3	S4
Land conversion	0.69	0.69	0.57	0.57
Crop sequestration	-0.47	-0.47	-0.47	-0.47
Conservation Sequestration	-0.12	-0.12	-0.25	-0.25
Fertiliser	0.03	0.03	0.03	0.03
N2O Emissions	0.04	0.04	0.04	0.04
Fuel Consumption	0.00	0.00	0.00	0.00
Net estate emission	0.17	0.17	-0.08	-0.08
POME	0.20	0.02	0.20	0.02
Diesel fuel	0.00	0.00	0.00	0.00
Purchased Electricity	0.00	0.00	0.00	0.00
Credit	0.00	-0.01	0.00	-0.01
Net Mill emission	0.20	0.01	0.20	0.01
Net GHG emission	**0.37**	**0.18**	**0.12**	**-0.07**

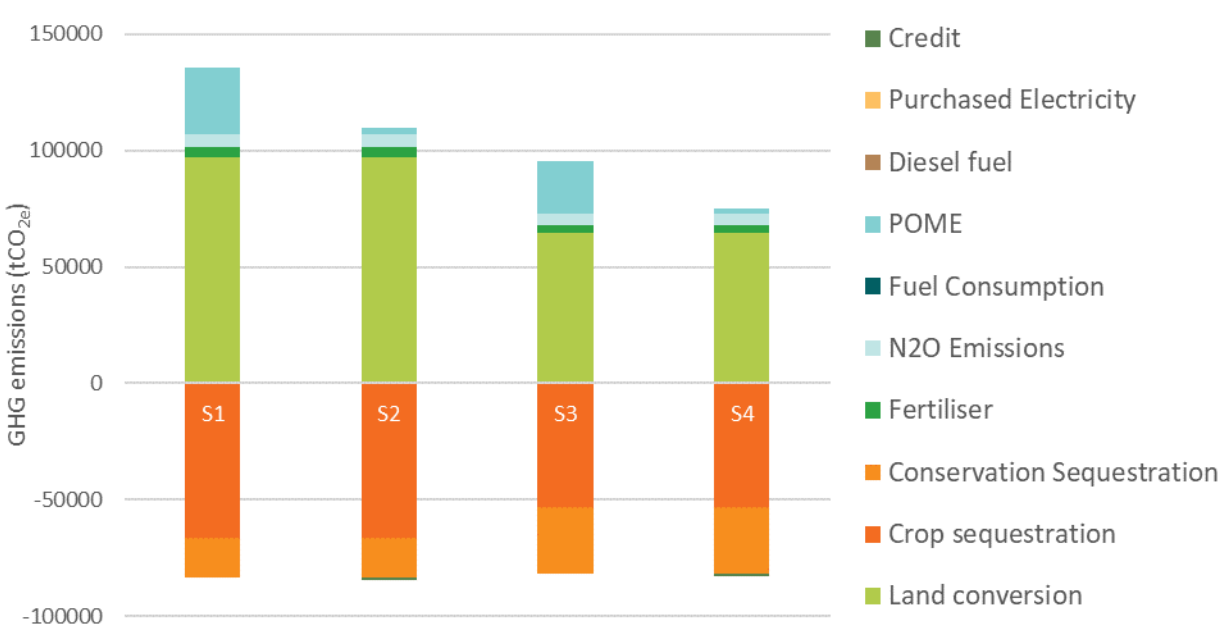


Figure A1-4: Projection of GHG emissions (tCO2e) associated with different development scenarios

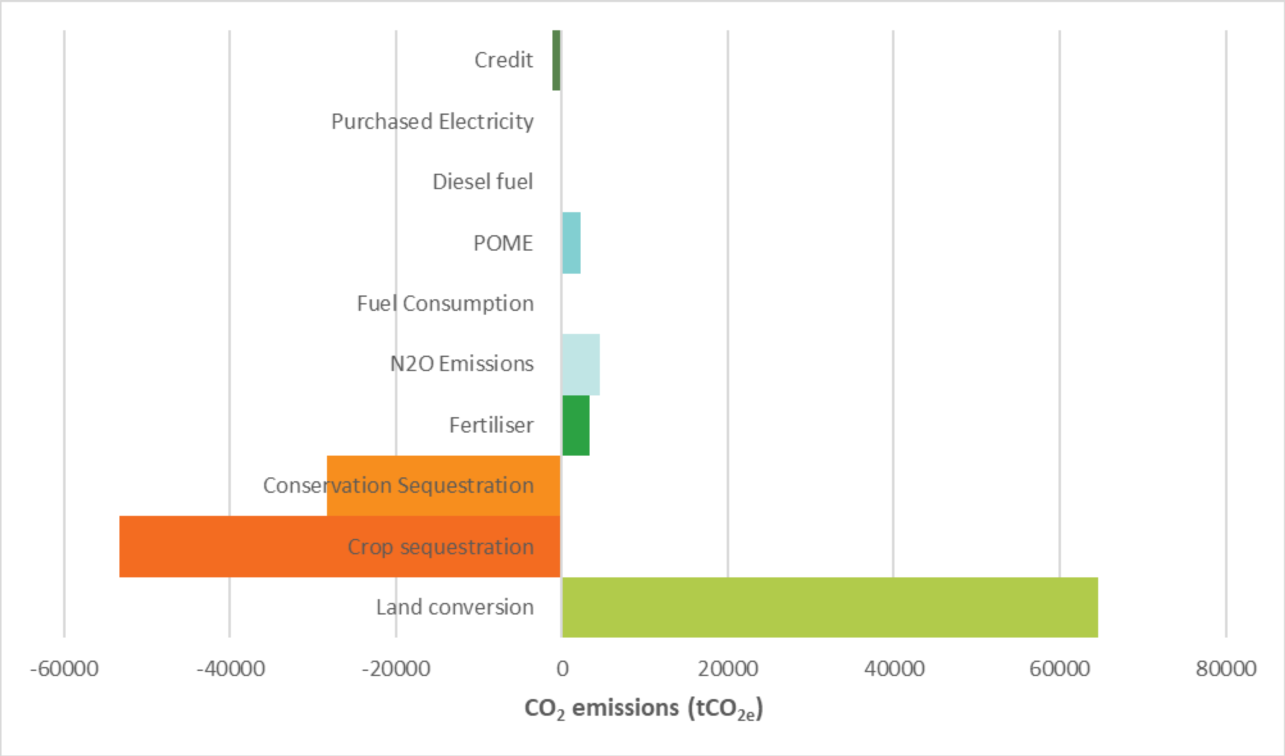
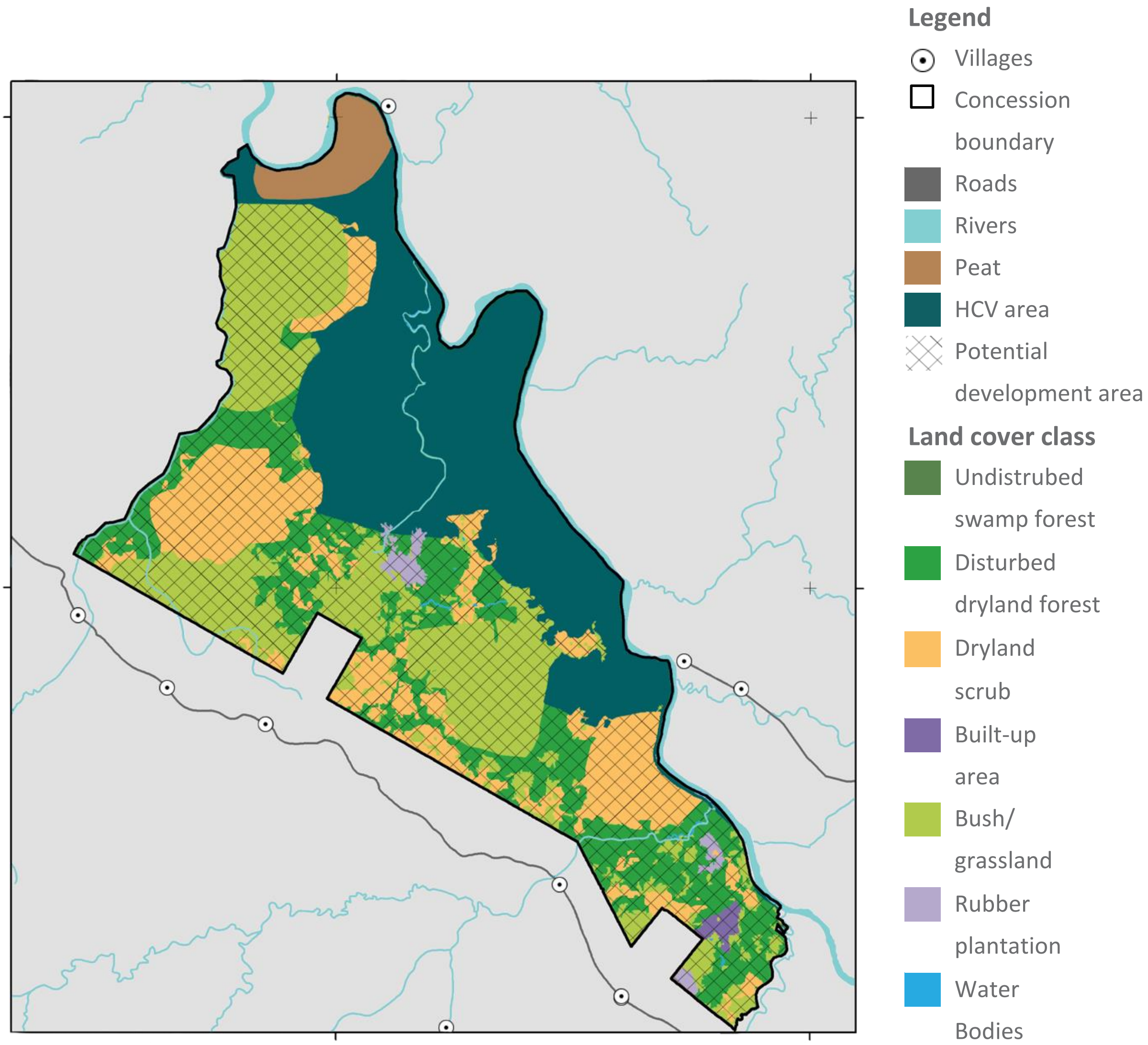
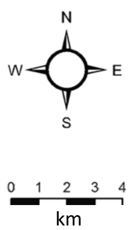


Figure A1-5: Summary of GHG emissions for new development plan for Case Study 2 (tCO_{2e})

Case Study: New Development Plan





Coordinate system: GCS WGS 1984
Prepared for: GHG assesment procedure
Prepared by: ERWG
Date: 2016

Figure A1-6: New Development Plan of Case Study[17]

[17] Example given for assumption of the selected scenario 4.

APPENDIX 2: SUGGESTED SOIL/PEAT MAP REFERENCES

Malaysia

- The Department of Agriculture has a database of soil maps of various resolutions that can be requested or purchased[18],
- Atlas of peat lands in Malaysia in 2004, developed by Wetlands International and visualised by the World Resources Institute (WRI)[19]

Indonesia

- An atlas of peatlands in Indonesia with indicative peat depths published by Wetlands International (Wahyunto et al. 2003, 2004, 2006).
- The Ministry of Agriculture has produced a 2012 peat map that has been visualised by the WRI

Additional peat datasets for Indonesia include:

- Those developed by the Indonesia Center for Agricultural Land Resources Research and Development (ICALRRD),
- The 1980s RePPProT Land Systems map[20], and
- Indicative priority peat restoration maps by the Badan Restorasi Gambut (BRG)

Other countries

Peatlands have a relatively restricted distribution globally, with the most significant known tropical peatlands occurring in Malaysia and Indonesia, where the best peat maps are available. Peatlands do occur elsewhere in the tropics and although high resolution maps are generally lacking, the Harmonised World Soil Database (HWSD) provides a coarse global soil map, with peat soils mapped as Histosols[21].

[18] A list of available soil maps for Malaysia can be accessed at: http://www.doa.gov.my/senarai-peta-yang-disediakan-doa

[19] http://www.globalforestwatch.org/map/7/4.33/108.96/MYS/grayscale/none/732?tab=analysis-tab&dont_analyze=true

[20] The RePPProT map is accessible here (note that this is not an official government source): https://databasin.org/datasets/eb74fe29b6fb49d0a6831498b0121c99

[21] http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/harmonized-world-soil-database-v12/en/

APPENDIX 3: AGB CARBON STOCK ESTIMATION (SELECTED SCENARIOS)

In most scenarios, the AGB estimation is derived from the Integrated HCV-HCSA **or** Standalone HCSA assessment. However, there are limited scenarios where neither of those assessments are required (refer to *RSPO Interpretation of Indicator 7.12.2 and Annex 5 document* for details).

In the absence of the AGB estimation from the Integrated HCV-HCSA **or** Standalone HCSA assessment, companies have the following options:

1. Estimate AGB from field sampling plots and BGB based on root:shoot ratio; **or**
2. National/regional default values for AGB and BGB (if available); **or**
3. RSPO default values for AGB and BGB.

Note: For option 2 & 3, the suitability to use these AGB and BGB values would depend on the compatibility of the identified land classification on the planned development area and the default values. In absence of compatible default values, Option 1 shall be used.

ESTIMATION OF AGB VALUES FROM FIELD SAMPLING

If a field-based carbon stock assessment is to be carried out, sample plots which allow for the extrapolation of results to the whole area of interest should be established. The preferred approach is to sample the different land cover strata present but making sure that the locations of sampling plots are randomised within each stratum (Hairiah et al., 2001) i.e. located across the stratum in an unbiased way (Walker et al., 2012), and not only in areas with the most or least dense (carbon rich) vegetation (Hairiah et al., 2011).

There are many manuals and guidance documents available on determining the design (number, size and distribution) of sample plots and for calculating associated sampling errors including by Brown (1997), Pearson et al. (2005), Hairiah et al. (2011) and Walker et al. (2012). In deciding on the sample design, there will be trade-offs involving accuracy, precision and resources needed for the sampling effort (Pearson et al., 2007; Walker et al., 2012). These documents should be studied in detail before embarking on any sampling exercise.

To perform a reliable carbon stock estimation from each land class, the sampling size must fulfil 10% of sampling error at 90% confidence interval, and the sampling plots distribution must be proportionally to the area of each land class (Loetsch, F. and Haller, K. 1964. Forest Inventory. Volume 1. BLV-VERLAGS GESE LLSCHAFT, München in VCS VM0015, 2012).

Once the plot design has been decided upon, the field survey team needs to collect the relevant data using standard data sheets. The key measurement to be taken is the diameter at breast height (dbh) of trees in the sample plots. Tree height may or may not need to be measured, based on the allometric equation selected for converting the field data to AGB values.

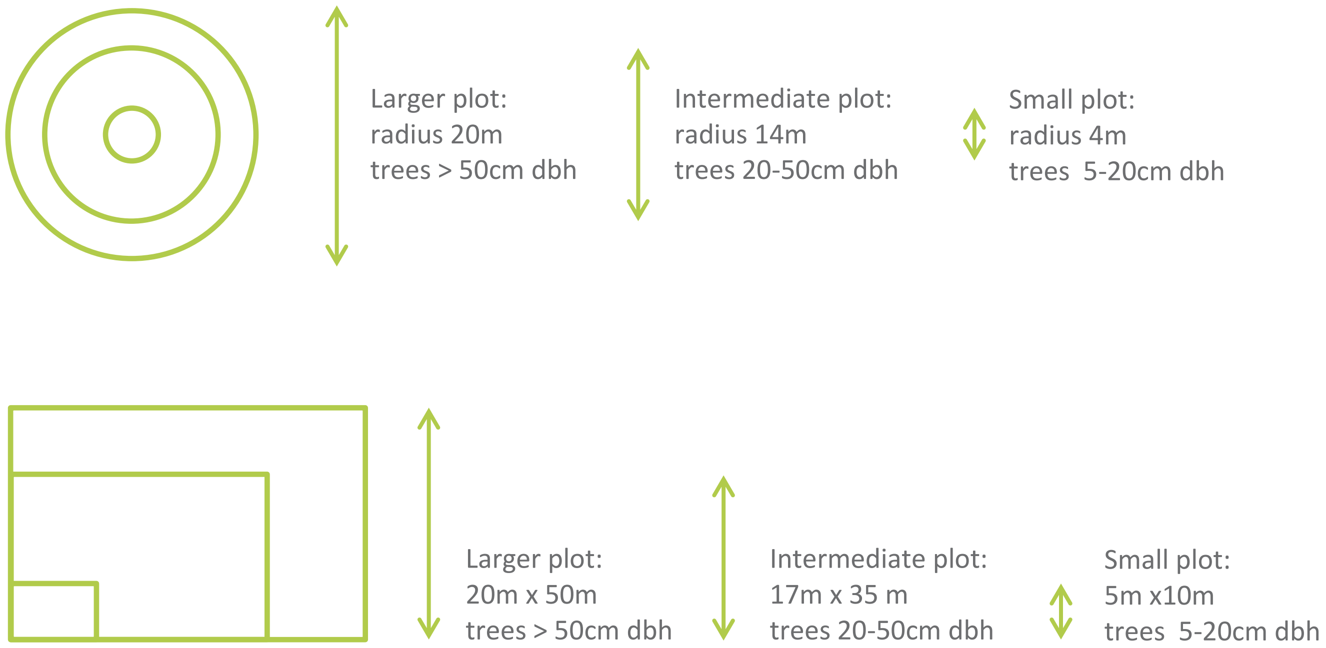
All allometric equations require dbh values. In addition to dbh, some allometric equations require values for tree height and/or wood density (for generalised equations, a weighted average value for wood density is the norm).

If wood density value is needed in an allometric equation, the range provided by Brown (1997) for tropical tree species in the Asian region is 0.40-0.69 g/cm3 while some other researchers have used a value of 0.67 for Borneo and the Amazon (Chave et al., 2006; Fearnside, 1997; Paoli et al., 2008) or 0.60 in Sumatra (Ketterings et al., 2001) and Sabah (Morel et al., 2011).

Allometric equations allow for the conversion of dbh (and height) value(s) to the AGB value per tree. The total AGB for a particular sampling plot can then be calculated by adding up the AGB value for each tree within the plot, and subsequently the tC/ha value can be calculated (as the size of the plot is known). Appendix 4 provides further details on scaling up of dbh measurement to estimate carbon stock.

GUIDANCE FOR DETERMINING SAMPLE PLOTS

Nested plots are recommended for land cover with a wide range of tree diameters and stem densities with an uneven size distribution (Pearson et al., 2007) such as in tropical forests. Nested plots could be rectangular or circular (see Figure A3-1 below) but some researchers prefer rectangular plots as they tend to include more of the within-plot heterogeneity, and thus will be more representative than square or circular plots of the same area (Hairiah et al., 2011). The most appropriate size and shape may also be dependent on the land cover found in the sampling area (Walker et al., 2012).



Source: Pearson et al. (2005)

Figure A3-1 Schematic diagram showing a three-nest sampling plot in both circular and rectangular forms

It is advisable to select a larger set of sampling locations than the actual number required, in order to provide alternatives in case of unexpected field conditions, such as inaccessibility (Hairiah et al., 2011). Ground-truthing (which could be done in conjunction with Step 3) prior to the actual plot sampling is important to finalise the location of sampling plots and identify the most efficient routes to reach them.

Winrock International (2008) has developed an online Excel tool called the Winrock Sample Plot Calculator that helps in the calculation of the number of samples and the cost involved for baseline studies as well as monitoring.

ESTIMATING ABOVE GROUND BIOMASS

Tree measurements are taken within the sampling plots. The most important measurement is the diameter at breast height (dbh) which is usually set at 1.3m above ground level. Detailed guidance on how to take dbh measurements and the equipment needed can be found in many publications including Brown (1997), Pearson et al. (2005), Hairiah et al. (2011) and Walker et al. (2012). In a nested plot, larger trees (e.g. dbh>50cm) are measured in the larger plot while the smaller plots are for measuring trees of smaller dbh classes (as illustrated in Figure A3-1 above).

Although measuring both the dbh and height of a tree would provide a more accurate estimation of its biomass, measuring tree height can be time-consuming (Pearson et al., 2005) and often difficult because treetops are hidden by the canopy layer. A decision should be made during the planning phase of sampling – based on resources available, data gathered on the land cover and field conditions – whether or not to measure tree height. There are allometric equations available for estimating Above Ground Biomass with or without height measurement.

Once the dbh measurements of the trees in a sampling plot have been obtained, the Above Ground Biomass can be calculated using an allometric equation that relates tree biomass with the dbh, height (optional), and wood density.

There are generally two approaches in using allometry to convert dbh measurements into Above Ground Biomass. If the trees can be identified up to species or at least genus level, and their respective wood density is known, species- or genus-specific allometric equations can be used to estimate the Above Ground Biomass. Average wood density values for a range of species or genus are available from Brown (1997), IPCC (2006) and the World Agroforestry Center's Wood Density Database.

However, tree diversity in the tropics is very high with one hectare of tropical forest containing as many as 300 different species (de Oliveira & Mori, 1999), making species-specific allometry not practical (Chave et al., 2005). Instead, grouping all species together within a particular land cover strata and using generalised allometric equations is highly effective for tropical regions because dbh alone accounts for more than 95% of the variation in above-ground tropical forest carbon stocks, even in highly diverse regions (Brown, 2002). Generalised allometric equations are based on large numbers of trees covering a wide range of diameters (Brown, 1997; Chave et al., 2005).

All allometric equations require dbh values. In addition to dbh, some allometric equations require values for tree height and/or wood density (for generalised equations, a weighted average value for wood density is the norm). Brown (1997) provides an allometric equation for tropical moist forests using data collected from Kalimantan and other tropical regions while others have developed allometric equations for specific forest types e.g. lowland dipterocarp forests (Basuki et al., 2009). The RSPO Secretariat has compiled a database of relevant allometric equations for a range of vegetation/ecosystem types and geographical regions and this will be made available to interested parties. As a general guideline, allometric equations should be chosen on the basis of similarities between the vegetation type that the particular equation was developed and that of the proposed new planting area, and also the geographical regions concerned. For example, if the proposed new planting area is a degraded secondary forest in Papua New Guinea (PNG) it makes sense to select an allometric equation that was developed for a similar area in Sulawesi if there is no equation available for PNG itself or surrounding areas, rather than selecting an allometric equation developed for an area in Peru. An alternative is to select allometric equations that were developed using data from more than one region, as in the case of pan-tropical allometric equations developed by Brown (1997).

If wood density value is needed in an allometric equation, the range provided by Brown (1997) for tropical tree species in the Asian region is 0.40-0.69 g/cm3 while some other researchers have used a value of 0.67 for Borneo and the Amazon (Chave et al., 2006; Fearnside, 1997; Paoli et al., 2008) or 0.60 in Sumatra (Ketterings et al., 2001) and Sabah (Morel et al., 2011).

Above-ground non-tree or understory biomass is only to be measured if it is a significant component, such as for grassland or shrubland where trees are only present at low densities (Pearson et al., 2005). For forested land cover, above-ground non-tree biomass is generally not a significant component.

APPENDIX 4: SCALING UP OF DBH MEASUREMENT TO ESTIMATE CARBON DENSITY FOR EACH STRATUM

	Step	Measurement output (unit)
Items needed	Measure dbh	Diameter of one tree (cm)
• Dbh value • Height (optional) • Wood density (weighted average values from published sourced, optional) • Allometric equation (select appropriate one from published sources)	Use allometric equation to convert dbh measurement to Above Ground Biomass	Above Ground Biomass of one tree (tonnes)
	Repeat process for all measured trees	
	Total up biomass of all trees within a plot	Above Ground Biomass of one plot (tonnes)
• Above Ground Biomass value • General ratio of Below Ground Biomass to Above Ground Biomass (from published sources)	Calculate root biomass and add to Above ground Biomass	Above Ground and Below Ground (root) Biomass of one tree (tonnes)
• Size of each stratum (ha)	Total up biomass of all plots for each land cover stratum and calculate average per hectare	Average biomass per hectare for each stratum (tonnes/ha)
• Average biomass per hectare value for each stratum • Carbon conversion factor (use default value)	Use carbon conversion factor to convert biomass to carbon amount	Average carbon density for each stratum (tC/ha)

Figure A4-1 Steps for scaling up of dbh measurement to estimate carbon density for each stratum

The average carbon density value for each stratum should be compared with the relevant RSPO default value for the stratum. If the two values are very different (e.g. the calculated value is close to the default value of another stratum), it is necessary to check if the land cover stratification has been done correctly and if the sampling plots are actually in the stratum that they are supposed to be. Independent verification (Pearson et al., 2005) by a third party may also be considered. If the discrepancy in values remain after these additional efforts, the calculated value may be used instead of the default value if there is a high level of confidence in the robustness of the field sampling exercise, which is likely to yield more accurate results as compared to the default values which are average values that may not be applicable in all cases.

RSPO is an international non-profit organisation formed in 2004 with the objective to promote the growth and use of sustainable oil palm products through credible global standards and engagement of stakeholders.

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