INSTRUCTIONS FOR USING THESE DOCUMENTS

One of the pillars of REDD+ is the design, operationalization and institutionalization of a functioning National Forest Monitoring System for the Measurement Reporting and Verification (MRV) of REDD+ results.

It is good practice to clearly describe processes and outcomes. This allows for consistency of processes, better understanding of the system itself, and helps to report the results.

The templates provided here are designed to define the process for sample-based area estimation. The templates are designed to be integrated in a NFMS or similar system. Users can use these templates as a basis to develop their own, specific documents by adjusting any part of the template to their specific circumstances and needs.

Different types of documents are provided here:

- Templates for Standard Operating Procedures (SOPs): These contain current best practice for the steps and methods to be used to complete a sample-based area estimation
- Forms: The form templates are designed to create a record of the application of the SOPs and to demonstrate that the process and activities have been conducted in the way described in the SOPs. Forms are the blank templates to be filled in with information that will become these records.
- Background notes: This is not a template but rather contains information that might be useful when designing your own SOPs and when applying the SOP. Users can choose to incorporate the notes into any training manuals that are part of their NFMS.

In the SOP, text in *italic grey* indicates instructions for completing the SOP to reflect your specific circumstances and needs. This should be replaced with your own specific text in the actual SOP. In the form templates, the same *italic grey* indicates instructions to the end users of the forms. **Format of text should be Calibri 10pt** so as to differentiate from the guidance text.

When following the SOPs, a set of key decisions must be taken that outline the project objective and the approach to area estimation. When taking the key decisions, it is important to bear in mind subsequent steps and limitations in resources and available data. For example, if the estimates rely on geospatial data and satellite data is only available in the area of interested from 2000, then the temporal scope should not start before this date.

Prerequisites and preparatory work

Before starting a sample-based area estimation, there are a number of prerequisites in terms of decisions that need to be made, including consideration of:

- The objective of the project and the variables of interest (e.g. hectares of deforestation per forest type x) to be quantified through the collection of survey data.
- The geographical scope of the assessment / area of interest
- The temporal scope of the assessment
- The allowable margin of error of the variables of interest or the key variable of interest at the desired level of confidence.

Besides these general considerations, some of the SOP templates also contain prerequisites that need to be in place before the SOP can be applied

In order to develop realistic expectations a pilot survey can be undertaken that generates information on:

- Order of magnitude of variables of interest
- Order of magnitude of variance of variables of interest
- Efficiency of the stratification used/planned (e.g. change maps) and improvements that could be made to the stratification/change maps
- Best reference data to be used and time span covered by that data
- Time estimate per sample unit
- Quality Control and Quality Assurance that might be required
- Logistics for data collection including
    - Hardware
    - Software
    - Adequate time, resources and facilities for data collection and quality management

Assigning roles and responsibilities

In the SOP templates, there is a requirement to define the responsibilities within each SOP. Typical roles and responsibilities in area estimation include the following:

Typical Role	Potential Responsibilities	Relevant SOPs
Coordinator	• oversees the completion of all steps: sampling design, response design, data collection and analyses	SOP1, 2, 3, 4
	• generates the classification scheme	SOP2
	• validates that the definitions are comprehensive and unambiguous	SOP2
	• formalizes the decision tree	SOP2
	• distributes sample units amongst interpreters	SOP3
	• determines data to be reassessed for quality management	SOP3
	• upholds quality management (QA/QC) practices	SOP3
Logistics manager	• arranges logistics for data collection, including space for data collection, sufficient time for data collection, salary arrangements	SOP3
Trainer	• prepares material for consistent training of interpreters and delivers training to ensure best practices are followed for data collection	SOP3
Interpreter	• carries out the visual interpretation of the samples, including samples rechecked for quality management	SOP3
Statistician	• undertakes sample allocation and crosschecking plot allocation in strata	SOP1
	• estimates class areas and their uncertainties	SOP4

Multiple roles can be assigned to one person.

STANDARD OPERATING PROCEDURE 1 (SOP1): SAMPLING DESIGN

Version	*1.1*	**Date of Issue**	14/06/2021

Purpose	This SOP serves to establish a spatially referenced, probability-based and geographically balanced sampling design for the estimation of areas in land surveys. Notes: ● Where permanent sample plots are used and already established from previous surveys, this SOP needs not to be used. ● If stratified sampling is not selected under step 1, the SOP template can be simplified, and this is indicated in the relevant sections
Responsibilities	**Coordinator** responsibilities include: • discuss with the expert statistician to identify a statistically valid sampling design. • form and lead an inventory team. • report directly to the director of climate change unit of the forestry commission. • consult and coordinate with the manager of GIS and forest inventory of the resource management support centre to decide on the sampling size and the sampling unit and report the same to the MRV working group. • similarly, consult the leader of the national GHG inventory team. • nominate and collaborate with a statistician **Coordinator** : 'Mr Yakubu " Forestry Commission P. O. Box MB 434 Accra-Ghana Phone: +233 302 401210 Website: http://www.fcghana.org/
Prerequisites	If stratified sampling is selected under step 1 below, maps will need to be generated for every monitoring period as a stratification frame.
Related documents	This SOP shall make reference to sop 2,3 and 4, and standard forms 1-5. It shall also refer to IPCC 2006 guidelines, the GHG inventory report and the biennial GHG inventory report. It shall as well make reference to the FPP 2012 report, 2000 multi-resource report and 2019 and the current landuse / landcover map. It shall make reference to the National definition of forest and the current national forest inventory report. It shall also make reference to all forest reference level report submitted to the UNFCCC

Procedure	
Step 0: Pilot survey	**Step 0a.** The Coordinator in coordination with relevant staff from the Forestry Commission determines the need to conduct a pilot survey that will serve to inform the sampling design. **Step 0b.** The Coordinator follows steps 1 to 4 and SOP 2-4 to implement the pilot survey and documents the lessons learned from the results using form 1.

Step 1: Determining the basic sampling design	**Step 1a.** The Coordinator in coordination with the Statistician and relevant staff from the Forestry Commission including the GIS and mapping, mensuration and inventory, and plantations units determines the basic sampling design, including the type of sampling (stratified STR, systematic SYS or simple random SRS), type of sample unit (map pixel, points) and the shape and size of the spatial support used for the interpretation including the definition of any sampling sub-units. **Step 1b.** The Coordinator shall document the justification for the chosen sampling design using form 1. If the selected sampling design is different from previous sampling designs used for the reference period or previous monitoring period, the documentation shall also address how the change in design affects the comparability and accuracy of the results. The justification shall be documented and stored with the climate change unit, RMSC, and ICT of the forestry commission.
Step 2: Determining the stratification	**Sub-step 2a.** The Coordinator in coordination with the GIS and mapping unit and the inventory and mensuration unit of RMSC determines the stratification to be used based on the classes of interest in the area. **Sub-step 2b.** The Coordinator shall document the stratification using form 1. At minimum, this shall include: (i) Number of strata (H) and (ii) a description of each stratum indicating the name of the stratum and description or definition. **Sub-step 2c.** The Coordinator generates the stratification map that partitions the region of interest into discrete, non-overlapping strata while ensuring a geographically balanced representation. For this, the Coordinator shall consider the administrative units that the activity data area is reported by, the stratification used to report emission factors and areas that are most likely to contain changes. An example of stratification is the vegetation zones that the emission factors are reported by and a forest change map. If there is post-stratification, the Coordinator shall document and store the post-stratification criteria in form 1. It shall be stored with the climate change unit, RMSC, and ICT of the forestry commission.
Step 3: Establishing the number of sample units	The coordinator shall involve the GIS and mapping unit and the inventory and mensuration unit of RMSC, the coordinator of the national GHG inventory and the coordinator of the MRV sub working group to calculate the total sample size using an iterative process that to reach an overall sample size that is feasible considering the time and resources available and for each variable of interest or key variable of interest. Where stratified sampling is not selected under step 1 the number of strata is H=1 and the equations simplify accordingly. **Sub-step 3a.** The coordinator shall involve the GIS and mapping unit and the inventory and mensuration unit of RMSC, the coordinator of the national GHG inventory and the coordinator of the MRV sub working group to estimate the expected area of each stratum from the stratification map. The Coordinator estimates the expected area proportions based on a judgement about likely occurrence of the variables of interest in the area or based on the pilot survey conducted in Step 0. **Sub-step 3b.** The Statistician in coordination with the coordinator shall involve the GIS and mapping unit and the inventory and mensuration unit of RMSC, the coordinator of the national GHG inventory and the coordinator of the MRV sub working group calculates the total sample size using the following equation. The Coordinator iteratively modifies the expected variables, mainly the allowable margin of error d, to reach an overall sample size that is feasible considering the time and resources available. The Coordinator summarizes this in Form 1 and uses excel and the grid of samples to determine the overall sample size. $n \approx \left(\frac{t_{\alpha,df}\cdot\sum_{h=1}^{H} W_h \cdot S_h}{d}\right)^2$

	Sub-step 3c. The Statistician in coordination with coordinator defines the allocation rules of the sample units to each stratum and summarizes the allocation of the samples in Form 1. **Sub-step 3d.** The Statistician in collaboration with the Coordinator adjusts the number of sample units in each stratum until reaching satisfactory expected percentage uncertainty for the variable(s) of interest and ensuring a spatially balanced sample, while not unduly increasing the overall amount of sample units. If there is intensification, the Coordinator shall document how the intensified samples relate to the existing sample units, e.g. in systematic design, are the intensified samples aligned with the existing samples. The justification shall be documented and stored in Form 1.
Step 4: Selecting sample units	**Sub-step 4a.** The Coordinator establishes the spatial locations of sample units using the database of samples for Ghana, which were created using a globally consistent systematic grid of samples. The Coordinator documents the steps taken in Form 1.

Quality management	
QA / QC procedures	The Statistician provides guidance through the sample design to assure the quality of the design and adherence to statistical best practices. An external entity can be involved for quality control of the sampling design. A two-stage approach for the QAQC shall be applied. 1. QAQC shall be applied along every stage of the sample based inventory 2. an independent institution shall be responsible for the overall QAQC at the end of the inventory process.

Version Log

Version	Author/s	Material changes from previous version	Release Date
1.1	1. Mr. Yakubu Mohammed 2. Mr.Thomas Gyambrah 3. Mr. Jacob Amoako 4. Mr.Frank Kwadwo Owusu 5. Ms. Tessia Boateng 6. Dr. Marieke Sandker 7. Ms. Yelena Finegold		14/06/2021

STANDARD OPERATING PROCEDURE 2 (SOP2): RESPONSE DESIGN

Version	*1.1*	**Date of Issue**	14/06/2021
Purpose	This SOP explains how to assign labels (e.g., a land cover / land use class) to a sample unit. The response design allows for the best available classification of change for each spatial unit sampled and contains all information necessary to reproduce the process of attribution of a label to the sample unit. The response design lays out an objective procedure that interpreters can follow and that reduces interpreter bias		

Procedure	
Step 1: Specifying the classification scheme	**Sub-step 1a.** The coordinator shall involve the GIS and mapping unit, the inventory and mensuration unit plantation and any other relevant institution to define a classification scheme with detailed definitions and review it together with the interpreters. The classification scheme is consistent with the national land cover / land use definitions. In cases where the classification scheme definition is different from the national definition, a justification is provided. The Coordinator documents the classification scheme in a tree-diagram using Form 2. The form shall be stored with the climate change unit, RMSC, and ICT of the forestry commission. **Sub-step 1b.** The Coordinator documents the detailed definitions for each class using Form 2. The form shall be stored with the climate change unit, RMSC, and ICT of the forestry commission.
Step 2: Specifying the data sources	**Sub-step 2a.** The coordinator shall involve the GIS and mapping to create an overview of all satellite imagery used for the interpretation, including the data periods for each sensor and review it together with the interpreters. The overview is recorded using Form 2. The form shall be stored with the climate change unit, RMSC, and ICT of the forestry commission.
Step 3: Specifying the unit's spatial support	**Sub-step 3a.** Based on the available data sources, the Coordinator shall involve the GIS and mapping, the inventory and mensuration units of RMSC to define the assessment unit and document it with an illustration using Form 2. The form shall be stored with the climate change unit, RMSC, and ICT of the forestry commission.
Step 4: Specifying the interpretation key	**Sub-step 4a.** The coordinator shall involve the GIS and mapping unit and the inventory and mensuration unit of RMSC, CERSGIS and any other relevant institution to develop a visual guide to help the interpretation of each class of the classification scheme and to illustrate how the land cover or land use feature will look like in the images selected in step 2 and considering the sample unit's spatial support defined in step 3. The visual guide includes examples for all classes and for all data sources used. The form shall be stored with the climate change unit, RMSC, and ICT of the forestry commission and the approved platform for the national forest monitoring system.
Step 5: Specifying the decision tree	**Sub-step 5a.** The coordinator shall involve the GIS and mapping unit, mensuration unit, inventory unit, plantations unit and coordinator of the GHG inventory and any other relevant institution to develop a set of hierarchical rules that help the interpreter assign an overall land use class when the sample is composed of mixed land cover features.

	Sub-step 5b. The Coordinator reflects the rules from sub-step 5a in a decision tree and documents the decision tree using a textual description of the observations that were the basis for building the decision tree, including reference to previous work and illustrations of both the overall decision tree and each of the decisions in the tree. **Sub-step 5c.** The Coordinator reviews the decision tree together with the interpreters and adjusts as necessary. **Sub-step 5d.** The Coordinator stores the form with the final decision tree with the climate change unit, RMSC, and ICT of the forestry commission.
Step 6: Implementing the response design	**Sub-step 6a.** The Coordinator of the assessment chooses a software to be used for data collection and implements the response design by creating the necessary survey questionnaires. Collect Earth has been used to create such a survey. The Collect Earth survey can be modified using the Open Foris Collect software. The existing Collect Earth survey is stored with the climate change unit, RMSC, and ICT of the forestry commission and the approved platform for the national forest monitoring system. **Sub-step 6b.** The Coordinator in coordination with the GIS and mapping unit, mensuration unit, inventory unit, plantations unit and coordinator of the GHG inventory to include an indicator of the confidence of the interpretation when implementing the response design and defines a level for the indicator (e.g., high / low, or high / medium / low or similar). This is defined in a way that all interpreters use the same criteria using Form 2.

Quality management	
QA / QC procedures	The Collect Earth survey is tested by the interpreters before data collection to ensure the built in validation rules and overall survey functions as required. A two-stage approach for the QAQC shall be applied. 1. QAQC shall be applied along every stage of the sample based inventory 2. an independent institution shall be responsible for the overall QAQC at the end of the inventory process.

Version Log

Version	**Author/s**	**Material changes from previous version**	**Release Date**

STANDARD OPERATING PROCEDURE 3 (SOP3): DATA COLLECTION

Version	*1.1*	**Date of Issue**	14/06/2021
Purpose	This SOP details how to set up and execute data collection for sample based visual interpretation using primarily remotely sensed data for collecting sample information.		

Procedure	
Step 1: Planning the data collection	**Sub-step 1a.** The Coordinator estimates the necessary level of effort for the data collection using the following formula *Minutes to interpret 1 sample unit * number of sample units = required level of effort for data collection* **Sub-step 1b.** The Coordinator identifies the persons who may be involved in the data collection as Interpreters. The minimum qualifications for participating in the data collection are: BSC Natural Resource Management, geography and resource management, Remote Sensing GIS and forest Inventory. The person shall have knowledge in visual interpretation of satellite imagery. The Coordinator records the names and contact information of all the participants in the data collection and training using Forms 3 and 4. The form shall be stored with the climate change unit, RMSC, and ICT of the Forestry Commission. **Sub-step 1c.** Based on the outcomes of sub-step 1a and 1b, the Coordinator decides on the format and modality for the data collection and on a timeline. **Sub-step 1d.** The Logistics Manager arranges logistics, including space for data collection, sufficient time for data collection, salary arrangements.
Step 2: Preparation of the classification manual	**Sub-step 2a.** The Coordinator compiles a classification manual based on the results of applying SOP 2 for interpreters. The Coordinator makes it available in electronic and hard-copy formats. The classification manual will include at least the following information: ● The tabular list of available data sources ● The definition of the spatial support of the sampling unit ● The classification scheme with detailed definitions ● The interpretation key with example illustrations in a synthetic format that is easy to refer to (one class per page) ● The decision tree ● The validation rules applied ● The definition of the level of confidence of the interpretation The classification manual shall be stored with the climate change unit, RMSC, and ICT of the forestry commission and the approved platform for the national forest monitoring system.
Step 3: Training and calibration	**Sub-step 3a.** As a first step in the data collection, the Coordinator and the Trainer organize and prepare a training event for the persons identified in sub-step 1b as Interpreters, who have confirmed their participation. The training should cover the following topics as a minimum: • The classification manual • Reviewing location specific examples from all the classes in the classification system with visualization from multiple data sources available • the software used for the data collection and how to ensure the data management and

<table>
<tr><td></td><td>storage

the data sources available
quality management practices
knowledge of the landscape
conversant with the classification scheme

Sub-step 3b. The Trainer implements the training event following these basic principles:

environment for active participation, where participants can share questions and opinions
encourage communication between the interpreters
record attendance of the interpreters
assess the capacity of the Interpreters at the end of the training and record the results.

Sub-Step 3c. The Coordinator and the Trainer prepare a report summarizing the training actions taken, the attendance and the results of the assessment of capacity. The report shall be prepared using Form 4. The report shall be stored with the climate change unit, RMSC, and ICT of the forestry commission </td></tr>
<tr><td>Step 4: Distribute the sample units among interpreters</td><td> Sub-Step 4a. The coordinator shall involve the GIS and mapping unit and the inventory and mensuration unit of RMSC to decide on a fraction of sample units to be assessed multiple times by all Interpreters for cross-checking. The sample units that are duplicated have a unique identification.
Sub-Step 4b. The Coordinator allocates sample units to Interpreters based on a random allocation modality. The Coordinator uses a standardized naming structure to distribute the samples to the interpreters.
Sub-Step 4c. The Coordinator records the number of sample units, the interpreter assigned to assess those samples and the file location using Form 3. The form shall be stored with the climate change unit, RMSC, and ICT of the forestry commission. </td></tr>
<tr><td>Step 5: Data collection by interpreters</td><td> Sub-Step 5a. The Interpreters assess the sample units, using the interpretation key as a guide for assessing different land use classes and transitions. The Interpreters consult one another and the Coordinator if they have any doubts about the image interpretation.
Sub-Step 5b. The coordinator collects the data from all Interpreters at defined intervals (intervals can be defined by number of samples or by time intervals) and arranges for cross-validation based on a set of samples that were assessed by two or more interpreters. For performing the cross- validation, the Coordinator will

Establish a reference interpretation for each of the cross-validation sample units. The reference interpretation will be the basis for establishing the performance of individual interpreters. It is to be established through a majority rule with a tiebreaker.
Calculate agreement for each interpreter with the reference interpretation.
For each pair interpreter, create a confusion matrix using Form 3.
Based on the confusion matrices, calculate the overall agreement with the reference, for each interpreter, as follows:

Agreement between interpreter and the majority = Sum of counts in call on the diagonal / Sum of all counts

Report the overall agreement per interpreter using Form 3.
Analyze the per-class agreement amongst interpreters using Form 3.

Sub-Step 5c. During the data collection, the Coordinator organizes regular discussions and group assessment of samples with all the interpreters to ensure a mutual understanding of the interpretation techniques. </td></tr>
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	Sub-Step 5d. The Coordinator notes challenges and limitations during the data collection as well as potential sources of bias during the data collection.
Step 6: Data assembly	**Sub-Step 6a.** After the data collection is completed, the Coordinator compiles data tables for archiving, which will include the following information: ● A database of the sample data collected by the interpreters including: ○ The geographical coordinates in ESPG: 4326 (WGS 84) ○ The unique identification code for each sample unit ○ The interpretation of all sample units including the previous interpretation(s) of the sample unit in the case this was revised or corrected ● The interpretation of sample units conducted by the Coordinator ● Metadata regarding the interpreter that collected the sample data, when the data was collected, which data sources were used A description of the column names from the database are included with the database. Each sample in the consolidated database notes the round of data collection. The database can be amended to include additional rounds of data collection. Multiple versions are recorded and explanations between versions are included in the documentation. **Sub-Step 6b.** The Coordinator checks that all necessary metadata and sample information is archived and included in the final database. The Coordinator will store the data collection report and the data tables digitally using the following naming convention Data_collection_date[year/month/day]_version number. Everything is stored in the following location:It shall be stored with the climate change unit, RMSC, and ICT of the forestry commission and the approved platform for the national forest monitoring system.

Quality management	
QA / QC procedures	**Sub-step Q1.** The Coordinator excludes impossible transitions through logical checks built into response design. **Sub-step Q2.** Involve an external member to assess the implementation of the data collection procedure and ensure that all quality management procedures are in place. **Sub-step Q3.** The Coordinator conducts ongoing hot, cold and auxiliary data checks during data collection and conduct regular review meetings among all interpreters. Auxiliary data checks: use an external data source, such as externally created maps, to compare to the sample unit classification. Discrepancies between the two datasets can be flagged for rechecking. Confirmed differences between the two datasets can be documented to showcase why sample-based area estimation may give difference results than other data sources. Cold checks: sample units that are randomly selected from the data produced by interpreters. The decisions made by the interpreters are reviewed by the coordinator or group of interpreters meeting together. If the error by the interpreter reflects a systematic error in their interpretation, it is discussed directly with the interpreter and the affected sample units are corrected. Hot checks: sample units that are flagged as low confidence. These marked sample units should be further reviewed by the coordinator or group of interpreters meeting together. Once reviewed, labels that are deemed to be incorrect on these sample units should be adjusted by the interpreter.

Version Log

Version	Author/s	Material changes from previous version	Release Date
1.1	Mr.Yakubu Mohammed Mr.Thomas Gyambrah Mr. Jacob Amoako Tessia Boateng Dr. Marieke Sandker Ms.Yelena Finegold		14/06/2021

STANDARD OPERATING PROCEDURE 4 (SOP4): DATA ANALYSIS

Version	*1.1*	**Date of Issue**	14/06/2021
Purpose	This SOP provides for area estimates and their uncertainties through the combined use of reference data and maps (i.e., sample-based area estimation		

Procedure

Step 1: Establishing the proportion matrix

Sub-step 1a. The excel form for calculations is used to calculate the required outputs. The Statistician builds a matrix that shows the strata (map classes) and the reference classes. The matrix lists counts of sampling units and areas of the stratification map in accordance with the table below

	Reference data (j)			
Strata (h)	*Class j1*	*Class j2*	*Class j3*	*Total*
Stratum h1	*n11*	*n12*	*n13*	*n1.*
Stratum h2	*n21*	*n22*	*n23*	*n2.*
Stratum h3	*n31*	*n32*	*n33*	*n3.*
Total	*n.1*	*n.2*	*n.3*	*n*

The error matrix is recorded using Form 5.

In building the error matrix, no-response observations, e.g., no data available such as persistent clouds throughout the period, shall be excluded. That means that for no-response observation, the total count in the relevant stratum (map class) is reduced. The coordinator records the number of non-response samples and the reasons they were excluded using Form 5.

Sub-step 1b. The Statistician calculates strata weights dividing the area of each class or stratum by the total reporting area in accordance with the table below.

Stratum	Map area in hectares	Strata weight (wh)
Stratum h1	$a_{1.}$	$a_{1.}/a$
Stratum h2	$a_{2.}$	$a_{2.}/a$
Stratum h3	$a_{3.}$	$a_{3.}/a$
Total	a	*1*

The table with the strata weights is recorded using Form 5.

Sub-step 1c. The Statistician calculates area proportions per class in accordance with the table below. For each cell, the area proportion is defined as:

$$\hat{p}_{hj} = w_h \cdot \frac{n_{hj}}{n_{h\cdot}}$$

where *h* and *j* stand for row and column, respectively.

	Reference data (j)			
Stratum (h)	*Class j1*	*Class j2*	*Class j3*	Total
Stratum h1	$\hat{p}_{11}$	$\hat{p}_{12}$	$\hat{p}_{13}$	$\hat{p}_{1\bullet}$
Stratum h2	$\hat{p}_{21}$	$\hat{p}_{22}$	$\hat{p}_{23}$	$\hat{p}_{2\bullet}$
Stratum h3	$\hat{p}_{31}$	$\hat{p}_{32}$	$\hat{p}_{33}$	$\hat{p}_{3\bullet}$
Total	$\hat{p}_{\bullet 1}$	$\hat{p}_{\bullet 2}$	$\hat{p}_{\bullet 3}$	*1*

The table with the area proportion per reference class is recorded using Form 5.

Sub-step 1d.

The coordinator shall store standards form 1-5 with the climate change directorate of the forestry commission, the resource management support centre and the national forest monitoring system.

Step 2: Estimating areas and their uncertainty

Sub-step 2a. The Statistician estimates the area per class:

Aj = p.j * a

Sub-step 2b. The Statistician estimates the standard error for the reference class area proportions:

$$S(p.j) = \sqrt{\sum_h \quad w_h^2 \frac{p_{hj}(1-p_{hj})}{n_h-1}}$$

Sub-step 2c. The Statistician estimates the standard error for the reference class areas:

S(Aj) = S(p.j) * a

Sub-step 2d. The Statistician estimates the percentage uncertainty of the estimated area per class. The value for Student's t must be chosen for the appropriate confidence level α and the degrees of freedom, $df = n_h - H - 1$.

$$U\%(Aj) = t_{\alpha,\, df} * S(Aj) / Aj$$

Sub-step 2e. The Statistician builds a summary table and reports it in Form 5. The form shall be stored data hub hosted by the Climate Change Directorate.

Quality management	
QA / QC procedures	**Sub-step Q1.** The Coordinator checks that the calculations comply with this SOP, including the script used for calculations. **Sub-step Q2.** The Coordinator cross-checks the estimates against previously reported estimates for the same classes. Estimates are additionally cross-checked and compared with globally reported estimates.

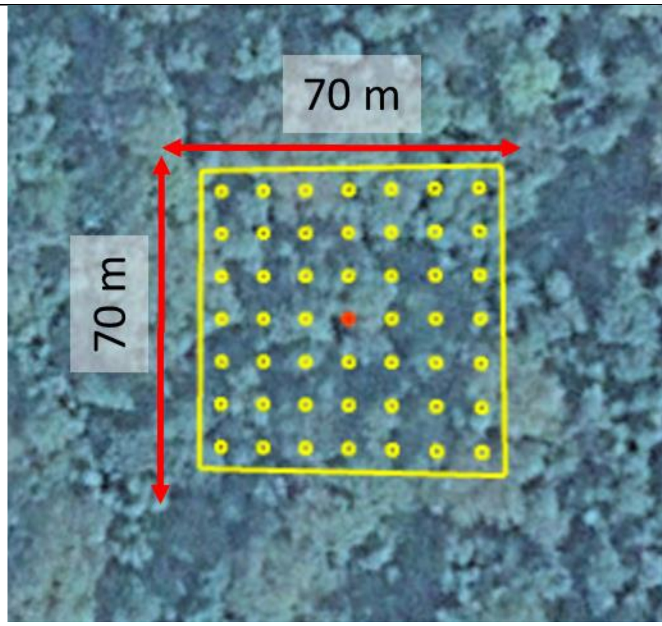
Version Log

Version	Author/s	Material changes from previous version	Release Date
1.1	1. Mr.Yakubu Mohammed(Coordinator) 2. Mr.Thomas Gyambrah 3. Mr.Jacob Amoako 4.Ms.Tessia Boateng 5.Dr.Marieke Sandker 6.Ms.Yelena Finegold		14/06/2021

FORM 1: SAMPLING DESIGN	
Purpose and scope	The sample design purpose and scope covers the Ghana Cocoa Forest REDD+ Programme (GCFRP) area and is used for reference level estimates reported in the Emissions Reductions Program Document (ERPD) to the Forest Carbon Partnership Facility (FCPF). The sampling design is also used for the monitoring period report.
Version	Version 1
Date	September 2020

Basic characteristics of the sampling design

Type of sampling and sample units	Stratified systematic Points
Shape and size of the spatial support	The shape of the spatial support area is a square with the size of 0.5 hectare with an internal 7 x 7 grid of control points. The size of the control points are 2 meters, the distance between the control points is 10 meters and the distance between the control points and perimeter of the spatial support square is 5meters.

	 *Figure 1: Spatial support unit*
Explanation	The size and shape of the spatial support frame was chosen to be consistent with previous national scale sample based area estimation exercises. The national scale sample based area estimation showed robust results and the same parameters were used to intensify for the GCFRP area. During the data collection with the Planet data, which has an online viewing resolution of about 5 meters, the size of the spatial support made it difficult to assess the land cover class and change. In order to effectively incorporate images with a resolution 5 meters or greater, a larger spatial support unit can be considered in future pilot surveys. The pilot survey data for this assessment was assessed before there was access to Planet Labs, therefore it is not a suggestion from the pilot phase but from the operational phase.

Definitions of strata (for cases where stratified [random/ systematic] sampling has been selected)

Stratum number	Stratum name	Description of the stratum	Area in stratification map ah
1	Forest mask	Areas mapped as forest in the available land cover maps between 2000-2015	3,295,919
2	Outside forest mask	Areas mapped as non-forest in the available land cover maps between 2000-2015	2,555,905
3	Upland evergreen	Upland evergreen vegetation zone	62,601

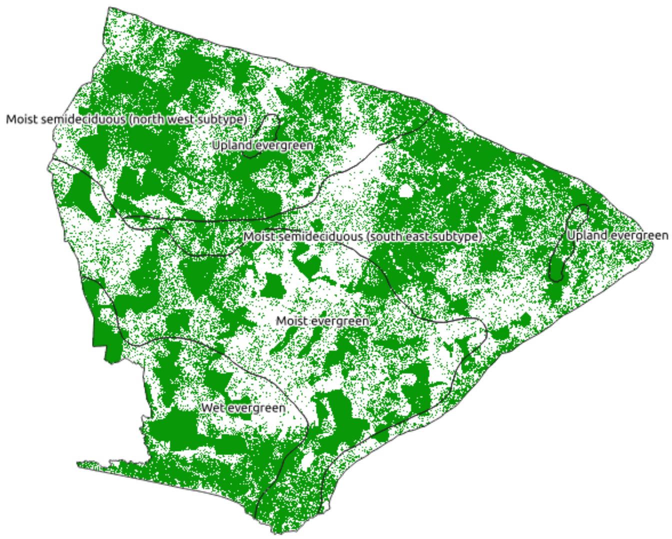


Figure 2 Forest mask used for stratification of intensified sampling and vegetation zones used as stratification and post-stratification

***Explanation*:**
Initially a systematic sample without stratification was used as a pilot study then the systematic sample was consistently intensified using stratification. First 8 x 8 meter grid of samples was assessed at the national scale as a successful pilot study and was then intensified to a 4 x 4 meter grid in the GCFRP area. It was decided to use a stratification to further intensify the sample in forested areas in order to target areas that could potentially be deforested or degraded. The areas inside the forest mask were intensified with a 2 x 2 meter systematic grid, except in the upland evergreen vegetation zone. The forest mask was the choice stratification because a map of deforestation and forest degradation had yet to be finalized for the GCFRP area. Intensification in forested areas was considered a conservative approach for delineating areas of increased potential for forest change. In the upland evergreen vegetation zone, the sampling was intensified to a 1 x 1 meter grid. Upland evergreen was chosen as an additional stratification because estimates are reported by vegetation zone and as this is the smallest vegetation zone it required additional samples to sufficiently quantify change in this area.

Vegetation zones are used as a post-stratification to estimate areas within each vegetation zone with the exception of upland evergreen which is considered a stratum. Vegetation zones are chosen as a stratum (upland evergreen) and post-stratification because emission factors are reported by these areas and corresponding activity data for these data should be reported.

Post-stratum name	**Area in post-stratification map ah**
Moist evergreen	1,832,389
Moist semideciduous (north west subtype)	1,557,590
Moist semideciduous (south east subtype)	1,727,082
Wet evergreen	734,763

The stratification is not sufficient for reducing the variance in activity data estimates and in future assessments a pure systematic sample approach can be considered or other stratification that effectively reduces the sampling error. New stratification should first be piloted to understand whether the stratification reduces the sampling error as explained in the instructions.

Number of sample units allocated

	Number of sample units per vegetation zone	Grid spacing (km)	Area per stratum (ha), $A_{e,i}$	Number of sample units per stratum, $n_{e,i}$	Weight per sample unit (ha/unit)	Number of deforestation plots (2005-2014)	Number of degradation plots (2005-2014)
Moist evergreen	2,123	2x2	886,983	1,384	641	7	12
		4x4	945,406	739	1,279	16	4
Moist SemiD NW	2,045	2x2	962,079	1,554	619	31	17
		4x4	595,511	491	1,213	9	4
Moist SemiD SE	2,148	2x2	989,659	1,543	641	32	17
		4x4	737,423	605	1,219	8	2
Wet evergreen	981	2x2	457,198	753	607	4	3
		4x4	277,565	228	1,217	2	1
Upland evergreen	392	1x1	62,601	392	160	11	5

Data collection phase	**Sampling intensity**	**Number of points**	**Sample distribution**	**scale**	**Assessment period**	**Date of data collection**
1	8 x 8	Nationally: 2,936 Cocoa area: 737	systematic	national	2000-2019	5-14 June 2019
2	4 x 4	3,601	systematic	sub-national scale, cocoa forest programme area	2000-2019	16-20 December 2019
3	2 x 2 & 1 x 1	2x2 grid: 6,328 1x1 grid: 588	stratified systematic	sub-national scale, cocoa forest programme area, 2 x 2 systematic grid in forested areas within 4 vegetation zones and 1 x 1 systematic grid in, upland evergreen vegetation zone.	2000-2019	3-11 February 2020

***Explanation*:**

A pilot survey was conducted using the first 8 x 8 meter spacing grid of sample plots.
The samples were further intensified using a 4 x 4 meter grid in the GCFRP and a second round of intensification in areas identified using a 2 x 2 meter grid forest in the forest mask (excluding the Upland Evergreen vegetation zone) and a 1 x 1 meter grid in the Upland Evergreen vegetation zone.

Sample unit allocation

The systematic grid is extracted for the spatial extent of Ghana from a globally generated systematic grid. A database of additional samples is archived in order to ensure the consistency with the original grid. The starting point of the global grid is random and includes sampling intensities at 1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 15, 16, 20, 25, 30, 50, and 100 meters. The systematic grid is stored in the Climate Change Directorate of Forestry Commission, Google Drive.

FORM 2: RESPONSE DESIGN	
Purpose and scope	The response design purpose and scope covers the Ghana Cocoa Forest REDD+ Programme (GCFRP) area and is used for reference level estimates reported in the Emissions Reductions Program Document (ERPD) to the Forest Carbon Partnership Facility (FCPF). The response design is also used for the monitoring period report.
Version	Version 2
Date	September 2020

Details of the classification scheme

The classification scheme was originally from a previous national scale data collection effort using Collect Earth.

Classification scheme diagram

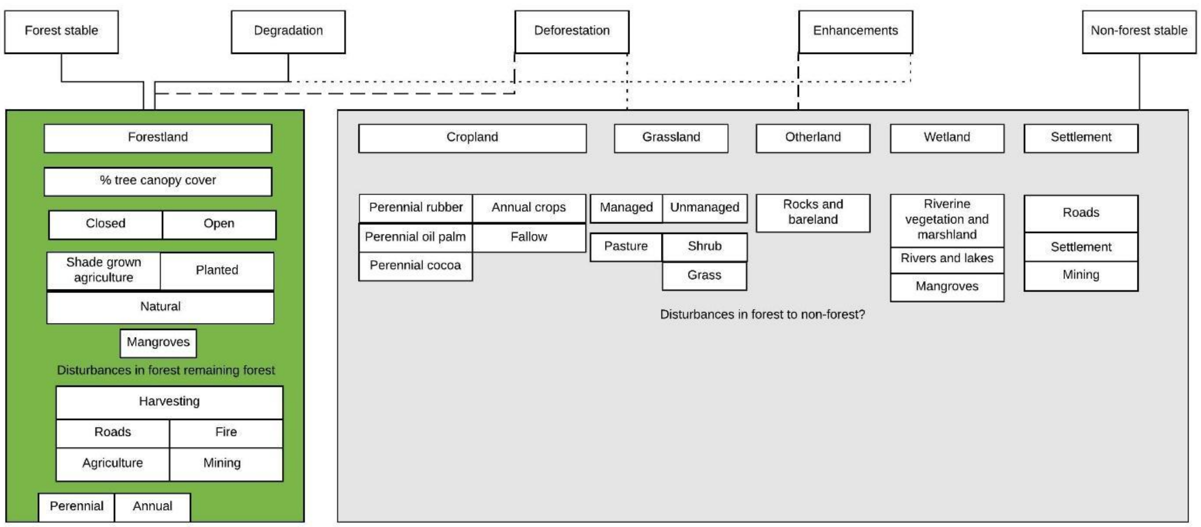


Figure 1 Classification system applied for the sample plot interpretation

Definitions

Table 1: Land use definitions

Name of the class	**Definition of the class**
Forest	Land covered by natural and planted forests. Includes all land with woody vegetation consistent with the thresholds in the forest definition adopted by the country. Based on the survey from Collect Earth, forests are identified in areas as small as 0.5 hectare, with tree canopy cover greater than 15% and where the presence of cropland or settlement is less than 20%.
Cropland	This category includes cropped land, currently cropped or in fallow, including rice fields, and agroforestry systems where the vegetation structure falls below the thresholds of the forest definition. Based on the survey from Collect Earth, Cropland is characterized as a 0.5 ha area that has crop cover greater than 20% where Settlement is less than 20%.
Settlement	This category includes all developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other categories
Grassland	This category includes rangelands and pasture land that are not considered Cropland. It also includes systems with woody vegetation and other non-grass vegetation such as herbs and brushes that fall below the thresholds in the forest definition.
Wetlands	These include land that is covered or saturated by water for all or part of the year and that does not fall into the Forest Land, cropland, Grassland or Settlements categories. It also includes reservoirs, natural rivers and lakes.
Other lands	This category includes bare soil, rock, mining operations and all land areas that do not fall into any of the other five categories.

Table 2: Forest land use sub-categories

Name of the class	**Definition of the class**
Open forest	Refers to all forest lands with canopy cover above 15% and less than 60%.
Closed forest	This refers to forest lands with canopy cover more than 60%.
Planted forest	This refers to afforestation sites.
Shade grown agriculture	This refers to croplands that are perennial and grows giving shade to undergrowth. These could be seen in an oil palm plantation.
Mangroves	Refers to wooded vegetation growing in marshy and salty environment. Mangroves are categorized in Ghana into white and red mangroves.
Natural forest	Forest land dominated with naturally grown trees and has tree crown density above 15% (densed canopy closure)

Table 3: Land use change definitions

Name of the class	**Definition of the class**
Forests to Cropland	The transition from forest to cropland is characterised by a complete removal of all forest within the area covered by the assessment unit. The forest is replaced by a cropland land use.
Forests to Grassland	The transition from forest to grassland is characterised by a complete removal of all forest within the area covered by the assessment unit. The forest is replaced by grassland.

Forests to Settlement	The transition from forest to settlement is characterised by a complete removal of all forest present within the area covered by the assessment unit. The forest is replaced by settlement.
Forests to Other land	The transition from forest to other land is characterised by a complete removal of all forest present within the area covered by the assessment unit. The forest is replaced by other land.
Forest degradation	Forest degradation is defined as forest land remaining forest land with visual evidence of at least one of disturbance, which can include fire, grazing, shifting cultivation, paths, logging, crops, flooding, settlement or other disturbance types. Degradation is characterized by evidence of human activities and reduction of tree canopy cover.

Explanation

The classification system and definitions use the IPCC land use categories and definitions as a basis.

Data sources to be used

Data name	Data type	Provider	Distributor	Resolution		Period available	
				Spatial	Temporal	Start	End
Landsat 8	Optical	NASA	Google Earth Engine	30 m	16 days	2013	ongoing
Landsat 7	Optical	NASA	Google Earth Engine	30 m	16 days	1999	ongoing
Landsat 5	Optical	NASA	Google Earth Engine	30 m	16 days	1984	2013
Sentinel-2	Optical	ESA	Google Earth Engine	10 m	5 days	2013	ongoing
Planet Scope	Optical	Planet	Planet	3-5m	Daily	2015	ongoing
RapidEye	Optical	Planet	Planet	5m	5 – 6 days	2009	2020
Spot 4	Optical	CNES	Google Earth	10 – 20 m	5 days	1998	2013
Spot 5	Optical	CNES	Google Earth	2.5 – 10 m	2 – 3 days	2002	2015
Spot 6	Optical	CNES	Google Earth	1.5 – 6 m	2 – 3 days	2012	ongoing
Spot 7	Optical	CNES	Google Earth	1.5 – 6 m	2 – 3 days	2014	ongoing
WorldView 1-4	Optical	Maxar/DigitalGlobe	Google Earth	< 1 m	Daily	2007	ongoing

Sample unit's spatial support

The shape of the spatial support area is a square with the size of 1 hectare with an internal 7 x 7 grid of control points. The size of the control points are 2 meters and the distance between the control points is 15 meters. The interpreter counts the land use features that intersect with the control points of the spatial support unit and according records the percentage of land use features. In order to quantify forest cover the interpreter counts the number of control points within the spatial support frame that fall directly over forest tree canopy (distinguishing the trees from tree crops). The number of trees that intersect with the control points is divided by the total number of points in the spatial support frame, 49. Considering the decision tree hierarchy, at least 8 of the 49 control points should fall on forest trees and there cannot be greater than 20% cover of settlement nor cropland to be considered a forest land use.

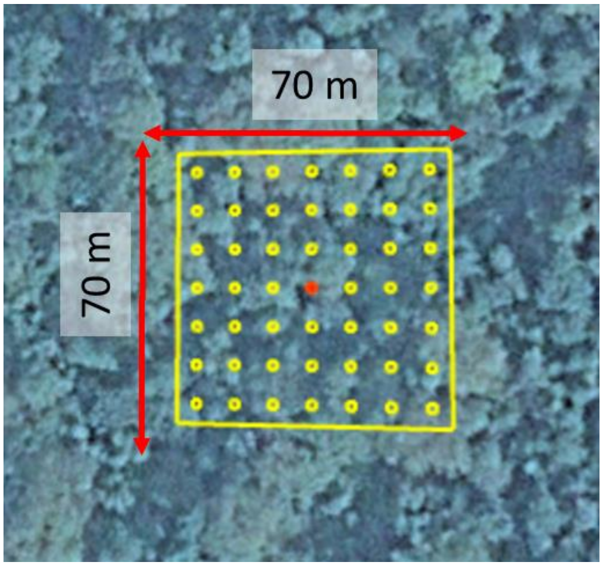


Figure 1: Spatial support unit

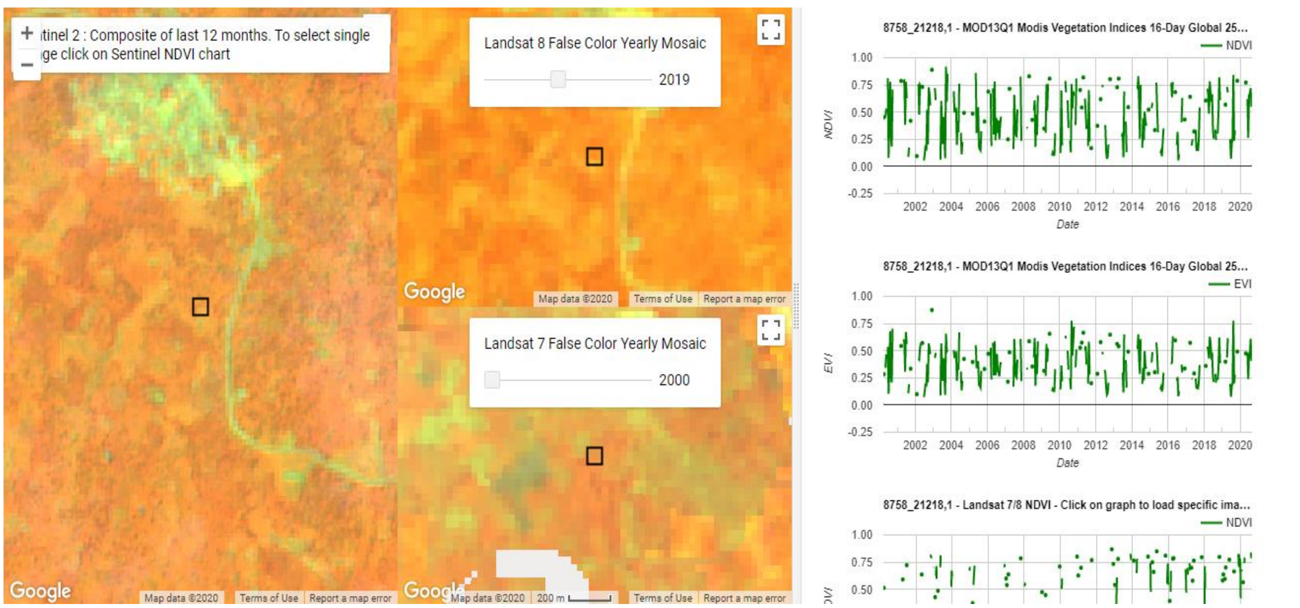
Interpretation key

8758_21212

Cropland Remaining Cropland

The Interpretation key below illustrates how the plot is visibly seen in the various sources of images used in interpretation.

Google Earth (2017)



Google Earth Engine (Sentinel 2, Landsat 8 and Landsat 7)

Bing Map

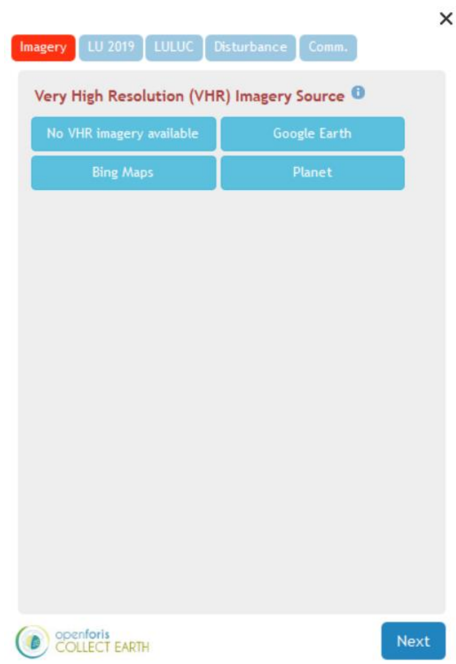
Decision tree

Ghana adopted the use of IPCC hierarchy classification as a benchmark in the interpretation of plots:

- Settlement = 20%
- Cropland = 20%
- Forest = 20%
- Grassland = 20%
- Wetland = 20%
- Otherland = 20%

Form

The Collect Earth data collection interface is split into 5 cards: imagery availability, land use 2019, land use change, disturbances and comments.



Imagery availability card

Imagery card aims to collect information about the primary high resolution imagery being used in the assessment. The information collected from this image is important for the description of the plot (cover elements) and to support the understanding of the other images being used in the data collection (such as Landsat, Sentinel-2 and MODIS imagery). If Google Earth is selected, the year of the most recent imagery is also specified.

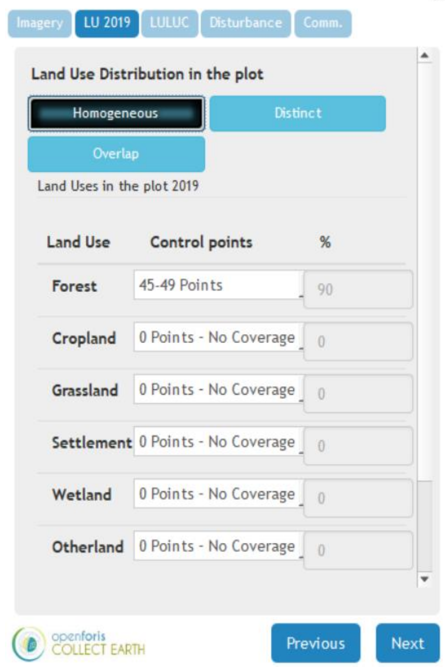
Validation rules

1. Year of the latest image from Google Earth should be between 2000 and 2020 (inclusive)

Attributes

Attribute Name	**Required**	**Description**
Very High Resolution (VHR) Imagery Source	Always required	The source of the VHR imagery used to assess the plot. Should be used the latest available imagery.
Year of the latest image from Google Earth	Required when Google Earth is selected as the Very high resolution imagery source	Year of the Google Earth VHR imagery

Land use 2019 card



The land use 2019 aims distinguishes the land use distribution and land cover using the control points. The land use distribution is identified by observing the land use features and if they are homogenous (includes only one land use class), overlapping (include multiple land use classes with vertical overlap; e.g. shade grown cocoa which includes overlap of forest and agriculture) or distinct (include multiple land use classes that do not overlap; e.g. agriculture next to a water body). If land use distribution on the plot is homogeneous, that land use is the one for the classification. If land use distribution on the plot is distinct, that land use is the one that covers the majority of the plot. If land use distribution on the plot is overlapping, that land use is the one that first meets the hierarchy: Settlement > Cropland > Forestland > Grassland > Wetland > Otherland.

The land use cover uses the IPCC land use classes and is determined by counting the land use features intersecting with the control points. Examples of the IPCC classes are provided in the interpretation key. The assignment of control points to the various classes within the assessment unit must add up to a minimum of 90% cover. This assignment represents the land use for the end of the reference period or the final land use.

Validation rules

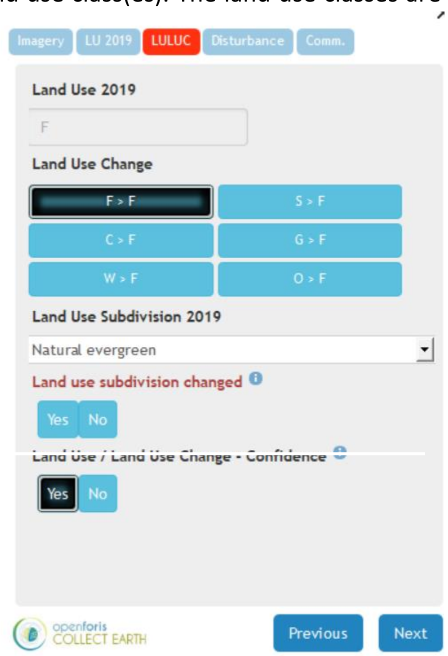
1. If homogenous is selected, then all the control points should fall into 1 land use
2. Control points cannot exceed more than 100% plot coverage.

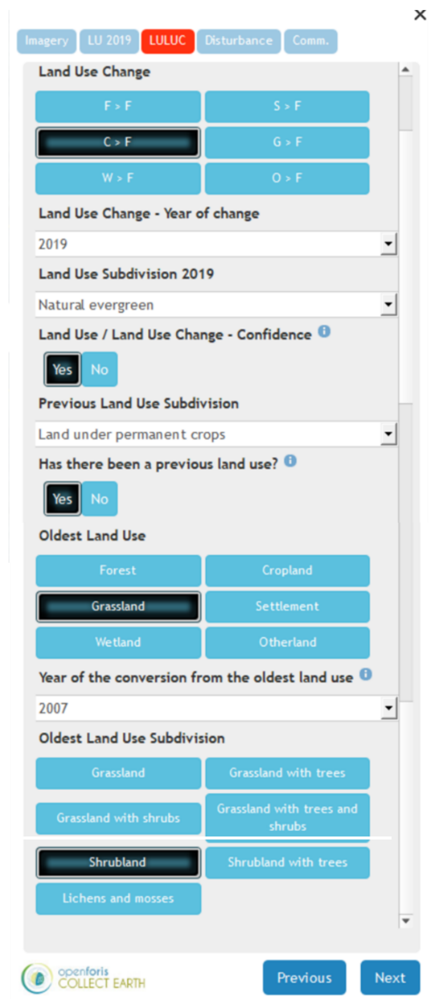
Attributes

Attribute Name	Required	Description
Land Use Distribution in the Plot	Always required	1. Homogeneous: Plots with one single land use. 2. Distinct: Plots with more than one land use within the plot, distinctly separated. 3. Overlapping: Plots with more than one land use within the plot that occur in the same area.
Control Points	Always required	The number of control points that cover a specific land use type.

Land use change card

The land use change card shows if there have been changes in land use. The final land use class is automatically determined based on the information provided in the land use 2019 card. The interpreter determines if there has been a land use change and the previous land use class(es). The land use classes are recorded for the IPCC classes and subdivision classes.





If the land use class has not changed as in Figure 3 (e.g., forest remaining forest) it is possible to record a land use subdivision change (e.g. natural forest to shade grown cocoa). The land use subdivision is based on the national classification system.

If the land use class has changed as in Figure 2 (e.g., cropland to forest) the most recent land use year of change is recorded as well as the land use subdivision in 2019 and the land use subdivision previous to the land use change. It is possible to record up to two land use change within the assessment period. If another land use change is observed, previous to the one already recorded, the interpreter selects the oldest land use class, year of change and the oldest land use subdivision.

After the land use and land use change is decided, the interpreter expresses their confidence in the interpretation of land use and land use change. 'Yes' signifies the interpreter is confident of their choices for land use and change. 'No' signifies the interpreter is not confident of their classification. If the confidence is marked as No the plot is reassessed by a second interpreter or by a group of interpreters that can discuss and come to a consensus on a classification they are confident about.

Validation rules

1. The end land use class is determined using the input from the 2019 land use card
2. The land use change classes selected correspond to the land use subdivision classes
3. The year of change only appears if a change classes is selected
4. Second land use changes classes only appear if a second change is specified
5. The interpreter selects their confidence and this is later used for quality assurance.

Attributes

Attribute Name	Required	Description
Land Use 2019	Calculated attribute based on previous attributes. See land use 2019 card description.	Automatically determined based on land use 2019 control points
Land Use Change	Always Required	Changes between land uses over the period 2000-2019

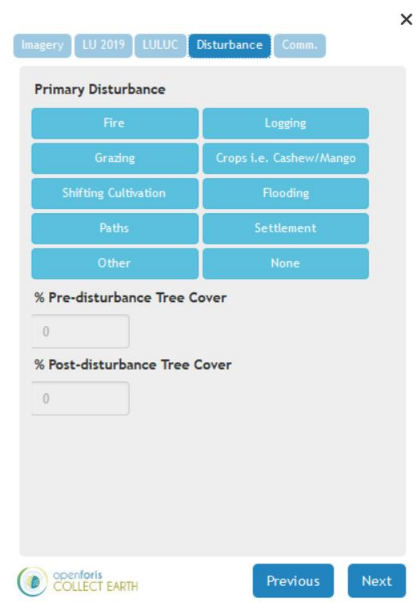
		Options are based on the classification of the Current Land use (2019). If **Settlement:** **S > S** Settlement remaining Settlement **C > S** Crop Land becoming Settlement **F > S** Forest Land becoming Settlement **G > S** Grass Land becoming Settlement **W > S** Wet Land becoming Settlement **O > S** Other Land becoming Settlement If **Cropland:** **C > C** Crop Land remaining Crop Land **S > C** Settlement becoming Crop Land **F > C** Forest Land becoming Crop Land **G > C** Grass Land becoming Crop Land **W > C** Wet Land becoming Crop Land **O > C** Other Land becoming Crop Land If **Forest**: **F > F** Forest Land remaining Forest Land **S > F** Settlement becoming Forest Land **C > F** Crop Land becoming Forest Land **G > F** Grass Land becoming Forest Land **W > F** Wet Land becoming Forest Land **O > F** Other Land becoming Forest Land If **Grassland**: **G > G** Grass Land remaining Grass Land **S > G** Settlement becoming Grass Land **C > G** Crop Land becoming Grass Land **F > G** Forest Land becoming Grass Land **W > G** Wet Land becoming Grass Land **O > G** Other Land becoming Grass Land If **Wetland**: **W > W** Wet Land remaining Wet Land **S > W** Settlement becoming Wet Land **C > W** Crop Land becoming Wet Land **F > W** Forest Land becoming Wet Land **G > W** Grass Land becoming Wet Land **O > W** Other Land becoming Wet Land If **Otherland**: **O > O** Other Land remaining Other Land **S > O** Settlement becoming Other Land

		C > O Crop Land becoming Other Land **F > O** Forest Land becoming Other Land **G > O** Grass Land becoming Other Land **W > O** Wet Land becoming Other Land
Land Use Change - Year of change	Always Required Only relevant when there is a change between land uses. Not relevant when: **S > S** Settlement remaining Settlement **C > C** Crop Land remaining Crop Land **F > F** Forest Land remaining Forest Land **G > G** Grass Land remaining Grass Land **W > W** Wet Land remaining Wet Land **O > O** Other Land remaining Other Land	Type the year where the change happened. 2001-2019
Land Use Subdivision 2019	Always Required	The subdivision if a more specific description of the land use. Nationally relevant classes were determined that are harmonized within the six IPCC categories. The classification used have the following subdivisions: **For Forest Land:** Natural deciduous Natural evergreen Natural mixed Riparian forest Riverine forest Mangrove forest Forest plantation Shade grown agriculture **For Cropland:** Land under permanent crops Land under temporary crops Rice paddy Palm plantation and coconut Rubber plantation Sunny cocoa plantation Fallow **For Grassland:** Grassland Grassland with trees Grassland with shrubs Grassland with trees and shrubs Shrubland Shrubland with trees

		For Settlement: City Town Village Mining Infrastructure Built up Urban park **For Wetland:** Permanent lake Seasonal lake Permanent River Seasonal river Swamp Lagoon Peatland Salt extraction Other Artificial Water Bodies Mangroves **For Otherland:** Rocks / Stone Sand / Dunes Barren soil Other
Land Use / Land Use Change - Confidence	Always Required	States if the operator is confident about the assessment of Land Use / Land Use Change
Previous Land Use Subdivision	Always Required	Related to the subdivision of the previous land use when change has occurred. It follows the same logic as the *Land Use Subdivision 2019.*
Has there been a previous land use?	Always Required	If there has been an additional land use change on the plot, this field can be marked YES in order to allow the addition of another land use change.
Oldest Land Use	Always Required Relevant only when there has been a previous land use change (additional)	Chose of the 6 IPCC Land Uses
Year of the conversion from the oldest land use	Always Required Relevant only when there has been a previous land use change (additional)	Year of the first conversion
Oldest Land Use Subdivision	Always Required Relevant only when there has been a previous land use change (additional)	Same options as Land Use Subdivision 2019

Grassland Management	Always Required Relevant only when Land Use 2019 is Grassland	Options are: Grazing Cultivated Grazing / Irrigated Grazing Naturally Grown No Grazing

Disturbance card



The disturbance card options is used to assess anthropogenic disturbances in forest land and grasslands. Up to three disturbance types can be selected for one plot. The year of the disturbance can be selected for multiple years and represents occurrences of that disturbance. The year of disturbance is only selected for the primary disturbance. The pre-disturbance and post-disturbance tree cover options allow the interpreter to quantify the level of forest disturbance and is effect on canopy cover. Information from this plot is used to derive estimates for forest degradation in open and closed forest.

Validation rules

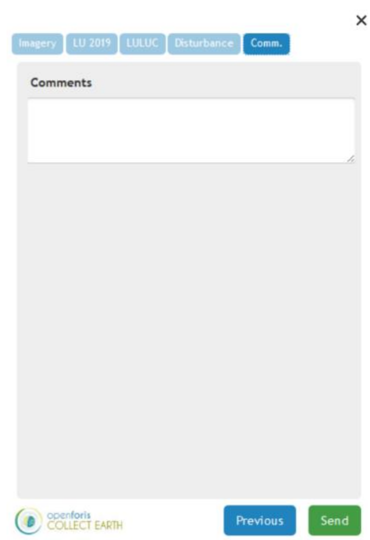
1. The options for disturbances only appear when the land use change classes, forest remaining forest or grassland remaining grassland
2. The pre and post disturbance options only appear when the land cover change class forest remaining forest is selected

Attributes

Attribute Name	Required	Description
Primary disturbance	Not required Relevant only when Land Use 2019 is Grassland or Forest land Only one disturbance is selectable	Anthropogenic disturbances in forest land and grasslands The options for disturbance are: Fire Grazing Shifting cultivation Paths Other Logging Crops Flooding Settlement None
Year of primary disturbance	Required when a primary disturbance is selected Multiple years are selectable	Years between 2000 and 2019 can be selected

Secondary disturbance	Not required Relevant only when a primary disturbance is selected	Anthropogenic disturbances in forest land and grasslands The options are identical to the options in primary disturbance
Tertiary disturbance	Not required Relevant only when a secondary disturbance is selected	Anthropogenic disturbances in forest land and grasslands The options are identical to the options in primary disturbance
Pre-disturbance tree cover	Required Relevant only when the land use change class, forest remaining forest is selected and a primary disturbance is selected	The tree canopy cover prior to the year that the disturbance occurred. Percent coverage by control points as the 2019 land use card
Post-disturbance tree cover	Required Relevant only when the land use change class, forest remaining forest is selected and a primary disturbance is selected	The tree canopy cover after the year that the disturbance occurred. Percent coverage by control points as the 2019 land use card

Comments card



The comments card allows interpreters to note any comment about what they have observed in the plot. If no confidence for the land use change assessment is select, the reasoning for selecting no confidence should be explained in the comment card (e.g., no cloud free high resolution imagery available, unclear if there is a change in the plot).

There are no validation rules for the comment card

Attribute Name	Required	Description
Comments	Not required	Any comments can be added in this section

FORM 3: DATA COLLECTION

Purpose and scope of the data collected	The data collection covers the Ghana Cocoa Forest REDD+ Programme (GCFRP) area and is used for reference level estimates reported in the Emissions Reductions Program Document (ERPD) to the Forest Carbon Partnership Facility (FCPF).
Version	1
Date	14/06/2021

Individuals involved

Name	Email	Institution	Role for data collection
Yusif Sitobu Abdullai	sitobuyusif14@gmail.com	Centre for Remote Sensing and Geographic Information Services	Sample interpretation
Foster Mensah	fkmawusi@gmail.com	CERSGIS	Sample interpretation
Ebenezer Kofi Baidoo	baidook32@gmal.com	ENVIRONMENTAL PROTECTION AGENCY	Sample interpretation
Christopher Ihejirika	chinihe123@gmail.com	Resource Management Support Center Forestry Commission, Kumasi	Sample interpretation
Justice Ankomah-Baffoe	ankoba.just@gmail.com	CSIR-Soil Research institute - Accra	Sample interpretation

Emmanuel Donkor	emmanueldonkor484@gmail.com	Forestry Commission	Sample interpretation
Richmond Konadu Amoah	Sarfoabredu3@gmail.com	Ministry of Food and Agriculture	Sample interpretation
Kofi Boateng Agyenim	bkofi646@gmail.com	Forestry Commission	Sample interpretation
Agyemang Afua Birago	nanaagyemangworship@gmail.com	Forestry Commission	Sample interpretation
ERIC OSEI	osieeric81@gmail.com	Forestry Commission	Sample interpretation
Jacob Amoako	jacobamoako2012@gmail.com	Forestry Commission	Sample interpretation
Nutefe Kwesi Dra	kwnutefe@gmail.com	Environmental Protection Agency	Sample interpretation
Nathanael Nii-Odai Laryea	niiodailaryea@gmail.com	Ministry of Food and Agriculture	Sample interpretation
Ebenezer Kwanin	ekwanin@gmail.com	Forestry Commission, RMSC	Sample interpretation
Senyo Yao Gakpo	senyogakpo@gmail.com	Ministry of Food and Agriculture	Sample interpretation
Mawuli Kwaku Gbekor	mgbekor@gmail.com	Environmental Protection Agency	Sample interpretation
Ernest Foli	efoli@hotmail.com	Forestry Research Institute	Sample interpretation
Frank Kwadwo Owusu	frankkwadwoowusu@gmail.com	Forestry Commission	Sample interpretation
Lawrence Akpalu	lakpalu@gmail.com	Forestry Commission, RMSC	Sample interpretation
Prince Boama	boamaprince@gmail.com	Forestry Commission, RMSC	Sample interpretation
Raymond Sakyi	rksakyi@yahoo.com	Forestry Commission	Sample interpretation
Tessia Boateng	tessiaboat@gmail.com	Forestry Commission	Sample interpretation

William Osei-Wusu	williamkay88@gmail.com	Forestry Commission, RMSC	Sample interpretation
Yakubu Mohammed	myakubu89@hotmail.com	Forestry Commission, RMSC	Sample interpretation
Baidoo			

Sample unit allocation to interpreters

The samples collected in the GCFRP area

Interpreter name	Number of sample units
A-Baffoe	45
agyemangafuabirago	13
Baidoo	625
CHRISTOPHER IHEJIRIKA	877
DONKOR EMMANUEL	55
Eben Baidoo	25
Ebenezer Kwanin	1139
Enerst	90
ERIC OSEI	28
Ernest	167
fowusu	898
Jacob Amoako	227
Kofi Boateng	28
kofibaffoe64	75
Lawrence	238
Mawuli	32
Prince Boama	462
Raymond Sakyi	271
remiremi	90
RICHMOND KONADU AMOAH	11
senyo yao gakpo	23

Tessia Boateng	1071
William	997
Yakubu Mohammed	18
Yelena	185
Yusif Abdullai	26

Cross validation

The duplicate samples were chosen by selecting samples that were marked as low confidence, had incomplete information and randomly selected samples. In total 598 sample were duplicated and assessed by two different interpreters. The duplicate sample that was used in the reference interpretation was selected by using the sample with high confidence and the most recently assessed sample.

Duplicate interpretation	
Interpreter name	**Number of duplicates assessed**
Baidoo	40
Christopher Ihejirika	32
Ebenezer Kwanin	156
Ernest	17
fowusu	187
Jacob Amoako	9
kofibaffoe64	8
Lawrence	15
Prince Boama	62
Raymond Sakyi	14
Tessia Boateng	205
William	148
Yakubu Mohammed	303
Grand Total	**1196**

Per class agreement and disagreement for duplicate samples

	Deforestation	Degraded forest	Forest gain	Stable forest	Stable non-forest	Grand Total
A	**9**	**4**	**6**	**167**	**412**	**598**
Agreement	2			140	348	490
Disagreement	7	4	6	27	64	108
B	**7**	**4**	**8**	**194**	**385**	**598**
Agreement	2			140	348	490
Disagreement	5	4	8	54	37	108
Grand Total	**16**	**8**	**14**	**361**	**797**	**1196**

Overall Interpreters' Agreement
82%

Matrix of duplicate samples

Interpreter A \ Interpreter B	Deforestation	Degraded forest	Forest gain	Stable forest	Stable non-forest	Grand Total
Deforestation	2	0	0	0	7	9
Degraded forest	0	0	0	2	2	4
Forest gain	0	0	0	3	3	6
Stable forest	0	2	0	140	25	167
Stable non-forest	5	2	8	49	348	412
Grand Total	7	4	8	194	385	598

Collect Earth output description

When exporting the sample data from Collect Earth, the database can be exported in CSV format. The CSV output includes the information collected for each sample in numerous columns. The description of each column from the Collect Earth database is provided here.

Column name	Description
id	Unique identifier for each sample. It can be matched with the ID from the intensification file.
round	Identifier for the number of times the sample was assessed. If a sample was assessed more than one time the most recent sample is used. The max value that can be entered is 10 1 = first time the sample was assessed 2= second time the sample was assessed, etc
round_label	Labels for the assessment phases, linked to the round column Ordinary = Round 1

	Re-assessment = Round 2 QA/QC = Round 3 4 = Round 4 5 = Round 5 6 = Round 6 7 = Round 7 8 = Round 8 9 = Round 9 10 = Round 10
location_srs	Spatial reference system for the coordinates
location_x	X coordinate
location_y	Y coordinate
operator	Name of person that assessed the sample
validation_comment	Hidden value – always blank
land_use_category	Land use category in 2019
land_use_category_label	Land use category label in 2019
land_use_subcategory	Land use change class between 2000-2019
land_use_subcategory_label	Land use change class label between 2000-2019
land_use_category_has_changed	Whether there has been a land use change identified TRUE = a land use change was identified FALSE = no land use change was identified
land_use_subcategory_year_of_change_know	Hidden value – always blank
land_use_subcategory_year_of_change	Year of change
land_use_subcategory_year_of_change_label	Year of change
aoi_classification	Country name
aoi_classification_label	Country name
land_use_subdivision	Land use subdivision in 2019
land_use_subdivision_label	Land use subdivision label in 2019

land_use_subdivision_change	Whether there has been a land use subdivision change identified TRUE = a land use subdivision change was identified FALSE = no land use change subdivision was identified
land_use_assessment_confidence	Confidence in the land use and land use change assessment TRUE = operator was confident in assessment FALSE = low confidence, the sample is rechecked by another operator
vhri_source	Primary high resolution source used for the assessment
vhri_source_label	Primary high resolution source used for the assessment
initital_aoi_classification	Country name
initital_aoi_classification_label	Country name
land_use_initial_subdivision	The land use subdivision before a land use change or a land use subdivision change
land_use_initial_subdivision_label	The land use subdivision label before a land use change or a land use subdivision change
land_use_subdivision_year_of_change	Land use subdivision year of change
land_use_subdivision_year_of_change_label	Land use subdivision year of change
second_lu_change	Whether a second land use change occurred Has the land use changed more than once since 2000? For example this might happen if there is a transition from Forest in 2000 to Grassland in 2005 that becomes settlement in 2010. TRUE = a second land use change occurred FALSE = only one land use change occurred Blank = no land use change
second_lu_conversion	Land use change class of the second land use change This is the oldest possible land use change. In the example Forest to Grassland to Settlement, it would be Grassland
second_lu_conversion_label	Land use change class label of the second land use change This is the oldest possible land use change. In the example Forest to Grassland to Settlement, it would be Grassland
plot_distribution	Distribution of the land use features within the plot

plot_distribution_label	Distribution label of the land use features within the plot
second_lu_conversion_year	Year of the second (oldest) land use change If the dynamic is Forest -> 2005 Grassland ->2010 Settlement, then here you would set 2005.
second_lu_conversion_year_label	Year of the second (oldest) land use change
oldest_aoi_classification	Country name or Global
oldest_aoi_classification_label	Country name or Global
second_lu_subdivision	Land use subdivision of the second (oldest) land use change
second_lu_subdivision_label	Land use subdivision label of the second (oldest) land use change
actively_saved	Whether the plot was completed and saved in Collect Earth When a sample is assessed and completed in Collect Earth a green check mark will appear in Google Earth next to the sample. TRUE = the sample was assessed and successfully saved FALSE = the sample was not successfully saved in Collect Earth
actively_saved_on_year	Year the sample was assessed
actively_saved_on_month	Month the sample was assessed
actively_saved_on_day	Day the sample was assessed
plot_file	Name of the input CSV with the samples that were assessed
elevation	Elevation from NASA SRTM Digital Elevation 30m
slope	Slope from NASA SRTM Digital Elevation 30m
aspect	Aspect from NASA SRTM Digital Elevation 30m
calculated_elevation_range	Codes for calculated elevation ranges
calculated_elevation_range_label	Calculated elevation ranges, binned in 100 m intervals
calculated_aspect	Calculated aspect (N,E,S,W)
calculated_aspect_label	Calculated aspect (N,E,S,W)
calculated_slope	Calculated slope

	Flat = 0 – 5 degrees Slight = 6 – 15 degrees Steep = 16 – 30 degrees Very steep = 31 – 45 degrees Extreme = 46 – 60 degrees Fall = 61 – 90 degrees
calculated_slope_label	Calculated slope
vhri_year	Year of the latest image from Google Earth
vhri_year_label	Year of the latest image from Google Earth
alu_2000_subcategory	Calculated land use subcategory in 2000
alu_2000_category	Calculated land use category in 2000
alu_2000_category_label	Calculated land use category label in 2000
alu_2000_subdivision	Calculated land use subdivision in 2000
alu_2000_subdivision_label	Calculated land use subdivision label in 2000
primary_disturbance	Primary disturbance in the sample
primary_disturbance_label	Primary disturbance label
primary_disturbance_year.1.	Year of primary disturbance Multiple years can be selected
primary_disturbance_year_label.1.	Year of primary disturbance Multiple years can be selected
primary_disturbance_year.2.	Year of primary disturbance Multiple years can be selected
primary_disturbance_year_label.2.	Year of primary disturbance Multiple years can be selected
primary_disturbance_year.3.	Year of primary disturbance Multiple years can be selected
primary_disturbance_year_label.3.	Year of primary disturbance Multiple years can be selected
primary_disturbance_year.4.	Year of primary disturbance

	Multiple years can be selected
primary_disturbance_year_label.4.	Year of primary disturbance Multiple years can be selected
primary_disturbance_year.5.	Year of primary disturbance Multiple years can be selected
primary_disturbance_year_label.5.	Year of primary disturbance Multiple years can be selected
secondary_disturbance	Secondary disturbance
secondary_disturbance_label	Secondary disturbance label
tertiary_disturbance	Tertiary disturbance
tertiary_disturbance_label	Tertiary disturbance label
climate	Climate codes from IPCC https://esdac.jrc.ec.europa.eu/projects/RenewableEnergy/
climate_label	Climate zones from IPCC
soil	Soil type codes from IPCC https://esdac.jrc.ec.europa.eu/projects/RenewableEnergy/
soil_label	Soil type from IPCC
gez	IPCC Global Ecologic Zone codes https://forest.jrc.ec.europa.eu/en/activities/lulucf/ipcc-classifications/
gez_label	IPCC Global Ecologic Zone labels
country	Country name from FAO GAUL: Global Administrative Unit Layers 2015
province	Province name from FAO GAUL: Global Administrative Unit Layers 2015
district	District name from FAO GAUL: Global Administrative Unit Layers 2015
land_useF_lu	"F" in all columns
land_useF_lu_label	"Forest" in all columns
land_useF_coverage	Forest land use percentage coverage in 2019

land_useF_coverage_label	Number of control points in sample with forest land use in 2019
land_useF_percentage	Forest land use percentage coverage in 2019
land_useC_lu	“C” in all columns
land_useC_lu_label	“Cropland” in all columns
land_useC_coverage	Cropland land use percentage coverage in 2019
land_useC_coverage_label	Number of control points in sample with Cropland use in 2019
land_useC_percentage	Cropland land use percentage coverage in 2019
land_useG_lu	“G” in all columns
land_useG_lu_label	“Grassland” in all columns
land_useG_coverage	Grassland land use percentage coverage in 2019
land_useG_coverage_label	Number of control points in sample with Grassland use in 2019
land_useG_percentage	Grassland land use percentage coverage in 2019
land_useS_lu	“S” in all columns
land_useS_lu_label	“Settlement” in all columns
land_useS_coverage	Settlement land use percentage coverage in 2019
land_useS_coverage_label	Number of control points in sample with Settlement use in 2019
land_useS_percentage	Settlement land use percentage coverage in 2019
land_useW_lu	“W” in all columns
land_useW_lu_label	“Wetlands” in all columns
land_useW_coverage	Wetlands land use percentage coverage in 2019
land_useW_coverage_label	Number of control points in sample with Wetlands land use in 2019
land_useW_percentage	Wetlands percentage coverage in 2019
land_useO_lu	“O” in all columns
land_useO_lu_label	“Otherlands” in all columns

land_useO_coverage	Otherlands land use percentage coverage in 2019
land_useO_coverage_label	Number of control points in sample with Otherlands land use in 2019
land_useO_percentage	Otherlands land use percentage coverage in 2019
dryland_category	Dryland category extracted from Drylands_UNCCD_CSV_july2014
biome	Biome from RESOLVE Ecoregions 2017
ecoregion	Ecoregion from RESOLVE Ecoregions 2017
land_prod	Land productivity code from UNCCD
land_prod_label	Land productivity label from UNCCD
grassland_mgmt	Grassland management in grassland land use
grassland_mgmt_label	Grassland management in grassland land use
watershed_lvl0	No value – always blank
watershed_lvl1	No value – always blank
project	No value – always blank
project_label	No value – always blank
comments	Comment left by operator
grid_type	How the samples are distributed Systematic samples are distributed in a consistent manner using the SIGRID grid
grid_type_label	How the samples are distributed Systematic samples are distributed in a consistent manner using the SIGRID grid
pre_disturbance_treecover	Percentage tree cover before the forest disturbance is recorded
pre_disturbance_treecover_label	Number of control points in the sample with tree cover before the forest disturbance is recorded
post_disturbance_treecover	Percentage tree cover after the forest disturbance is recorded
post_disturbance_treecover_label	Number of control points in the sample with tree cover after the forest disturbance is recorded

ecozone	Ghana ecozones
pre_deforestation_tree_cover	Percentage tree cover before deforestation is recorded
pre_deforestation_tree_cover_label	Number of control points in the sample with tree cover before deforestation is recorded
forestmask	Forest mask value
forestmaskcode	Forest mask value
forest_vegetation_zones	Combination of forest mask and ecozones
forest_vegetation_zones_label	Combination of forest mask and ecozones
game_reserve	Game reserve name
forest_reserve	Forest reserve name
vegcode.y	Ghana ecozones code
vegzone	Ghana ecozones
all_reserves	Calculated based on game_reserve and forest_reserve Presence (1) or absence (0) of forest or game reserves
forestreserves_binary	Calculated based on forest_reserve Presence (1) or absence (0) of forest reserves
gamereserves_binary	Calculated based on game_reserve Presence (1) or absence (0) of game reserves
Disturbance	Calculated based on primary_disturbance Presence (1) or absence (0) of disturbances
Disturbance on FF	Calculated based on primary_disturbance and land_use_subcategory Presence (1) or absence (0) of disturbances in forest remaining forest
land_use_REDD_2005	Calculated based on land_use_category_has_changed and land_use_subcategory_year_of_change and land_use_category Land use in 2005 (Forest/non-forest) Fo = Forest area in 2005 NF = Non-forest in 2005

land_use_2005_redd_label	Calculated based on land_use_category_has_changed and land_use_subcategory_year_of_change and land_use_category Land use in 2005 (Forest/non-forest) Forest = Forest area in 2005 Non-Forest = Non-forest in 2005
closed_open_degr	Calculated based on disturbance_ff_binary pre_disturbance_treecover Disturbance on open or closed forests 1=degradation in open forest 2= degradation in closed forest 0=no degradation
fm_eco_area_ha_combined	Area of stratum
fm_eco_label	Stratification class name
stratum	Sampling intensity – spacing in km between samples
closed_open_def	Calculated based on pre_deforestation_tree_cover Deforestation on Closed/Open Forest 1=deforestation in open forest 2= deforestation in closed forest 0=no deforestation
CODE	Concatenation of fm_eco_label stratum and CODE2
CODE2	FF = forest remaining forest, 0 = non-forest remaining non-forest, FN = forest to non-forest,

FORM 4: TRAINING	
Purpose and scope of the training	The training exercise preceded the data collection for the Ghana Cocoa Forest REDD+ Programme (GCFRP) area and is used for reference level estimates reported in the Emissions Reductions Program Document (ERPD) to the Forest Carbon Partnership Facility (FCPF).
Date of the training	First training (5th – 9th June, 2019) Second training (10th – 13th June, 2019)
Location of the training	Accra, Ghana
Trainer	Marcelo Rezende

Topics covered

05-07 June 2019, 09.00-17.30.

Training Workshop Agenda for the Advanced Training on Open Foris Collect, Open Foris Collect Earth and Sampling Methodology using Visual Interpretation

	Hour	Description
Day 1	09:00 – 09:30	Opening Remarks / Introductions
	09:30 – 10:30	Review of Agenda – Discuss proposed outcomes
	10:30– 11:00	Coffee Break

	11:00 – 11:30	Land Use and Land Use Change
	11:30 – 12:00	IPCC guidelines and Sampling Approach
	12:00 – 13:00	Lunch
	13:00 – 14:00	Open Foris Collect Features
	14:00 – 15:00	Open Foris Collect Survey Design
	15:00 – 15:30	Coffee Break
	15:30– 16:00	Open Foris Collect Survey Design
	16:00 – 17:00	
Day 2	09:00 – 09:30	Open Foris Collect Survey Design
	09:30 – 10:30	
	10:30– 11:00	Coffee Break
	11:00 – 11:30	Sampling Grid Creation
	11:30 – 12:00	
	12:00 – 13:00	Lunch
	13:00 – 14:00	Sampling Grid Creation
	14:00 – 15:00	
	15:00 – 15:30	Coffee Break
	15:30– 16:00	Uncertainties of Sampling
	16:00 – 17:00	Hands-on group data collection
Day 3	09:00 – 09:30	Open Foris Collect Earth Overview
	09:30 – 10:30	IPCC classification
	10:30– 11:00	Coffee Break
	11:00 – 11:30	Hands-on group data collection
	11:30 – 12:00	Hands-on group data collection

	12:00 – 13:00	Lunch
	13:00 – 14:00	Saiku anlysis
	14:00 – 15:00	Classification and Methodology Review
	15:00 – 15:30	Coffee Break
	15:30– 16:00	Discussion on the approach and methodology
	16:00 – 17:00	Roadmap for data collection

10-13 June, 09.00-17.30.

Training Workshop Agenda for Visual Interpretation and Data Collection

	Hour	Description
Day 1	09:00 – 09:30	Opening Remarks / Introductions
	09:30 – 10:30	Review of Agenda – Discuss proposed outcomes
	10:30– 11:00	Coffee Break
	11:00 – 11:30	Land Use and Land Use Change
	11:30 – 12:00	Land Degradation Neutrality and the SDG 15.1, 15.4 and 15.3
	12:00 – 13:00	Lunch
	13:00 – 14:00	Overview of FAO Open Foris tools
	14:00 – 15:00	Coffee Break
	15:00 – 15:30	FAO and UNCCD to support the LDN
	15:30– 16:00	**Open Foris Collect Earth**
	16:00 – 17:00	Main functionalities
Day 2	09:00 – 09:30	Installation and Testing
	09:30 – 10:30	Installation and Testing
	10:30– 11:00	Coffee Break

	11:00 – 11:30	Methodology of Assessment / Validation
	11:30 – 12:00	Methodology of Assessment / Validation
	12:00 – 13:00	Lunch
	13:00 – 14:00	IPCC, UNCCD and National Classifications
	14:00 – 15:00	Hands-on group data collection
	15:00 – 15:30	Coffee Break
	15:30– 16:00	Hands-on group data collection
	16:00 – 17:00	Hands-on group data collection
Day 3	09:00 – 09:30	Visual Guide on the Interpretation
	09:30 – 10:30	Discussion of the interpretation
	10:30– 11:00	Coffee Break
	11:00 – 11:30	Collect Earth Survey Overview
	11:30 – 12:00	Classification and Methodology Review
	12:00 – 13:00	Lunch
	13:00 – 14:00	Individual Data collection
	14:00 – 15:00	Individual Data collection
	15:00 – 15:30	Coffee Break
	15:30– 16:00	Individual Data collection
	16:00 – 17:00	Individual Data collection

Attendees with attendance record

Name	Email	Institution

Yusif Sitobu Abdullai	sitobuyusif14@gmail.com	Centre for Remote Sensing and Geographic Information Services
Foster Mensah	fkmawusi@gmail.com	CERSGIS
Ebenezer Kofi Baidoo	baidook32@gmal.com	ENVIRONMENTAL PROTECTION AGENCY
Christopher Ihejirika	chinihe123@gmail.com	Resource Management Support Center Forestry Commission, Kumasi
Justice Ankomah-Baffoe	ankoba.just@gmail.com	CSIR-Soil Research institute - Accra
Emmanuel Donkor	emmanueldonkor484@gmail.com	Forestry Commission
Richmond Konadu Amoah	Sarfoabredu3@gmail.com	Ministry of Food and Agriculture
Kofi Boateng Agyenim	bkofi646@gmail.com	Forestry Commission
Agyemang Afua Birago	nanaagyemangworship@gmail.com	Forestry Commission
ERIC OSEI	osieeric81@gmail.com	Forestry Commission
Jacob Amoako		Forestry Commission
Nutefe Kwesi Dra	kwnutefe@gmail.com	Environmental Protection Agency
Nathanael Nii-Odai Laryea	niiodailaryea@gmail.com	Ministry of Food and Agriculture
Ebenezer Kwanin	ekwanin@gmail.com	Forestry Commission, RMSC
Senyo Yao Gakpo	senyogakpo@gmail.com	Ministry of Food and Agriculture
Mawuli Kwaku Gbekor	mgbekor@gmail.com	Environmental Protection Agency

FORM 5: DATA ANALYSIS

Purpose and scope of the data collected	The data analysis purpose and scope covers the Ghana Cocoa Forest REDD+ Programme (GCFRP) area and is used for reference level estimates reported in the Emissions Reductions Program Document (ERPD) to the Forest Carbon Partnership Facility (FCPF).
Date	First exercise (16th – 20th December, 2019) Second exercise (3rd – 13th December, 2020) Third exercise (2nd – 5th March, 2020)
Data underlying this analysis	Data will be stored at the climate change unit of the forestry commission, the resources management support Centre and the, national forest monitoring system and the ICT unit. A data management and storage platform yet to be develop under the national forest monitoring system
Person that completed this form	Mr. Yakubu Mohammed, Mr. Thomas Gyambrah, Mr. Jacob Amoako, Mr. Frank Kwadwo Owusu, Ms. Tessia Boateng
SOPs used	Version 1, Version 2 and Version 3

Data analysis

Data analysis is completed in excel and the full spreadsheet can be found here: Information on this can be requested from the Climate Change Directorate or the GIS and Mapping of the Forestry Commission.

Strata (map) against reference classes (sample data)

Report a matrix of counts of sampling units per class in the stratification map and classes resulting from interpretation.

PLOT COUNT BY VEG ZONE			
GCFRP landscape			
vegzone	Forest	Non-forest	total
Moist evergreen	904	1219	2123
Moist semi deciduous (north west subtype)	691	1354	2045
Moist semi deciduous (south east subtype)	573	1575	2148
Wet evergreen	438	543	981
Upland evergreen	207	185	392

Non-response

PLOT COUNT BY VEG ZONE AND GRID INTENSITY					
GCFRP landscape					
vegzone	stratum	Fo	NF	(blank)	total

Moist evergreen	2	799	585	9	1384
Moist evergreen	4	105	634	5	739
Moist semideciduous (north west subtype)	2	647	907	3	1554
Moist semideciduous (north west subtype)	4	44	447	0	491
Moist semideciduous (south east subtype)	2	497	1046	3	1543
Moist semideciduous (south east subtype)	4	76	529	4	605
Wet evergreen	2	408	345	1	753
Wet evergreen	4	30	198	1	228
Upland evergreen	1	207	185	1	392

Strata weights

WEIGHTS PER STRATUM / EXPANSION FACTORS			
Strata	**area per stratum**	**number of sample units per stratum**	**expansion factor (the area that each sample in the stratum represents)**
Moist evergreen 2x2	**886,983**	**1384**	**640.88**
Moist evergreen 4x4	**945,406**	**739**	**1,279.30**
Moist SemiD NW 2x2	**962,079**	**1554**	**619.10**
Moist SemiD NW 4x4	**595,511**	**491**	**1,212.85**
Moist SemiD SE 2x2	**989,659**	**1543**	**641.39**
Moist SemiD SE 4x4	**737,423**	**605**	**1,218.88**
Wet evergreen 2x2	**457,198**	**753**	**607.17**
Wet evergreen 4x4	**277,565**	**228**	**1,217.39**
Upland evergreen	**62,601**	**392**	**159.70**
Total GCFRP area	**5,914,425**	**7689**	

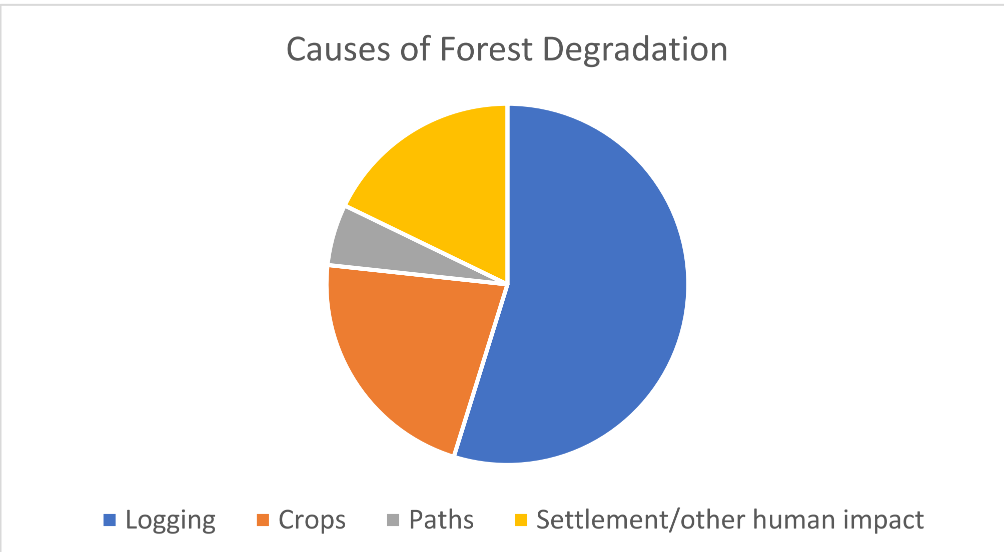
Open forest - annual degradation (ha/year)					
	Wet Evergreen	Moist Evergreen	Moist Semideciduous NW	Moist Semideciduous SE	Upland Evergreen
2005-2014	-	128	183	64	-
2015	-	-	-	-	-
2016	-	-	-	-	-
2017	-	-	1,213	-	-
2018	-	-	-	-	-
2019	-	-	-	-	-
Closed forest - annual degradation (ha/year)					
	Wet Evergreen	Moist Evergreen	Moist Semideciduous NW	Moist Semideciduous SE	Upland Evergreen

2005-2014	304	1,153	1,354	1,270	80
2015	1,214	3,845	8,048	1,860	160
2016	-	3,202	619	641	319
2017	1,217	4,481	2,476	2,502	639
2018	607	641	1,238	-	160
2019	607	1,282	3,095	4,426	-
Open forest - uncertainty (90% CI in ha)					
	Wet Evergreen	Moist Evergreen	Moist Semideciduous NW	Moist Semideciduous SE	Upland Evergreen
2005-2014	-	210	223	105	-
2015	-	-	-	-	-
2016	-	-	-	-	-
2017	-	-	1,989	-	-
2018	-	-	-	-	-
2019	-	-	-	-	-
Closed forest - uncertainty (90% CI in ha)					
	Wet Evergreen	Moist Evergreen	Moist Semideciduous NW	Moist Semideciduous SE	Upland Evergreen
2005-2014	264	513	531	505	58
2015	1,407	2,570	3,647	2,259	262
2016	-	2,777	1,015	1,052	370
2017	1,997	3,479	2,029	2,491	522
2018	996	1,051	1,435	-	262
2019	996	1,486	2,267	3,084	-
Open forest - uncertainty (90% CI in %)					
	Wet Evergreen	Moist Evergreen	Moist Semideciduous NW	Moist Semideciduous SE	Upland Evergreen
2005-2014		1.64	1.22	1.64	
2015					
2016					
2017			1.64		
2018					
2019					
Closed forest - uncertainty (90% CI in %)					
	Wet Evergreen	Moist Evergreen	Moist Semideciduous NW	Moist Semideciduous SE	Upland Evergreen
2005-2014	0.87	0.45	0.39	0.40	0.73
2015	1.16	0.67	0.45	1.21	1.64
2016		0.87	1.64	1.64	1.16
2017	1.64	0.78	0.82	1.00	0.82
2018	1.64	1.64	1.16		1.64
2019	1.64	1.16	0.73	0.70	

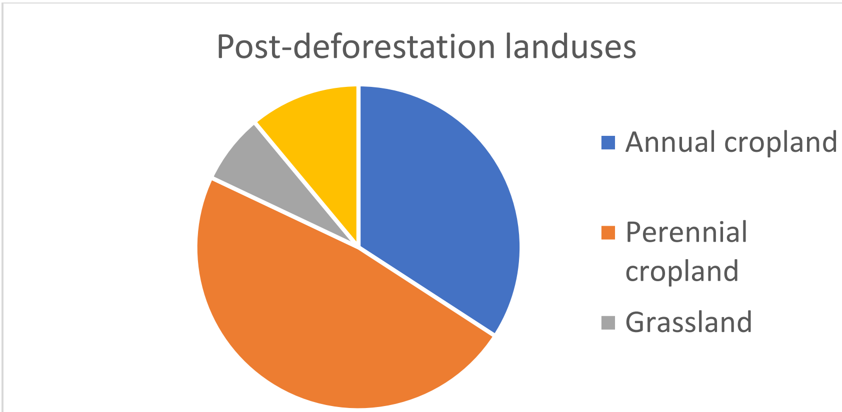
Open forest - annual deforestation (ha/year)					
	Wet Evergreen	Moist Evergreen	Moist Semideciduous NW	Moist Semideciduous SE	Upland Evergreen
2005-2014	182	768	1,840	1,950	15.97
2015	607	1,282	3,070	1,860	160
2016	1,217	641	1,832	1,860	-
2017	1,217	-	1,238	1,283	160
2018	-	1,279	619	641	-
2019	-	641	-	1,283	-
Closed forest - annual deforestation (ha/year)					
	Wet Evergreen	Moist Evergreen	Moist Semideciduous NW	Moist Semideciduous SE	Upland Evergreen
2005-2014	304	1,728	1,171	1,078	159.70
2015	607	3,202	1,857	641	319
2016	-	-	1,238	-	479
2017	-	1,282	1,238	641	160
2018	-	-	1,213	1,283	160
2019	-	-	619	-	-
Open forest - uncertainty (90% CI in ha)					
	Wet Evergreen	Moist Evergreen	Moist Semideciduous NW	Moist Semideciduous SE	Upland Evergreen
2005-2014	223	491	661	667	26
2015	996	1,486	2,654	2,259	262
2016	1,997	1,051	2,233	2,259	-
2017	1,997	-	1,435	1,487	262
2018	-	2,098	1,015	1,052	-
2019	-	1,051	-	1,487	-
Closed forest - uncertainty (90% CI in ha)					
	Wet Evergreen	Moist Evergreen	Moist Semideciduous NW	Moist Semideciduous SE	Upland Evergreen
2005-2014	264	730	482	472	82
2015	996	2,777	1,757	1,052	370
2016	-	-	1,435	-	452
2017	-	1,486	1,435	1,052	262
2018	-	-	1,989	1,487	262
2019	-	-	1,015	-	-

Additional analysis

Degradation causes	2005-2014	2015-2019
Logging	55%	66%
Crops	22%	18%
Paths	5%	3%
Settlement/other human impact	18%	13%
	100%	100%



Post-deforestation land use	Weighted average
Annual cropland	34%
Perennial cropland	48%
Grassland	7%
Settlement	11%


Post-deforestation landuses
Annual cropland
Perennial cropland
Grassland

Template Interpretation key

8776_21254

Cropland remaining Cropland