GRA Flagship on Soil Carbon Sequestration

Version of July 2017

Context and problem definition

The specific challenge lies in the identification and implementation of land use and soil management practices which create a positive agricultural soil/ecosystem carbon budget, sequester carbon, and restore soil quality. Close to half of all agricultural soils are estimated to be degraded. The annual cost of fertilizer to replace nutrients lost to erosion is US $ 110 – US $ 200 billion. Erosion generates annually huge losses of C, i.e. 0.3–1.0 billion tons of carbon mainly from agricultural land which aggravates degradation problems. Important concerns remain regarding the implications of draining peatlands, including tropical peatlands, and the impacts of erosion, and of dryland degradation in general.

Soil carbon sequestration (SCS) and afforestation are the only negative emission technologies which are readily available at a low cost. Moreover, restoring degraded soils by increasing soil organic matter content and, hence, soil carbon, provides adaptation to climate change (interreduced variability of yields, lower susceptibility to drought) and sustainable intensification (higher productivity).

A voluntary action plan was developed for agriculture under the Lima-Paris Agenda for Action (LPAA, COP21, UNFCCC), which is the fourth pillar of the climate agreement negotiated at COP21. This '4 per 1000 Initiative : Soils for Food Security and Climate' targets an annual growth in topsoil organic carbon of 0.4%. This target is slightly below the potential annual growth in topsoil organic carbon estimated at 0.5 %, based on a 1.4 billion ton global potential annual carbon sequestration (IPCC , 2014). The SCS flagship will collaborate with the research program of the 4 per 1000 initiative.

While SOC sequestration rates higher than the 4/1000 aspirational target have been observed in many long-term arable and grassland field trials this is more difficult to achieve in soils where SOC stocks are already high.

Targeting ambitious changes in agricultural practices that would restore and enhance soil carbon and soil health requires a Flagship within the GRA in order to better coordinate and upscale research, knowledge/technical transfer and capacity building. The Integrative Research Group (IRG), which has a dedicated mission on soils, knowledge integration and upscaling, will lead this soil carbon sequestration (SCS) flagship, in close collaboration with the Cropland, Paddy Rice and Livestock research groups (CRG, PRRG, LRG).

The SCS flagship meets the overarching goal of the GRA to 'bring countries together to find ways to grow more food without growing greenhouse gas emissions' by creating a series of policy relevant outputs and outcomes to match the needs of farmers, industries and public regulators.

Fundamental principles underlying the Soil Carbon Sequestration Flagship

- Unique GRA added value – utilise knowledge & expertise of 47 member countries and partners
- Inclusive – must give opportunities for all members to be engaged in some way
- Relevant – all Members need to have benefit from some or all of the Flagship, i.e. something in it for everyone
- Solution focussed – clear link to the development and implementation of mitigation practices/technologies
- Multifaceted – address greenhouse gas mitigation and/or soil carbon sequestration along with co-benefits and synergies for livelihoods & adaptation; supportive of policy needs
- Increase capacity/capability of member countries
- Supplement and support existing efforts by Member countries and Partners

The components of the Soil Carbon Sequestration (SCS) flagship

<table>
<tr><td colspan="3">Online collaborative knowledge hub</td></tr>
<tr>
<td>Developing solutions

Decision support toolbox
• Maps of SCS potential (e.g. to reach the 4 per 1000 aspirational target)
• Maps of crop and pasture practices suited to reach SCS targets
• Implications of SCS practices for
- yields,
- drought tolerance and climate change adaptation
- N_2O and CH_4 emissions, energy use
• Costs and benefits of transitioning to SCS practices</td>
<td>Monitoring solutions

Enabling methods to certify SCS
• Tiered methodologies for monitoring, reporting and verifying (MRV) soil organic carbon (SOC) stocks in crop and pasture systems
• Handbooks and guidelines for project scale MRV adapted to regional contexts and agricultural systems
• Technologies for rapid SOC stock verification
• Modelling of SOC stock change in crop and pasture systems</td>
<td>Adopting solutions

Enabling environment
• Regional stakeholder workshops on SCS
• Criteria for sustainable SCS projects supporting livelihoods
• Assessment of barriers to the adoption of SCS practices
• Value chains, business models and policy options
• Research funding strategy and international research cooperation</td>
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<tr><td colspan="3">Capacity building, knowledge transfer and training</td></tr>
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A multi-scale project: sharing data and methods at country and global scales

- A European Commission funded project named CIRCASA (Coordination of International Research Cooperation on soil CArbon Sequestration in Agriculture, coordinated by Jean-Francois Soussana, INRA, France) aims at:
    - Strengthening the international research community on soil carbon sequestration in relation to climate change and food security;
    - Improving our understanding of agricultural soil carbon sequestration and its potential for climate change mitigation and adaptation and for increasing food production;
    - Co-designing a strategic research agenda with stakeholders on soil carbon sequestration in agriculture;
    - Creating an International Research Consortium.

- It includes 24 partners from the following countries: Austria, Australia, Brazil, China, Colombia, Denmark, Germany, France, Italy, Madagascar, Nigeria, New Zealand, Netherlands, Russia, United Kingdom, United States of America and South Africa. CIRCASA plans for global and for regional workshops. The **GRA is a core member of CIRCASA** through its Secretariat (Hayden Montgomery) who is a permanent guest of the Executive Committee of the project.

- CIRCASA will contribute to the funding of the backbone of the SCS flagship: the development of an online knowledge hub and of shared databases and modeling tools. However, CIRCASA will be focused on the European and global scales, whereas the SCS flagship will bring **multiple benefits to countries members of the GRA by developing national and regional projects at a lesser cost given the infrastructure provided by CIRACASA**.

Figure 1. Online collaborative platform developed by CIRCASA to support the knowledge hub of the project.

- The knowledge hub developed jointly by CIRCASA and by the SCS flagship will facilitate the development of **national and regional SCS projects aiming at developing, monitoring and adopting soil carbon sequestration**. It will be supported by a dedicated online collaborative platform (Figure 1).
- Each national/regional project will **contribute to the knowledge hub and will benefit from the shared data, methods and models**
- **Training and capacity building** on the use and development of the knowledge hub will be organized in contributing countries and regions
- **The SCS flagship will be inclusive** and offer low tier global maps concerning SCS options, as well as general guidelines for developing, monitoring and adopting SCS
- Nevertheless, **national/regional task forces** will be required to develop, monitor and adopt SCS through dedicated projects. These national/regional task forces will be supported by in-kind funding and by direct or donor support to activities developed within the country.

Example of projects under the SCS Flagship

Example 1 (regional)

Region: e.g. Southern Cone, Latin America

Title: Planning for SCS development in grazing systems: an assessment of options

Task force: Name x, Institution X, Name z, Institution Z, etc.

Countries involved: All GRA countries in the Southern Cone, Latin America

Brief description: With support of donor agencies, develop an ex-ante assessment of regional options for developing Soil Carbon Sequestration (SCS) in grazing systems. Develop SCS solutions by regionalizing maps showing a range of suitable options and their implications for SCS, for livestock systems productivity, for climate change adaptation and mitigation and for production costs. Monitor SCS solutions by regionalizing monitoring, reporting and verification methodologies and by agreeing on the Tier needed (e.g. for carbon certification). Adopt SCS solutions through a regional enabling environment, including dialog with stakeholders, assessment of barriers and criteria for sustainable and equitable SCS implementation, assessment of value chains and policy options, enhanced international research cooperation and alignment.

Key partners and existing resources/projects: Integrative Research Group networks, LEAP partnership addressing soil carbon, FAO, World Bank, Global Environment Fund, Intergovernmental Technical Panel on Soils (ITPS), 4 per 1000 initiative, UNCCD action plan on land degradation neutrality.

Benefits and contribution to flagship: Strongly supports policy needs via contribution to soil carbon sequestration options matching INDCs (UNFCCC, Paris agreement) and Land degradation neutrality (SDG 15.3 and UNCCD) targets; develops capability; relevant to multiple countries; utilises and builds on existing resources; tangible product produced, contributes to other international processes (IPCC) and to research alignment.

Resourcing needs: Dedicated person (coordinator) to lead. Resources (funded time) for each country contact point, one of whom will lead the project, to identify, obtain and submit data supporting the regionalized maps, the stakeholder dialog and the policy options. This will lead to co-authored papers.

Resourcing mechanisms: LEARN or other post-doctoral award to support the coordinator. In-kind contributions by countries involved to support dedicated country contact points. Support by the CIRCASA team through the knowledge hub. In a second stage, funding by donors for SCS implementation.

Example 2 (maybe global rather than regional)

Region: e.g. North America, Central America and Caribbean (This is already underway in N America but could include other regions, or be global. Strong interest has been expressed from the UK and Ireland. Would also include Hawaii and therefore the Pacific region)

Title: Soil Microbiome for Soil Carbon Network

Task force: Name x, Institution ?X, Name z, Institution Z, etc.

Countries involved: Canada-Agriculture and Food Canada (AAFC), Mexico-?, USA-Agriculture Research Service (ARS), NIFA, NRCS, Soil Health Institute, ISCN, Puerto Rico, Costa Rica…

Description: Soil carbon and soil health are inextricably linked, and there has been a lot of progress in the last several years on understanding the linkages to the soil microbial community. The goal of this network is to develop molecular indicators of soil health, status of soil carbon, and potential for carbon sequestration. The network would conduct surveys and workshops with stakeholders and producers to determine the management practices that influence the carbon use efficiency of the soil microbial communities under different production systems and climatic regimes. This effort could lead to methods to monitor for soil carbon sequestration potential, and inform practices to increase that potential.

Key partners and existing resources/projects: Molecular indicators of soil health have already been developed separately in Canada and in the US, and there is already a network among Agricultural Research Service labs and a recent workshop was held where it was agreed to create a wider network that include labs in Canada and elsewhere. ARS and AAFC both have committed resources to this effort and a workshop is being planned for this year. Other key partners could include the Soil Health Institute (Noble Foundation), the US National Cooperative Soil Survey, 4 per 1000 initiative, UNCCD action plan on land degradation neutrality, and ISCN

Benefits and contribution to flagship: This effort would contribute to the decision support toolbox (first three bullets), could lead to monitoring solutions, and would support regional stakeholder workshops. Results would support database maps of SCS potential of soil types, production systems and climate, and inform needs of producers. It supports policy needs and refinement of goals for SCS.

Resourcing needs and mechanisms: Coordinator and database manager, travel funds for stakeholders to get to workshops, shipping costs for samples, and travel and communication costs for scientists or exchange. Mechanisms exist for network funding from US Department of Agriculture via a competitive process.

Example of possible country contributions and synergies with existing networks (as proposed by taskforce members from those different countries)

COUNTRIES

Argentina

Several contributions could be envisaged

1/ FOREST group

From INTA and in association with other institutions, there is an on-going project that evaluates the greenhouse gas emissions in very contrasting soils with cultivated forests (Eucalyptus grandis and Pinus radiata). Emissions of soil from these ecosystems are compared with emissions from other ecosystems. The work area corresponds to the south of Mesopotamia Argentina Region and SE of *Bs. As*. province. There are also studies with other research groups for the evaluation of emissions from livestock.

On the other hand, Argentina could contribute information from our database. For instance, in several regions information regarding C sequestration in forest soils in different climates is available (for native cover (forest), cultivated forests or natural grasslands):

1. Pampas Region, SE and SO- Buenos Aires Province- Temperate Climate
2. North Mesopotamian Region - Misiones Province - Subtropical climate
3. Patagonian Region- Cold temperate climate
4. Chauqueña Region (partial). Santiago del Estero Province

In the Mesopotamian region, in cultivated forests models have been developed by INTA for estimating biomass under the support of growth simulators. The simulators are for estimation of aerial biomass at different planting densities in *Pinus spp* and *Eucalyptus grandis*. In Patagonia, growth simulators are also available to estimate aerial biomass (and C) for species such as *Pinus ponderosa*. There are also models to estimate biomass in pampean region for *E. viminalis* and *Pinus radiate*.

2/ Sugarcane crop group

On-going project focused in measure GHG emissions in the sugarcane crop area (North West of Argentina). Possibility of sharing expertise and specific emissions data on this topic and interest in discussing methods for measuring the carbon stock and for evaluating the effect of sugarcane straw management (at harvest) in these systems.

Additionally, a project starting soon is aimed at reporting the actual state of soil carbon stocks and defining a sustainable sugarcane straw management.

3/ INTA has several research projects that deal with the issue of carbon sequestration. A contribution could be the compilation of the available information, which includes all the background we have measured, so as to add to the existing database.

4/ Contributing information from database of soil data, for some places in the province of Catamarca.

5/ Asociación de Cooperativas Argentinas (Association of Argentine Cooperatives) has a project called Valor Ganadero, supported by INTA, which aims to contribute for a better beef and dairy national production. It includes demonstrative fields, a postgraduate coursework, a national symposium, agricultural inputs, etc.

In the last years in Argentina, many fields turned from pasture or annual crops rotation to soybean production. This produced, and keep producing, soil degradation and thus carbon losses. Investigations are being carried out on how beef production based on pastures contribute to soil carbon sequestration on a field previously on soybean production for a long period of time.

The results of these investigations can provide valuable information for the SCS Flagships regarding:

- Carbon balance of different beef and agricultural production systems.
- Evaluation of beef production systems emissions.
- Improve the National emissions balances.
- Development of a tool for SCS replicable to others regions.

Australia

Several options:

1) Contribute data on soil carbon stocks – both point specific and interpolated/modelled
2) Aid in the development of methods capable of being used to initialise and monitor changes in soil carbon stock over time. Similar to the protocols developed by Australian government to allow Australian landowners to participate in Emissions Reduction Fund.
3) Contribute to the writing of any documents or training that might be provided.

Brazil

Embrapa: currently there are two ongoing large-scale (national) projects led by Embrapa but counting with the participation of several other institutions and universities that encompass the:

- evaluation of GHG flux dynamics, calculation of specific emission factors and the carbon balance in principal Brazilian ecosystems in grain production systems and in forestry production systems based on field measurements
- upscaling for regional and national scale
- the economic evaluation of technologies and policies for GHG emission mitigation and C sequestration
- simulation of GHG emissions and C sequestration in different climate and technology scenarios, adoption and adjustment of models
- development and maintenance of database
- development or selection of mitigating technologies or practices
- adapt and improve sampling and measurement strategies for GHG and soil C and N
- develop, adapt and improve monitoring (MRV) of low GHG emission and C sequestration strategies in agriculture

These two ongoing projects represent around 15,8 M US$ in research and running costs through the next 4 years. Of these the project on grains production will end this year and the one on forestry is just starting its 4-year period. However, there are projections for the continuation of the grains project focusing mainly on the technologies of the Low Carbon Emission Agriculture Plan of Brazil (ABC Plan) and also for a project on livestock systems. Further details on the financials of these projects cannot be provided as they are under elaboration.

Costa-Rica

The contribution that the Ministry of Agriculture and Livestock (MAG) could make through its research and transfer arm (INTA), would be the support for field trials that are required to be carried out, with a professional agronomist and per diem and transportation requiring the same. As well as the revision of documents and publications to be carried out, support in carrying out knowledge transfer activities.

France

France coordinates a range of actions aligned with the thematic scope of the SCS flagship:

- A national scientific assessment of the potential and implications for France of soil carbon sequestration in agriculture (under the 4 per 1000 target).
- A public-private partnership to develop molecular diagnosis tools for agricultural soils.
- Within FACCE JPI (European Joint Programing on Agriculture, Food Security and Climate Change), France coordinates the Thematic Annual Program on soils (TAP Soils) which is an alignment instrument for national research programs on soils.
- France has led the development of the 4 per 1000 initiative on soils for food security and climate since UNFCCC COP21. This initiative includes an international research program, which contributes to the activities of the Integrative Research Group of the GRA and which organized research side-events at the time of COP21 and COP22.
- France also leads international efforts on the digital soil map, a tool contributing to SOC stock maps improvements.

Further actions are being initiated, especially the CIRCASA proposal for an international coordination of SCS research which has been submitted to the European Commission.

Ireland

Ireland has a number of completed and ongoing activities that align with the scope of this SCS flagship:

- Recently completed national soil survey (http://gis.teagasc.ie/soils/) with associated databases.
- Completed investigation of soil carbon in grassland soils (Torres et al. 2017)
- New estimates of carbon stocks in forest soils (Premrov et al. 217)
- Teagasc and TCD are jointly involved in a GPLER project that is coordinated by Mike Beare in New Zealand (Agreement No SOW14-GPLER4-SP23-PFR) on full inversion tillage to accelerate soil C sequestration.

Lithuania

Lithuanian Research Centre for Agriculture and Forestry (and country also) possible contribution to the flagship:

4) Provide site specific information, research results on the stabilization and enhancement of SOC to soil in grasslands or arable land with different crop rotations and farming systems
5) Collaborate on the development of measures for enhancing and sustaining soil health, including soil microbial communities
6) Contribute to the preparation of a review on land and soil management impacts on SOC including identification of measures that increase SOC
7) Join to the development and implementation of SCS practices etc.

Spain

Spain would participate in all the three components of the SCS flagship: developing solutions, monitoring solutions and adopting solutions.

Developing solutions

Several Spanish researchers (Rodríguez Martín et al., 2016. Geoderma 264, 117-125) have recently obtained the first map of organic carbon content in Spanish soils. Besides, there are two main on-going studies regarding cost/benefit of different SCS practices (Sánchez et al. 2016, Journal of Environmental Management 170, 37-49 and Albiac et al., 2017, Science of the Total Environment 592, 495-502).

In this document maps would be included for C stability in soil, data on agricultural and forest residues management, and maps of degraded areas suitable to be restored. It could also include the NIR and other new technologies to study C stability in soil.

Monitoring solutions

Analytical technologies to monitor C evolution in soil should be included in the C stability. Spain is one of the countries with more degraded marginal land; afforestation could be considered as a useful tool. In that sense, national inventories should be integrated.

In Spain there are several studies on modelling, focused on Spanish cropping systems. Moreover, there is a working group on SCS simulation within REMEDIA network, aiming at knowledge sharing and cooperation among Spanish researchers.

Adopting solutions

The most limiting factor is how to make SCS profitable. Examples of successful experiences should be included. In Spain, there are previous studies on barriers (Sánchez et al. 2016 Mitigation and Adaptation Strategies for Global Change 21, 995-1028).

United States of America

The USA is currently piloting a program for funding international collaborations around the themes of soil health, reactive nitrogen, and soil microbial communities, and in particular have a priority for networks and databases for synthesis activities. Proposals are due June 21 and international partners

are encouraged. We are still working out the mechanism for additional funding on top of the standard grants (up to $450,000) to further encourage international engagement. Below are copied some excerpts from the solicitation:

Networks for Synthesis, Data Sharing and Management
Program Area Priority Code – A1411
Proposed Budget Requests –
• Budgets for Standard Grants, Strengthening Standard Grants, and New Investigator

Grants must not exceed $450,000 total per project (including indirect costs) for project periods of up to 5 years.

Program Area Priority Contact – Dr. Nancy Cavallaro (202) 401-5176 or ncavallaro@nifa.usda.gov
Program Area Priority –
For this program area priority, the emphasis is on networking and data sharing and management. Projects should use data and information already available or being collected rather than spending a substantial portion of award funds to collect new data. Emphasis should be on analyzing current data to achieve new, broader knowledge. The proposed synthesis work should be through coordinating networking activities around one of the research themes in the context of sustainable crop, livestock, or forest productivity. These projects should move the field forward and create new research directions or opportunities though increased coordination, networking, and synthesis. Moreover, these projects should foster communication that promote collaboration among research, education, and extension faculty and research agencies and institutions with common interests across disciplinary, geographical, and organizational boundaries; establish networks and collaborations between Tier 1 and Tier 2 institutions or between large research facilities and faculty at small, mid-sized, and minority serving institutions . Projects may be regional, national or international in scope. Outcomes of this priority include: minimizing isolation and maximizing cooperation so as to eliminate unnecessary duplication of efforts; coordinating the development of new tools and methods to generate community resources such as databases, sample archives, or instructional materials or facilities; and synthesizing existing knowledge in one of these two areas to come up with new research directions that move the science forward toward more useful and usable products and tools.
Applicants must address one of the following:
• Reactive nitrogen; or
• Soil health and microbiomes.

Additionally there is an *International Soil Carbon Network* being developed by Chris Swanston inside Rich Birdsey's unit at the Forest Service, it has grown and been adopted as the official network and database for some international groups. Money has been supplied by a US agency (NIFA) to get the database up and running, collaborations on this were made with Microsoft (not sure), the Department of Energy's Lawrence Berkeley people (including Margaret Torn). The database is housed through the fluxnet/ameriflux group there: http://iscn.fluxdata.org/ . Current lead is Jennifer Harden. Developments are on-going and there is a will to include colleagues from the GRA SCS flagship taskforce.