REPORT 2025

ATN/RF-18769-RG and ATN/RF-18770-RG

Soil organic carbon sequestration in Latin America and the Caribbean: identifying opportunities and quantifying their economic and environmental impact

MINISTRY FOR PRIMARY INDUSTRIES (MPI) OF NEW ZEALAND

GLOBAL RESEARCH ALLIANCE ON AGRICULTURAL GREENHOUSE GASES (GRA)

REGIONAL FUND FOR AGRICULTURAL TECHNOLOGY (FONTAGRO)

Te Kāwanatanga o Aotearoa
New Zealand Government

GLOBAL RESEARCH ALLIANCE ON AGRICULTURAL GREENHOUSE GASES

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Abbreviations

GHG: Greenhouse gases
CO2: Carbon dioxide
CH4: Methane
N2O: Nitrous oxide
IPCC: Intergovernmental Panel on Climate Change
SOC: Soil organic carbon
LAC: Latin America and the Caribbean
Tier: Level
UC Davis: University of California, Davis
EEUU: United Sates
LTE: Long-term experiments
INIA: National Institute of Agricultural Research
INTA: National Institute of Agricultural Technologies
AGROSAVIA: Colombian Corporation of Agricultural Research
MGAP: Ministry of Livestock, Agriculture and Fisheries
MAGyP: Ministry of Agriculture, Livestock and Fisheries
GEE: Google Earth Engine
BD: Bulk density
Ha: Hectare
C: Carbon
t: tonn
Mg: megagram
CC: Cover Crop
SOILCET: Soil Carbon in Ecological Transition
AACS: Argentinian Association of Soil Science
EX-ACT: Environmental eXternalities ACcounting Tool
EDGAR: Emissions Database for Global Atmospheric Research
FAO: Food and Agriculture Organization
GSOCseq: Global Soil Sequestration Potential

Executive Summary

There are several international efforts to find solutions to global problems such as climate change, food security, and environmental pollution. One possible solution to these problems is found in soil organic carbon (SOC). The importance of focusing on this topic lies in the fact that SOC is both an indicator of soil productivity and a key potential sink for the sequestration of greenhouse gases (GHG). The main objective of this project is to contribute to the design of land use and management practices with high SOC sequestration potential in the most important agricultural production systems in LAC and to generate capacities for the quantification and monitoring of SOC stocks and SOC stock changes related to land use and management. This objective is achieved through the development of a multi-agency platform that provides LAC countries with information to report their SOC inventories in TIER2. During its first year (2023), this project successfully established a multi-agency platform and set the annual agenda for monthly meetings to coordinate activities and inform project advances. The platform has facilitated remote collaborations and standardized work methodologies, such as soil sampling protocol, to ensure uniform baselines across all member countries. Each country identified and selected the field sites and the first soil samplings were performed (component 1, activity 1.1). During the second year, 2024, the main activities focused on soil sampling and laboratory processing (bulk density, pH, and encapsulation). Between late 2024 (November -December) and early 2025, the five countries sent a total of 2878 soils samples (560 from Argentina, 360 from Chile, 330 from Colombia, 636 from Costa Rica, and 992 from Uruguay), to the UC Davis laboratory (California, US) for determination of organic carbon and nitrogen concentration, as well as stable isotope ratios of C ($^{13}C/^{12}C$) and N ($^{15}N/^{14}N$). Due to internal issues in the UC Davis isotopes facilities, Argentina, Colombia, Costa Rica and Uruguay received the analysis report with more than a year of delay, while Chile is still waiting for the report, which pushed back deadlines in some project activities. Nevertheless, the platform continued working with the consultants strengthening technical capacities, building a common database and training in harmonized tools for SOC estimation. To date, 33 remote meetings have been held, together with 14 capacity-building activities (webinars and online theoretical–practical seminars on different topics), 10 participations in international congresses/symposia, and three in-person workshops, with the objective of defining common methodologies and working criteria to develop a local database on SOC stocks. The recurrent progress meetings involve the researchers who are part of the technical cooperation. In the webinar sessions, workshops, and seminars, in addition to the institutions involved in the project, external institutions also participated through related initiatives. Through national and international congresses and symposia, the project team has presented this cooperation project and partial results achieved so far to the scientific community. Three in-person workshops were developed under Component 3, including: Activity 3.1, "Workshop for capacity building to determine SOC stocks at a site" (Chile, 2023); Activity 3.2, "Workshop for capacity building to monitor changes in SOC stocks over time under a land use and management" (Costa Rica, 2024); and Activity 3.3, "Workshop III – "Simulation models for the determination of soil carbon stocks" (Buenos Aires, Argentina and Colonia del Sacramento, Uruguay, 2025).

All photographs included in this report were taken during project activities. Their publication has been authorised by the project team members depicted.

FONTAGRO-MPI-GRA: Partnering for Innovation and Sustainability

We gratefully acknowledge the Ministry for Primary Industries (MPI) of New Zealand and the Global Research Alliance on Agricultural Greenhouse Gases (GRA) for their support of the project “Soil organic carbon sequestration in Latin America and the Caribbean: identifying opportunities and quantifying their economic and environmental impact (ATN/RF 18769–18770 RG)”. MPI–GRA support has been instrumental in establishing and sustaining a multi-agency platform across five countries (Argentina, Chile, Uruguay, Colombia, and Costa Rica) to harmonise protocols, build shared technical capacity, and generate internationally comparable evidence to strengthen Tier 2 reporting of soil organic carbon (SOC) stocks and changes. Over the reporting period, this support underpinned coordinated site selection and soil sampling, the agreement of common processing and encapsulation protocols, and the shipment of a large, standardised sample set to a single laboratory for analysis (2,878 encapsulated samples across 952 sampling sites), while also enabling a substantial programme of technical exchange—remote coordination meetings, training activities, and in-person workshops—to consolidate methodologies and accelerate progress toward a shared regional SOC database.

This project delivers clear benefits to New Zealand by strengthening the global methodological and evidence base that underpins credible soil-carbon monitoring, modelling, and reporting—areas that New Zealand is actively advancing through national soil carbon benchmarking/monitoring and related research programmes. New Zealand’s agricultural emissions research community has an explicit focus on quantifying and monitoring changes in SOC stocks under different land uses and management over time, and on improving measurement approaches and uncertainty management at scale. In that context, the project’s multi-country harmonisation of field sampling, laboratory workflows, and data structures—combined with capacity building on simulation models and digital tools—contributes transferable learning on how to run robust SOC programmes across diverse soils, climates, and production systems, including the practical integration of measured data with Tier 2 reporting needs. Finally, the project’s emphasis on scalable, technology-enabled approaches (e.g., digital mapping/data layers and the use of spectroscopy in training) aligns strongly with New Zealand’s own interest in cost-effective, farm-to-region SOC assessment methods, reinforcing New Zealand’s leadership through MPI–GRA’s international science partnerships.

I. Introduction

The increase in the atmospheric concentration of greenhouse gases (GHGs) in recent decades has encouraged groups from different fields of work to carry out research to determine their GHG emission sources and mitigation pathways. The main GHGs are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) (IPCC, 2023). From our field of research, we will focus on analysing emissions derived from agricultural activities, with our main object of study being the changes in land use and soil management. In recent years there has been a shift in the paradigm in which agricultural production is presented as a solution to the problem of global warming. The importance of this new approach lies in the fact that soils are the main terrestrial reservoir of carbon and, depending on their use and management, they can behave as a source or a sink of CO_2 (Lal, 2004).

Carbon sequestration refers to the capture of atmospheric CO_2 by plants through the photosynthesis process and its long-term storage, mainly in soils as SOC. It is estimated that carbon sequestration in degraded soils may offset up to 30% of gross N_2O and CH_4 emissions. Therefore, the role of soils in carbon sequestration is highly relevant; however, the management of pastures and agricultural soils affects their potential as a sink for soil organic carbon (SOC). Management alternatives that increase SOC, such as the inclusion of service crops in agricultural sequences, the integration of cropping and livestock systems, the increase in the availability of water and nutrients (irrigation, fertilization, organic amendment), and the restoration of sown pastures and degraded natural grasslands, may not only increase the productivity of soils, but also sequester carbon. Bearing in mind that the main use of soils in LAC is for agriculture, it is important to join regional efforts to find the most effective strategy for each country to increase the national stock of SOC.

Currently, several international initiatives, such as the Paris Agreement, are ongoing to quantify and mitigate GHG emissions. Under this agreement, the governments of the signatory parties commit to periodically reporting their national emissions inventory from all activities and GHG mitigation pathways (UNFCCC, n.d.). The Intergovernmental Panel on Climate Change (IPCC) is the international body responsible for monitoring inventories and providing methodologies for their preparation and calculation, so that all parties report based on common protocols and are comparable with each other (IPCC, 2019). The methodologies developed by this panel are classified by three levels (Tiers) that increase in data requirement, complexity and accuracy.

Countries lacking locally derived emission factors estimate their emissions using the Tier 1 approach, which relies on globally generic emission factors published by the IPCC and supported by a robust scientific evidence base. At this level, several authors have reported a high percentage (15% or more) of overestimation of the factor provided by Tier 1 compared with the factor calculated for local conditions (Berhongaray & Alvarez, 2013; Peter et al., 2016). Tier 2 calculation methodology involves a higher level of technical and methodological detail, resulting in country-specific emission factors, thereby increasing the level of accuracy. Finally, Tier 3 requires an even higher level of capacity (relative to Tier 1 and 2), both technical and in terms of measurements, and the involvement of statistical models for calibration under local conditions.

In order to generate a source of local SOC information that allows the elaboration of inventory reports in the Tier 2 system (Tier 3 in some cases), it is important, to the multi-agency platform, to have a record of the current levels of soil organic carbon present in the most relevant agricultural production systems of each member country.

II. Project Portfolio Execution and Results

Soil organic carbon sequestration in Latin America and the Caribbean: identifying opportunities and quantifying their economic and environmental impact (ATN/RF -18769-RG and ATN/RF-18770-RG)

II.1 Objective

The main objective of this project is to contribute to the design of land-use and land-management practices with high potential of soil organic carbon (SOC) sequestration in agricultural production systems across Latin America and the Caribbean (LAC), to generate locally derived coefficients for the reporting of SOC stocks that are internationally accepted , as well as to build capacity in LAC for SOC quantification and monitoring. The specific objectives are: i) to assist LAC countries in reporting and monitoring their SOC stocks according to land use and management, ii) to identify a SOC sequestration opportunity in five LAC countries and quantify its impact on net greenhouse gas emissions and on-farm economic performance, and iii) to build capacity in LAC for SOC stock quantification and monitoring.

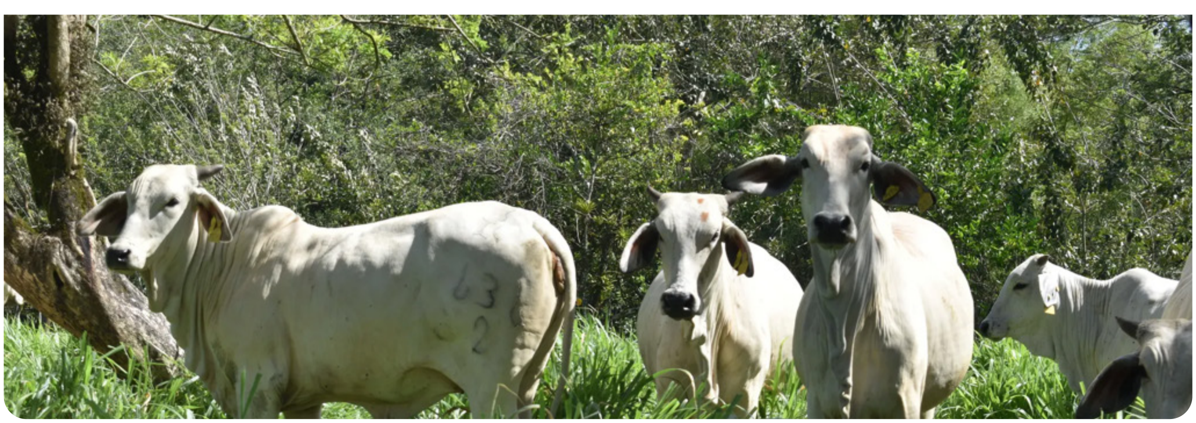
II.2 Summary of Project Activities

Project implementation (Table 1) effectively began in 2023 with focus on developing and articulating a multi-agency platform among five LAC countries (Argentina, Chile, Uruguay, Colombia, and Costa Rica). Monthly virtual meetings were held to define the line of work, which was formalised through letters of commitment from the institutions that make up the platform and from associated institutions. The first project workshop, focused on capacity building to determine SOC stock at a site, was held in Chile in May 2023.

In 2024 (second year of execution), the main activities were the soil samplings of the selected sites and the development of common protocols. Site selection, farmers' interviews, and the sampling campaign were carried out. The five countries sent samples to the same laboratory, so common protocols for soil processing and encapsulation for organic carbon and nitrogen, as well as stable isotopes of C ($^{13}C/^{12}C$) and N ($^{15}N/^{14}N$), were discussed and agreed. Activities also included laboratory skills to determine bulk density (BD) and the procedures to encapsulate and send samples to UC Davis (California, USA). By the end of 2024 and early 2025, all countries sent a total of 2,879 encapsulated samples to UC Davis for analysis, covering 909 sampling sites. Of these, 338 sites belong to 25 long term experiments (LTE) from INTA and INIA research institutes in Argentina (19 LTE), and Uruguay (6 LTE), while the remaining sites correspond to commercial farms in Chile, Colombia, Costa Rica and Uruguay. During 2025, data analysis did not progress as planned, mainly due to a delay in sample analysis at UC Davis lab. Other planned activities for the year progressed normally. A workshop on simulation modelling for SOC determination was held in May, between Argentina and Uruguay). Additionally, the project advanced in the harmonisation of data, aligning concepts, and defining common variables for the database. Since the beginning of the execution, a total of 33 remote meetings, 14 training activities (webinars and online theoretical–practical seminars on different topics), 10 participations in international congresses/symposia, and three in-person workshops have been carried out, with the aim of defining methodologies and working criteria to build a local database of soil organic carbon stock.

Table 1: Project components and activities

Component	Activities	Results	Current Status
Component 1	1.1 Consolidation of local data on soil carbon stocks and management factors for different soil types, climate, and land use relevant to LAC.	Soil laboratory results were received by Argentina, Colombia, Costa Rica and Uruguay, while Chile is still waiting for the lab report.	Execution (90%)
Component 2	2.1 Identification of soil carbon sequestration opportunities.	AA consultant was hired and the activities to fill in the economic information regarding the selected opportunity of SOC sequestration on each have started .	Execution (50 %)
	2.2 Quantification of the economic impact of on-farm implementation of the soil carbon sequestration opportunity.	A functional prototype of the DSS for grazing and pasture conservation was developed and made available in the cloud.	Execution (20%)
	2.3 Quantification of the net impact on greenhouse gas emissions of the identified soil carbon sequestration opportunity	Activities keep going with the consultant as it was established in the agreement, including bibliographic review, and capacity building for project team members.	Execution (35%)
Component 3	3.1 Capacity building workshop for determining SOC stocks at a site.	Activity completed: In Chile, a training workshop focused on the determination of organic carbon stocks in soil was held. A total of 15 technicians from different institutions participated in the training.	Completed
	3.2 Capacity building workshop for monitoring changes in soil organic carbon stock over time for land use or management	Activity successfully concluded. A training workshop was held in February 2024 in Costa Rica, focusing on the monitoring over time of changes in soil organic carbon stock for a given land use or management. A total of 35 technicians participated (15 in person).	Completed
	3.3 Capacity building workshop for the use of soil organic carbon stock simulation models	Activity successfully concluded. A training workshop was held in May 2025 between Argentina and Uruguay, focusing on simulation modelling for SOC determination. A total of 36 technicians participated in person and 66 attended online.	Completed



III. Project Implementation and Results

III.1 Component 1

As of the date of this report, a multi-agency platform has been formed between five countries (Uruguay, Argentina, Chile, Colombia, and Costa Rica) and associated institutions. The institutions that make up this platform are INIA Uruguay, INTA Argentina, INIA Chile, INTA Costa Rica, and AGROSAVIA and associated institutions MGAP Uruguay (Ministry of Livestock, Agriculture and Fisheries), MAG Costa Rica (Ministry of Agriculture and Livestock from Costa Rica), and MAGyP Argentina (Ministry of Agriculture, Livestock and Fisheries).

To successfully complete the activities of this component, several meetings and seminars were performed and two common protocols were elaborated (Figure 1). In the first stage of the project execution (2023-2024), the selection of sampling sites was completed in each country, including previous coordination with the commercial farms selected as sites of the project. Each country carried out the sampling campaign of commercial sites (at least 60 sites per country), with exception of Argentina, where all selected sites were from long term experiments from INTA. The samples were processed in local laboratories of the respective institutions, which included several tasks and highly delicate work carried out by specialized professionals. One set of subsamples was used to determine pH and bulk density. Additionally, another set of subsamples were encapsulated and packaged for shipment to the isotope analysis laboratory at Davis University, California, USA, for the analysis of carbon and nitrogen organic content, and stable isotope ratios of C ($^{13}C/^{12}C$) and N ($^{15}N/^{14}N$).

Figure 1: Protocols generated by the technical teams for soil sampling and laboratory processing activities

The main land use and management sampled and the geographical location from each country is described in the following paragraphs.

In Argentina (Figure 2) the land use and management categories considered were continuous cropping systems, mixed crop–livestock systems, beef cattle systems, cropping systems under agroecological transition, and horticultural production systems.

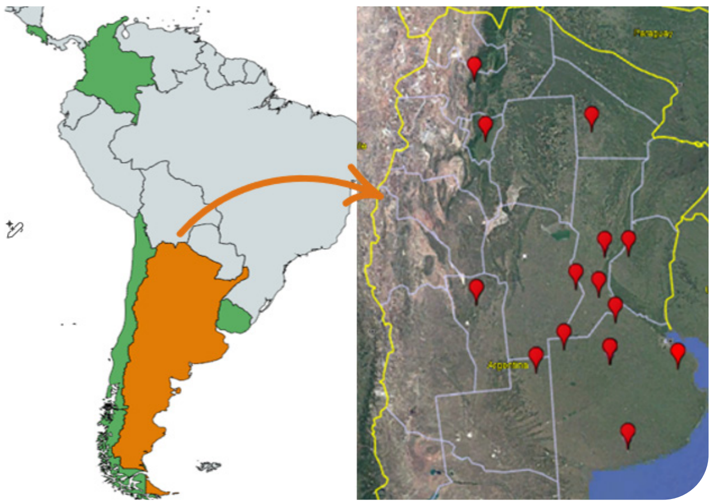


Figure 2: Area of study and sampling sites in Argentina. The location of the study area and a closer view of the selected long term experiment (LTE) are indicated by the red markers.

In total, 187 sites were sampled (19 LTE) at three depth intervals (0–10, 10–30, and 30–60 cm), resulting in 561 soil samples sent for laboratory analysis (UC Davis) in November 2024. The report with the results was received in November 2025. The team has already started processing and analysing the data and preliminary results of Argentina are presented in figures below.

Preliminary results from three sites from one LTE sampled in Argentina focused on land management changes on beef cattle system, located in the Salado Depression region were submitted to the Second International symposium SOILCET, France. Such results, reported a significant (Tukey P < 0,05) increase of 15.89 Mg C ha^{-1} in SOC stock at 0-30 cm depth after 15 years of legume forage promotion versus control treatment (Figure 3).

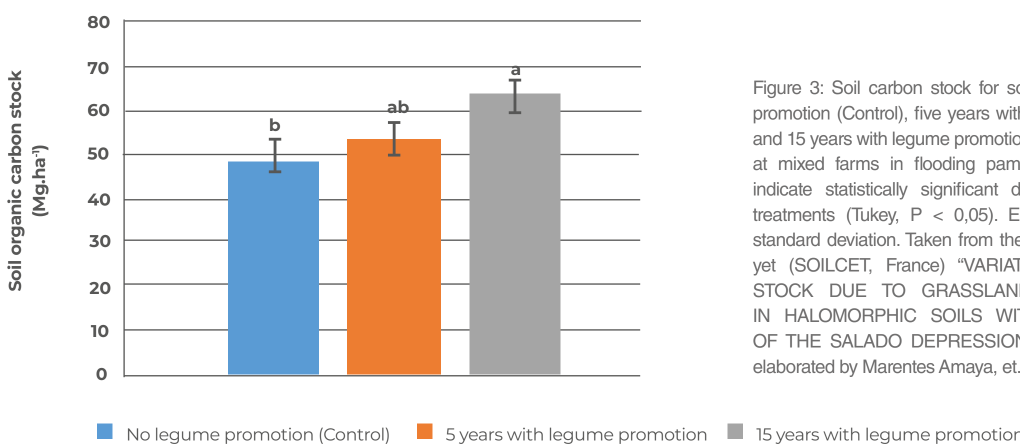


Figure 3: Soil carbon stock for soils with no legume promotion (Control), five years with legume promotion and 15 years with legume promotion up to 30 cm depth at mixed farms in flooding pampa. Different letters indicate statistically significant differences between treatments (Tukey, P < 0,05). Error bars represent standard deviation. Taken from the abstract not public yet (SOILCET, France) "VARIATION IN CARBON STOCK DUE TO GRASSLAND MANAGEMENT IN HALOMORPHIC SOILS WITH CARBONATES OF THE SALADO DEPRESSION OF ARGENTINA" elaborated by Marentes Amaya, et. al., 2026.

Another study conducted in a LTE located in Marcos Juarez (Córdoba), Argentina evaluated the inclusion of cover crops (CC) in SOC sequestration (Figure 4). Preliminary results reported an increase of 9.4 Mg of C/ha in rotations with CC, after 15 years of management (Tukey P < 0.05).

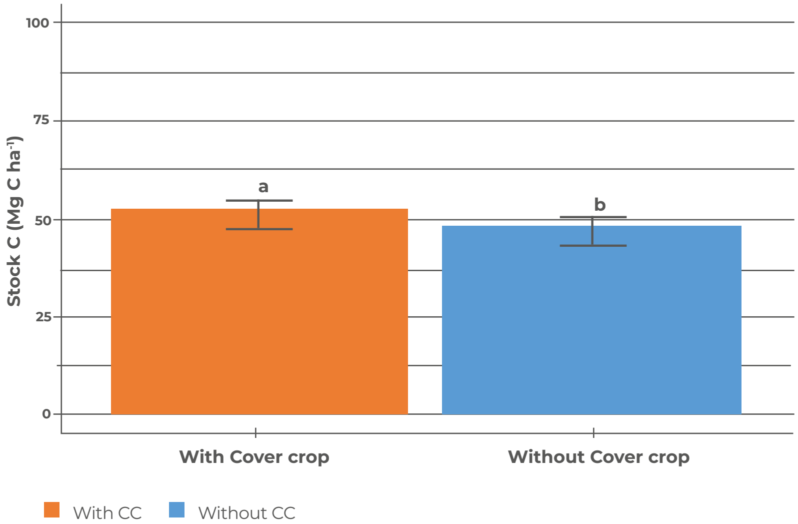


Figure 4: Effect of cover crops (CC) over SOC sequestration at 0-40 cm depth in Marcos Juarez, Buenos Aires, Argentina. Different letters indicate statistically significant differences between treatments (Tukey, P < 0.05). Error bars represent standard deviation. Taken from the abstract not public yet (SOILCET, France) "VARIATION IN CARBON STOCK DUE TO GRASSLAND."

In Chile (Figure 5), the land use and management categories considered were continuous cropping systems, horticultural systems, beef cattle systems, and dairy cattle systems. Sampling covered a total of 120 sites at three depth intervals, resulting in 360 soil samples, which were sent to UC Davis in January 2025. The laboratory analysis report is still pending.

Figure 5: Area of study and sampling sites in Chile. Blue markers indicate the location of the sampling sites.

In Colombia (Figure 6), the land use and management categories considered were native savanna, degraded pastures, improved pastures, and silvopastoral systems. Sampling covered 110 sites at three depth intervals, generating a total of 330 soil samples, which were sent to UC Davis in February 2025. The laboratory report was received in January 2026.

Figure 6: Area of study and sampling sites in Colombia. Yellow markers indicate the location of sampling sites.

In Costa Rica (Figure 7), the land use and management categories considered were cattle grazing systems, dairy cattle grazing systems, double-purpose cattle systems, sheep grazing systems, forest, horticultural systems, and fruit-crop systems. Sampling covered a total of 212 sites at three depth intervals, generating 636 soil samples, which a part of them were sent to UC Davis for analysis. The laboratory results were received in December 2025, and the team has already started with data processing and analysis.

Figure 7: Area of study and sampling sites in Costa Rica. Green markers indicate the location of sampling sites.

The Costa Rica team has processed and exchanged results for approximately 60–70% of the total sample set and expects to submit the remaining 30% at the beginning of 2026. Preliminary results indicate that most land-use types and managed systems exhibited SOC stocks comparable to, or higher than, those of the mature forest reference, particularly within the 0–30 cm soil layer. In this context, both the horticultural and coffee–avocado systems tended to maintain higher SOC stocks than the forest reference across soil depths, while tropical (basal) pasture showed SOC levels slightly above those of the reference system (Figure 8).

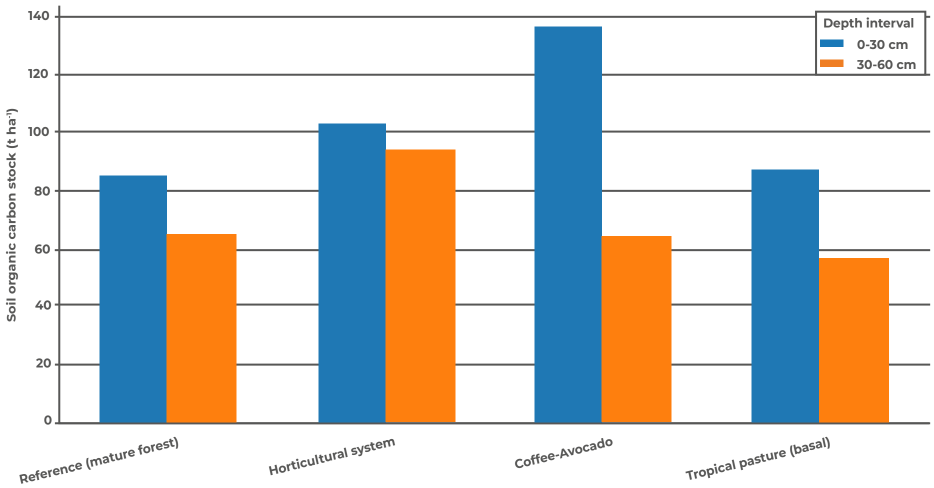


Figure 8: Soil organic carbon stock (SOC) by depth interval (0–30 and 30–60 cm) in reference forest vs. agricultural land use across different agro-ecological regions in Costa Rica. Taken from the technical report "ALMACÉN DE CARBONO EN EL SUELO PARA DIFERENTES USOS Y MANEJOS DE LA TIERRA EN COSTA RICA" elaborated by Arguedas-Acuña et. al.,2025 (unpublished data).

In Uruguay (Figure 9), the land use and management categories considered were continuous cropping systems, mixed crop–livestock systems, beef cattle systems, natural grassland systems, improved grassland systems, grazing management change and dairy cattle grazing system. Sampling covered a total of 280 sites (129 sites from 60 commercial farms and 151 sites from 6 LTE) at three depth intervals, generating 992 soil samples, which were sent to UC Davis for laboratory analysis in December 2024, and a preliminary report was received on 12 January 2026. The Uruguayan team is currently working on data processing and analysis.

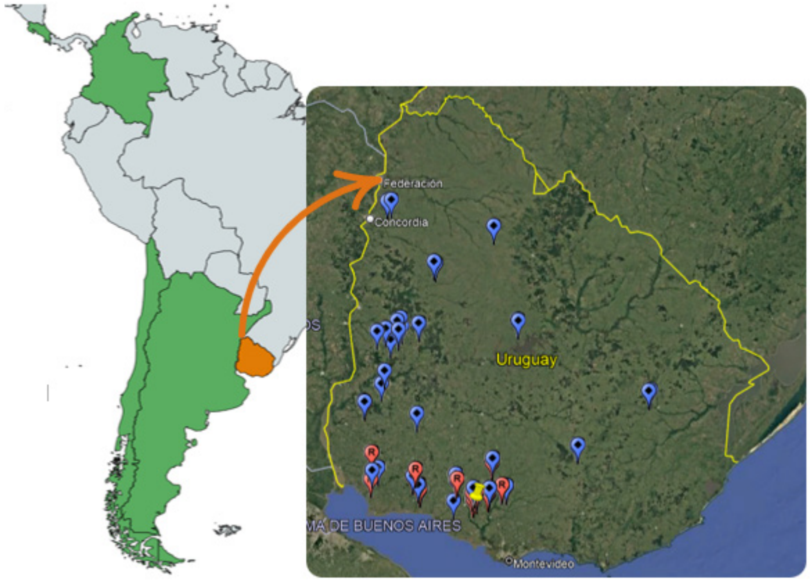


Figure 9: Area of study and sampling sites in Uruguay. Blue markers indicate the location of sampling sites.

III.2 Component 2

As foreseen in the initial procurement plan, three consultants will be needed to carry out the activities under this component. During 2024, two consultants were hired, and started working with the team members in activities related to identification of soil carbon sequestration opportunities, and quantification of the net impact on greenhouse gas emissions of the identified soil carbon sequestration opportunity.

The work with the consultants has focused on aligning concepts across all project partners on SOC stock calculations and GHG emission estimation. This has been supported through several online technical seminars and training sessions, including an introduction to harmonized SOC methodologies (IPCC-aligned) and an introductory workshop on the EX-ACT model. Each seminar lasted two and a half hours, and 63 and 29 team members gathered, respectively. In addition, a specific training session on GHG emissions calculations will be delivered in March 2026. A shared database is being developed, and consultants jointly with team members have been working on defining key variables and harmonized calculation methods to assess changes in SOC stocks over time under different land use and management changes. This framework is already being applied to process the laboratory results received to date, and will continue to guide data analysis as the remaining country datasets become available, ensuring a consistent methodology across the five participating countries.

One key output from this work is a public Google Earth Engine (GEE) repository/app, built from the information provided by the five participating countries. At the moment, the app includes raster layers and associated data such as: productivity dynamics, land use, SOC stocks, potential SOC sequestration, global change issues, agricultural emissions (EDGAR), IPCC climate class, IPCC soil class, fire frequency, and wetlands and water bodies, as well as several soil and terrain covariates (e.g., clay content (0–30 cm), soil pH (0–30 cm), slope, elevation, tree cover, mean annual precipitation, annual potential evapotranspiration, and mean annual temperature). The repository will be updated progressively as additional layers and country datasets are fully processed and quality checked. A screenshot of the app interface is provided to illustrate one of the current layers available (Figure 10).

Link to the website: https://ee-fontagro-gp.projects.earthengine.app/view/fontagro-carbono

Activities with the economics consultant will start once the main SOC sequestration opportunity has been selected for each participating country. In the meantime, we are already preparing and structuring the information needed (data inputs, assumptions, and basic parameters) to support the economic assessment.

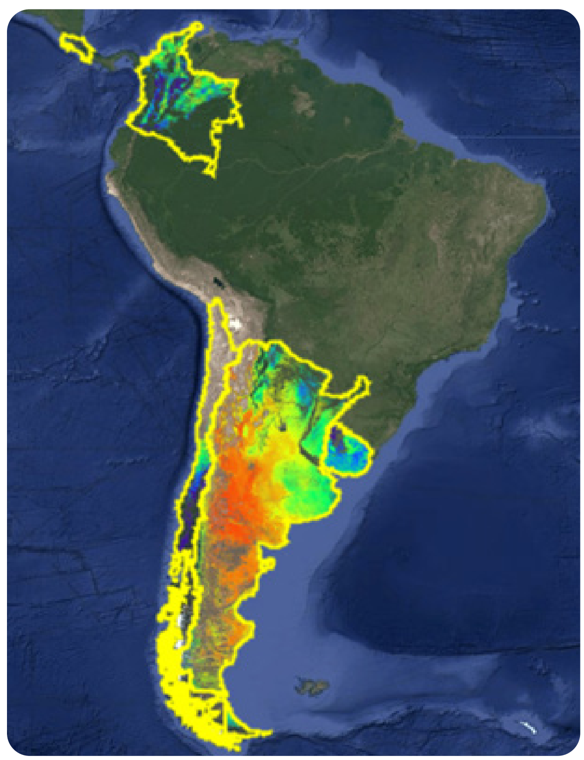


Figure 10: Potential carbon sequestration for country members (GSOCSEQ FAO) Screenshot taken from GEE-app

III.3 Component 3

This component is made up of three activities, and each activity is a workshop with focus on different subjects:

Activity 3.1 took place in Frutillar, Chile on May 2023 (Figure 11); the main objective of the workshop was to strength capacities between teams' members about soil carbon stock estimation and COS calibration using NIRs technique. The workshop gathered (on site and online) 34 participants from Argentina, Chile, Colombia, Costa Rica and Uruguay, from different institutions such as University of Chile, University of Concepcion and University of La Frontera both from Chile, and the institutions of the project`s members. The presentations were focused on: near-infrared spectroscopy (NIRS) as an economical and non-destructive tool for analyzing solid matrices, including practical guidance on developing predictive models for quantification using NIRS; soil carbon sequestration and stabilization mechanisms, and the role of clay and silt fractions in soil carbon accumulation, including a farm visit to study a volcanic soil profile in Los Lagos Region.

As key outcomes of the workshop, the participating countries generated a common soil sampling protocol to be applied across the platform, and local capacity was strengthened to support the technical team in NIRS calibration and model development for organic carbon and nitrogen determination. Furthermore, the workshop helped strengthen working links, allowing a valuable exchange between institutions, improving understanding of different productive realities, and promoting collaboration among technicians with different areas of expertise.

Figure 11. Participants of workshop held in Frutillar, Chile: "Determination of SOC at a site and NIRS calibration"

Activity 3.2 took place in Guápiles, Costa Rica in February-March 2024 (Figure 12). The workshop gathered 35 participants in total (14 on site and 21 online), the main objective was strengthening capacities across the platform to monitor SOC stock over time and to generate harmonized internationally comparable data. Presentations focused on geospatial sampling design, SOC in Costa Rican pastures, training workshop on GEE to support digital mapping. The agenda also included farms visits, which provides a valuable opportunity to learn about traditional production systems and soil profiles

Figure 12. Participants of workshop held in Costa Rica "Monitoring changes in SOC stocks over time for land use or management".

Activity 3.3 was delivered as a four-day hybrid workshop held in May 2025, between Argentina and Uruguay, taking advantage of the geographical proximity and logistical facilities (Figure 13).

Figure 13: Participants of workshop held in Argentina and Uruguay: "Simulation models for SOC determination on LAC soils" .

The first two sessions took place at INTA San Telmo, Buenos Aires, and the last two sessions were held in Uruguay, at INIA La Estanzuela. Attendance was high, with 36 people attending in person and 66 joining online, enabling technical exchange among participants from 21 institutions and 11 countries. The technical modules were mainly oriented to IPCC Tier 1 and Tier 2 guidance, GHG balance concepts, and the development of a shared database to support harmonised reporting. In addition, the workshop provided hands-on training on key simulation models used for SOC and GHG assessments, including DayCent (inputs/outputs, applications and limitations), CYCLES (model structure and examples), and RothC (introduction and applications), including an international session on RothC experiences in Germany delivered by colleagues from the Thünen Institute invited by the Uruguayan–German dialogue on agriculture - DAUA project (https://dialogoagro.uy/en/). Field activities in Uruguay included a visit to INIA La Estanzuela, with an overview of the 60-year LTE "José Lavalleja Castro". Overall, this workshop strengthened local capacities for model-based SOC and GHG estimation, supported the harmonisation of protocols and database structure across countries, and created a valuable space for discussion and future collaboration among the project partners.

IV. Conclusion

In the first year of the project execution (2023), a multi-agency platform was formed between five countries in Latin America and the Caribbean, signing the corresponding inter-institutional agreements that allow the co-execution of funds to the participating institutions in each country. As the day of this report, 33 remote meetings have been held, in which in the very first stages of the project execution, the objectives and a common work plan for the countries that make up the platform have been defined. Nowadays, the focus of these meetings is to present the state of progress of the activities, to generate a space for the exchange of knowledge and experiences. We keep them recurrent every third Tuesday of each month (with exceptions), considering we have accomplished the continuity and fluid interaction among member countries. A total of 14 capacity-building activities (online training sessions, webinars, and theoretical–practical seminars on different topics), 10 participations in international congresses/ symposium, and three in-person workshops were carried out, with the objective of defining common methodologies and working criteria to develop a local database on soil organic carbon (SOC) stocks and the participation of many different institutions, which fulfil our expectations regarding technical exchange.

In 2024 (second year of implementation), the project advanced mainly with Component I activities in all countries, including identification of sampling sites, interviews with farmers, field soil sampling, and laboratory processing and conditioning of samples to be sent for external analyses (UC Davis, California, USA). Sampling campaign covered a total of 909 sites across the five participant countries (Argentina, Chile, Colombia, Costa Rica, and Uruguay), generating 2,879 encapsulated samples. The sampled sites include 338 sites belong to 25 long-term experiments managed by research institutes (INTA in Argentina and INIA in Uruguay), while the remaining sites correspond to commercial farms in Chile, Colombia, Costa Rica, and Uruguay representing a wide range of land use and management categories, including continuous cropping systems, mixed crop–livestock systems, beef and dairy cattle systems, natural and improved grassland systems, silvopastoral systems, horticultural systems, and forest reference sites. Also, a workshop was held in Costa Rica to strength technicians' capacities about monitoring changes over time in soil organic carbon stock under land use/management. Also, we delivered a seminar with the objective to create a common protocol for sample processing to measure stable isotope ratios of C ($^{13}C/^{12}C$) and N ($^{15}N/^{14}N$) for organic carbon and nitrogen concentration in soils.

In 2025, the project continued focusing on strengthening technical capacities, building a common database, and applying simulation models to estimate SOC stocks. The main focus was to provide the team members with conceptual and practical tools for a harmonized SOC estimation in Latin America and the Caribbean, aligned with IPCC methodologies. One interesting technical exchange made in activity 3.2 with the Thünen Institute from Germany, provided hands-on training on models adapted to Latin American conditions. This aims to use our local data generated to validate these models in LAC countries. We held a web seminar on the application of the Roth-C simulation model in R, focusing on the carbon dynamics model and practical aspects of using it in R, including the main differences and limitations compared to the Windows version later in the year. Also, we delivered a seminar on determination of organic C and N using NIRS to share experiences on calibration curves and to work towards a common protocol for the team's members. Finally, we also contributed to capacity building on harmonized methodologies for emissions calculations, including an introduction to the EXACT model in an online workshop. In addition, new collaborations were established to support the generation of consistent data and tools aligned with Tier 2 reporting needs, reinforcing regional cooperation and progress toward climate goals.

A key aspect of this initiative, particularly in the context of international cooperation, is the coordinated advancement of activities across participating countries. The working group considers that substantial progress has been achieved in establishing institutional linkages, consolidating technical knowledge, and promoting the exchange of experiences among the researchers responsible in each country. These foundations are essential for the successful implementation of the project, which has resulted in the development and executing a work plan for a highly ambitious and innovative initiative aimed at generating a database of locally derived information, with benefits extending to the entire Latin America and the Caribbean (LAC) region.

V. Digital Links

Project's web site

https://ee-fontagro-gp.projects.earthengine.app/view/fontagro-carbono

VI. Cited References

Berhongaray, G., & Alvarez, R. (2013). The IPCC tool for predicting soil organic carbon changes evaluated for the Pampas, Argentina. Agriculture, Ecosystems & Environment, 181, 241–245. https://doi.org/10.1016/j.agee.2013.09.012

Intergovernmental Panel on Climate Change. (2019). Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 4—Agriculture, Forestry and Other Land Use. Chapter 2: Generic methodologies applicable to multiple land use categories. https://www.ipcc-nggip.iges.or.jp/public/2019rf/vol4.html

Intergovernmental Panel on Climate Change. (2023). Framing, Context, and Methods. In Climate Change 2021 – The Physical Science Basis: Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (pp. 147–286). Cambridge University Press.

Lal, R. (2004). Soil carbon sequestration impacts on global climate change and food security. Science 304 (5677), 1623–1627. https://doi/10.1126/science.1097396

Peter, C., Fiore, A., Hagemann, U., Nemecek, T., Gaillard, G., & Mazzetto, F. (2016). Improving the accounting of field emissions in the carbon footprint of agricultural products: A comparison of default IPCC methods with readily available medium-effort modeling approaches. The International Journal of Life Cycle Assessment, 21(6), 791–805. https://doi.org/10.1007/s11367-016-1056-2

United Nations Framework Convention on Climate Change. (s.f.). UNFCCC. Recuperado el 28 de julio de 2025, de https://unfccc.int/

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