D6 REPORT: Feasibility analysis of the sampling framework

ACTION A.5

UNITUS, CREA FL E PEFC ITALIA

Summary

INTRODUCTION

In order to increase the calculation accuracy and ultimately contribute to the GHG inventory at national level, the project has proposed a system for data collection at farm level based on standardized procedures targeting the main parameters (e.g. soil carbon sampling, trees carbon evaluation etc.) that can be used to determine the carbon evaluation in field due to the carbon farming practices, as well as for the inventory purposes. The two following protocols take into consideration the timing, number of sample and sampling methodologies and costs necessary to achieve the optimal tradeoff between representativeness of the sample and operational costs.

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CARBON FARMING CERTIFICATION SYSTEM

SOIL DATA COLLECTION FRAMEWORK FOR CARBON FARMING CERTIFICATION SYSTEM

1 Introduction

This protocol contains the guidelines for the identification of Soil Organic Carbon (SOC) changes over time adapting the document recently proposed by FAO (FAO 2020) providing instructions on how to develop a sampling plan for a carbon farming project.
This soil sampling protocol provides instructions for implementing a simple and feasible yet rigorous soil sampling design adapting the so-called "stratified simple random sampling with compositing across strata". This method is able to combine the identification of SOC changes over time while reducing sampling expenses.
In addition, we defined the criteria used to group the Intervention Areas, established as reference units for the SOC measurement.

2 Definition of the Intervention Areas (IAs)

The project area is divided into one or more Intervention Areas (IAs) according to the following criteria:

I) land use prior to the beginning of the carbon farming project;
II) physical characteristic of soil (e.g., texture and structure);
III) the management activities undertaken as part of the carbon farming project;
IV) land morphology (e.g., flat, hilly or mountainous)

When the variables introduced above are very different, it would be necessary to establish more than one IA. The IA can be any size, there are no restrictions on it.

3 Sampling design: stratified simple random sampling

The stratified simple random sampling method is considered advantageous when no prior knowledge on the internal variability of SOC in the IA is available (FAO 2020). This case faces the needs of the Carbon Farming Certification system which is of recent introduction and which does not have a reliable historic dataset to use such as a reference for SOC change calculations.

In order to obtain a reliable estimate of SOC that is typical across the IA as a whole, the next sampling scheme is proposed:

- from three to five plots of the same size within each IA;
- from five to fifteen sample for each plot randomly taken, occupying the entire plot surface and avoiding to sample the borders of the plot;
- the sampled surface area of the plots must cover 20% of each IAs

Within each plot, a sampling site to remove a soil core is chosen at random to create a composite sample (Figure 2).
There is no requirement that the quantity of samples in a stratum be proportional to its area but the ability to identify changes in SOC concentration and consequently stock over time will be significantly improved by collecting more samples, especially by increasing the number of plots.

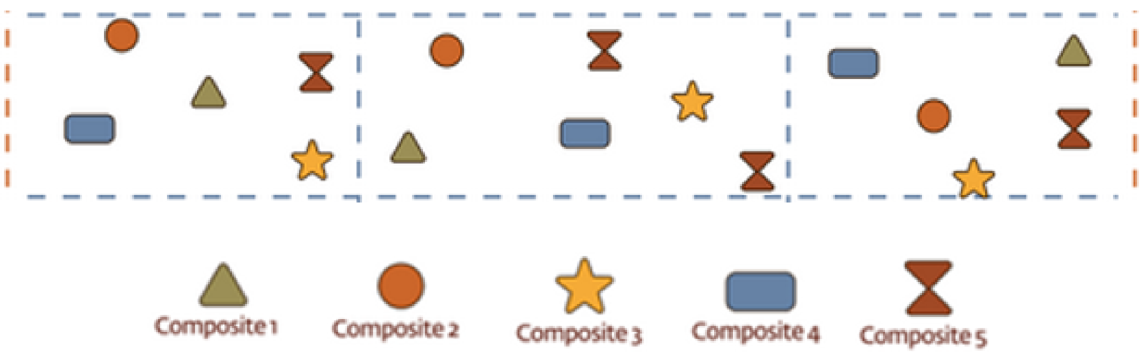

FIgure 2 - Adapted from FAO 2020 shows a grid-based Intervention Area with 3 plots. Samples from the locations marked with each coloured symbol are combined to form one composite.

3.1 Soil sampling application examples

The following Table 13 gives an example of the stratified simple random sampling design, showing the minimum number of plots, minimum number of samples for each plot and defining the minimum surface (20% of the IAs) to be sampled.

Table 13 - Example of the stratified simple random sampling design

Extension of the IAs (ha)	Area in ha to be investigated (20% of IAs)	Minimum number of plot	Number of soil sampling per plot
50	10	3-5	5-15
25	5	3-5	5-15
10	2	3-5	5-15
5	1	3-5	5-15

4 Soil depth

The SOC concentration measurements are carried out in order to investigate the concentration of carbon within the 0-30 cm soil layer, according to IPCC recommendations (IPCC, 2006; 2019). This depth of SOC measurement is considered the right compromise to analyse the variations imposed by carbon farming management practices. Indeed, several authors in literature highlight how differences generated by land management are found both in the topsoil layers (0-5 cm; 5-10 cm) to greater soil depth till 1 metre (Olson and Al-Kaisi, 2015).
This protocol suggests that each soil sample within the plot must be taken at least from 0-10 cm and 10-30 cm soil depth. In order to comply with, soil organic carbon stocks for the 0–30 cm layer should be reported.

5 Cost of the analyses

The process of combining different soil cores into one homogenous composite (or bulked) sample, which is then examined for SOC content, is referred to as compositing (or bulking).
To form a composite sample, more than one soil sample taken at different soil depth must be blended as explained in the section 3 of this document. This operation reduces the costs associated with laboratory examination where the SOC content of each composite sample is analysed.
In this section, we provide an overview of the minimum costs (table 14) for the laboratory and field analysis for each established IAs.

Table 14 Cost of laboratory and field analysis for each IAs

Minimum number of plot for each IA	Minimum composite soil sampling	Soil depth	Total Sample	Cost (€) Excluded taxes	Cost per sample (€) Excluded taxes	Sampling Cost (€)
3	5	0-10	10	150	15	45 + 1 €/km
		10-30				

Selected References

- FAO. 2020. A protocol for measurement, monitoring, reporting and verification of soil organic carbon in agricultural landscapes – GSOC-MRV Protocol. Rome. https://doi.org/10.4060/cb0509en
- IPCC. 2006. IPCC Guidelines for National Greenhouse Gas Inventories. Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). IGES, Japan
- IPCC. 2019. Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Agriculture, Forestry and Other Land Use. IPCC
- Olson, K. R., & Al-Kaisi, M. M. 2015. The importance of soil sampling depth for accurate account of soil organic carbon sequestration, storage, retention and loss. Catena, 125: 33-37.

TREE CARBON STOCK SAMPLING PROTOCOL FOR CARBON FARMING CERTIFICATION SYSTEM.

1. Introduction

This protocol outlines the procedures for identifying carbon stocks in trees through a sampling design known as "stratified random sampling" The method described in this protocol offers a practical and effective approach to assess carbon stocks in trees, while also minimizing sampling time and costs. By utilizing this sampling design, it becomes possible to track changes in carbon storage over time in a convenient and resource-efficient manner.

2. Definition of the Intervention Areas (IAs)

The project area is partitioned into one or more Intervention Areas (IAs) based on several criteria:

I) differences in wood production and missing trees;

II) pre-existing land use before starting the carbon farming project;

III) physical soil characteristics, including texture and structure;

IV) management activities implemented as part of the carbon farming project;

V) land morphology, considering factors such as flatness, hilly terrain, or mountainous regions;

VI) varieties or clones utilized in the plantation area.

When the variables introduced above are very different, it would be necessary to establish more than one IA. The IA can be any size, there are no restrictions on it.

3. Sampling Design: Stratified Simple Random Sampling

To ensure a reliable estimation of Carbon stocked in trees that is representative of the entire study area, a proposed sampling scheme is implemented. The scheme consists of the following components:

1. Selection of Plots: within each individual sampling stratum (IA), a range of one to five plots is chosen for data collection. The size of each plot is 706 square metres, a

circle with a radius of 15 metres which should contain about 20 trees (the number depends on the planting distances). Sampling areas must avoid plantation borders.

2. Coverage of Sampled Area: The cumulative surface area of the sampled plots should encompass at least 10% of each IA, thereby guaranteeing an adequate representation of the entire study area.

4. Sampling guidelines

To determine the volume of a tree, it is necessary to collect data on the stem diameter and total height of the tree, which can be accomplished using a tree caliper and a hypsometer. The tree caliper is used to measure the diameter of the tree at a standardized height of 130 centimetres (diameter breast height) above the ground. Since tree are not perfectly circular, it is common practice to take two measurements by rotating the caliper by 90° and then averaging the obtained values.

The total height of the trees can be measured using a hypsometer. To assess the amount of carbon stored in the plants, the first step is to calculate the volume of the stem, branches, and roots of each tree within the sampled area. This can be achieved by utilizing the measurements of stem diameter and total height of the plant following the "UNI EN 16449 - Wood and wood-based products - Calculation of the biogenic carbon content of wood and conversion to carbon dioxide" norm. By applying a dendrometric reduction coefficient to account for stem taper, the corresponding mean cylindrical volume of the trees can be determined. For poplars, the dendrometric reduction coefficient is 0.4, as indicated by Chiarabaglio and Coaloa (2002).

It's important to note that the measured volume represents only the aboveground part of the plant. To consider the belowground part, which typically represents 26% of the total volume of the plant, the measured volume needs to be multiplied by 1.26. The volume calculation can be performed using the following formula:

Volume (m3) = (Diameter (cm) / 200)2 * 3.14 * Height (m) * 0.4 * 1.26

Once the volume of the trees is determined, the next step is to calculate the dry matter in kilograms by multiplying the volume by the wood density. Assuming a carbon content equal to 50% of the dry biomass, a simple stoichiometric calculation can be performed to convert the carbon content into CO_2. Since the atomic weight of carbon is 12 and the molecular weight of CO_2 is 44, then 1 gram of carbon equals 3.67 grams of CO_2.

The kilograms of CO_2 can then be converted into metric tons using the following formula:

$$\text{Sequestered } CO_2 \text{ (t)} = \text{Total volume (m3)} * \text{Wood density (kg/m3)} / 2 * 3.67 / 1000$$

To determine the amount of CO_2 sequestered per hectare, the sequestered CO_2 value is divided by the area of the sampling in square meters and then multiplied by 10,000. The formula is as follows:

$$CO_2 \text{ (t ha-1)} = CO_2 \text{ (t)} / \text{Sampled area (m2)} * 10{,}000$$

Finally, to find the total CO_2 sequestered by the plantation, this value is multiplied by the total area where the sampling was conducted.

5. Cost of the analyses

In order to assess the sampling time, it was assumed that 10 minutes were allocated for evaluating the plantation, along with an additional 10 minutes for each sample plot conducted within the intervention area. A maximum total time of one hour is allocated for each plantation, considering that these plantations typically span an average of 5-7 hectares. This time limit is imposed due to the constraint that a maximum of 5 samples can be conducted within the same area. Accounting for an additional 30 minutes required for travel between plantations, the total estimated time amounted to 1.5 hours. Consequently, it is feasible to measure six poplar groves within a standard working day.

Taking into account that the work is performed by two operators, with a daily cost of 250 euros per person, along with an additional 40 euros allocated for food and 50 euros for transportation, the total daily cost amounts to approximately 600 euros. Considering that 6 poplar plantations can be measured each day, the cost of measuring each individual plantation is around 100 euros.

Selected References

CHIARABAGLIO P. M., COALOA D. 2002 – Stima del pioppeto Criteri oggettivi per la valutazione del pioppeto maturo. Supplemento al n. 34 di "Quaderni della Regione Piemonte - Agricoltura", pp. 47 + CD-ROM allegato.

UNI - EN 16449, 2014 Wood and Wood-based Products. Calculation of the Biogenic Carbon Content of Wood and Conversion to Carbon Dioxide. European Committee for Standardization.