Submission to Decision FCCC/SB/2018/L1 on

The Koronivia Joint Work on Agriculture (KJWA)

Topic 2(c) Improved soil carbon, soil health and soil fertility under grassland and cropland as well as integrated systems, including water management

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As a group of research and higher education institutions and programs-—hereinafter referred to as 'the Group'—, observers and non-observers to the UNFCCC, we welcome decision 4/CP23 and on the Koronivia Joint Work on Agriculture (KJWA), as well as the subsequent submissions by Parties, observers and non-observers to the UNFCCC, as well as the decisions FCCC/SB/2018/L1 and FCCC/SB/2018 L7 taken at SBSTA/SBI 48 and at SBSTA/SBI 49, respectively.

The Group welcomes the opportunity to submit its science based views for the workshops taking place at SBSTA/SBI 50 in June 2019 on topic 2(c) Improved soil carbon, soil health and soil fertility under grassland and cropland as well as integrated systems, including water management. In this submission the Group will refer to a former collective scientific submission to the KJWA on topic 2(a) Modalities for implementation of the outcomes of the five in-session workshops on issues related to agriculture and other future topics that may arise from this work[3].

(A) Key messages

- Soil organic carbon (SOC) stocks, the largest in the terrestrial biosphere, are an important component of the global carbon cycle.

- Increasing SOC can improve food security and contribute to adaptation to and mitigation of climate change. It can also have a range of additional co-benefits such as contributing to soil structure, affecting soil hydrology, controlling below and partly above ground biodiversity and related ecosystem services, and nutrients cycles. These co-benefits make the active management of SOC pivotal to realizing the synergies among the Rio conventions.

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1 The acronyms of the signatories are explained at the end of the submission.

2 Institutions and programs members of the CIRCASA -Coordination of International Research Cooperation on soil CArbon Sequestration in Agriculture- consortium https://www.circasa-project.eu/About-us

3 Submission signed by CIRAD, EMBRAPA, FACCE-JPI, Hochschule Geisenheim University, IIASA, INIA, INRA, IRD, ISRA, ISRIC - World Soil Information, JRC, University of Antananarivo, University of Life Sciences Lublin and WLE.

- The rate and magnitude of SOC change depends on soil, climate, vegetation and management (e.g. crop rotation, input of organic matter, irrigation). Improvements in SOC through sustainable land management (SLM) have strong beneficial impacts on soil properties and processes and therefore on land restoration.

- Launching and implementing SLM approaches and techniques to increase SOC stocks requires participative and inclusive reflection with smallholder as well as other farmers. Moreover, these activities need to provide locally appropriate and integrated technical solutions in agricultural systems and landscapes. In addition sharing the importance and implications of improving SOC stocks with policy-makers, interested stakeholders and citizens is crucial.

- National assessments need to be conducted to identify agroecological zones and other conditions and farming systems at risk of losing SOC, especially in organic soils (soils rich in organic matter), as well as areas of high potential for SOC increases and multiple benefits (e.g. drylands).

- There is a need to improve and strengthen the understanding and dynamic tools for assessing and monitoring SOC and the knowledge of the potential of different SLM approaches under different conditions. Science may advise decision-makers to appropriate the knowledge and tools to (1) provide them with best options adapted to the local circumstances, available expertise and funds; (2) and to allow them to better take into account soil carbon sequestration (SCS) activities in national greenhouse gas (GHG) emissions inventories and adaptation action plans.

- Maintaining and increasing SOC stocks requires continuous effort to avoid the release of the stored carbon, therefore SLM practices must be secured for the medium term (~ 10 years) and the long term (> 20 years). Therefore, related policies and measures should be integrated in broader coherent and structural policies and backed by continuous science based advice.

- An enabling environment, considering the complex dimension of innovation processes, is required to (1) engage a sustainable transition towards achieving SCS actions at a national scale, and to (2) minimize risks for farmers, in particular via insurance and guarantee schemes.

(B) The context

The objective of the Paris Agreement is to maintain global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C. To achieve this, net zero GHG must be reached in the forthcoming decades. Agriculture and land use change account for about 25% of the CO_2, 50% of the CH_4 and 70% of the anthropogenic N_2O emissions produced, however increasing SOC stocks could help offset these emissions. Efforts to enhance SOC stocks would contribute to food security, adaptation to and mitigation of climate change and to achieving the Sustainable Development Goals, including but not limited to SDG 2 (zero hunger), SDG 13 (climate action) and SDG 15 (land conservation and restoration).

In their Initial Nationally Determined contributions (INDCs), 104 countries included the agricultural sector in their reduction emission effort and 126 countries listed it as a priority for adaptation. In addition, according to an analysis of the 162 INDCs, eight countries explicitly identified improvement of soil carbon as a measure for mitigation and 41 countries identified “soil” as a priority for adaptation. With respect to the global framework of Land Degradation Neutrality (LDN), 121 countries have committed to set LDN targets since 2017, 83 of these have officially validated those targets and 51 of these have had their targets adopted by government. In all LDN target-setting countries, enhancing SOC is one of core indicators and thus is fundamental to the design and delivery of LDN transformative projects and programmes.

To provide scientific guidance to countries to (a) build policies and projects on improved SOC and to (b) enhance ambition in their NDCs in 2020 in this sector, several initiatives have been launched:

- SOC is one of three sub-indicators that make up SDG indicator 15.3.1 “Proportion of land that is degraded over total land area” and at the same time is an indicator for the global framework of LDN, which was endorsed by the 197 Parties to the United Nations Convention to Combat Desertification (UNCCD) in 2017. The Science-Policy Interface (SPI) of the UNCCD will deliver for consideration by Parties, at COP14 in India (September 2019), a technical report for practical guidance on methods to monitor SOC stocks and estimate their change with specific interventions. The aim is to help countries i) to identify suitable and region-specific SLM practices and approaches to maintain or enhance SOC stocks, and ii) to estimate and monitor SOC, for land use planning and for monitoring LDN.

- The Global Soil Partnership and the Intergovernmental Technical Panel on Soils conducted a global SOC assessment based on country-level spatial soil data sets, combined into a new global SOC map. This map is being continuously updated. The science that was used to create the map was presented in the GSOCMap Technical Report.

- The development of the new Methodology Report to refine the current Intergovernmental Panel on Climate Change (IPCC) inventory guidelines (2006 IPCC Guidelines for National Greenhouse Gas Inventories), is being carried out by the Task Force on National Greenhouse Gas Inventories (TFI) in accordance with the decision taken at the 44th Session of IPCC in Bangkok, Thailand, in October 2016. The final draft of this new Methodology Report titled “2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories” (2019 Refinement) will be considered by the IPCC for adoption/acceptance at its Plenary Session in May 2019.

- The Scientific and Technical Committee (STC) of the 4 per 1000 Initiative (4 per 1000 STC) produced as Set of Reference Criteria for Project Assessment on agricultural soil carbon sequestration.

- The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) and the 4 per 1000 STC are currently conducting a global analysis of the NDC commitments for soil carbon sequestration and how this compares with the mitigation potential, as well as constraints and issues that countries face by increasing their ambition. Preliminary results will be presented at SB50 and the results will be delivered at the United Nations Framework Convention on Climate Change COP25 in Chile (December 2019).

- The Global Research Alliance on Agricultural Greenhouse Gases (GRA) is currently launching an Inventories and NDC Support Network to improve the evidence base and to better connect governments and relevant expertise to subsequently improve the quality of agricultural NDCs and the way their achievements are reflected by national GHG inventories.

(C) Science based knowledge for policy advice in relation to topic *2(c) Improved soil carbon, soil health and soil fertility under grassland and cropland as well as integrated systems, including water management*

From improved Soil Carbon to Soil Carbon Sequestration (SCS)

Carbon is the main component of soil organic matter (more than 58%). Improved soil carbon is understood as the increase of SOC stocks, which is calculated from the SOC content at a reference soil depth and from the soil bulk density at the same depth.

Practices that increase soil organic matter content include: a) land use change to an ecosystem with higher equilibrium soil carbon levels (e.g. from annual cropland to agroforestry, cropland to grassland); b) management of soil carbon inputs (increased quantity and improved quality) through vegetation, for example deep rooting of improved varieties, crop rotations, cover crops and stubble retention; c) nutrient management and organic material input to increase carbon returns to the soil, including optimized fertilizer and organic material application rate, type, timing and precision application; d) reduced tillage intensity and increased residue retention; e) water harvesting and irrigation in arid / semi-arid conditions; and f) improved management of grasslands (pasture, silage and hay).

Changes in soil use and management to increase SOC stocks have been identified as a mean of mitigating climate change, as long as these approaches do not increase GHG emissions and fossil energy consumption to the extent of increasing GHG emissions in CO_2 equivalents. Soil Carbon Sequestration (SCS) is the net CO_2 removal from the atmosphere to the soil, where the carbon is stored in soil organic matter. Therefore, practices to improve SOC, when considered in the perspective of climate change mitigation, require an analysis at the relevant scale, often at the landscape scale, since organic carbon can be transferred (e.g. through organic fertilizers) within a landscape. Such a holistic approach could be based on the concept of "climate-smart landscape" to reflect on the possible synergies between production, mitigation and adaptation.

Potential and costs of SCS for climate change mitigation

The world's soils hold 1500 ± 230 GtC down to 1 m depth, which is twice the amount of carbon as CO_2 in the atmosphere. The global potential of agricultural (croplands and rangelands) SCS for increasing soil organic matter stocks in mineral soils to mitigate GHG emissions is estimated to be about of 2–5 $GtCO_{2eq}$/ yr. About 20% of the mitigation from SCS is achieved at negative cost and 80% below US$100/$tCO_{2eq}$ making SCS a low-cost mitigation option. This can be delivered through a range of technically effective measures that can be deployed in a variety of farm and land-use systems.

Potential of improved soil carbon for food security and adaptation to climate change

Improved soil organic carbon has large benefits for **food security** by increasing crop yields and yield stability for soils initially low in SOC. It has been estimated by economic modeling that improved soil carbon could reduce calorie loss per capita associated with the potential rise in food prices under strong global and regional agricultural mitigation measures by 65%, saving 60–225 million people from undernourishment compared to a baseline agricultural mitigation scenario without improvement of SOC. Improved SOC increases the water holding capacity in sandy soils thereby conferring resilience to climate change and **enhancing adaptation capacity**, especially in water scarce environments.

Other co-benefits of improved soil carbon

With over 2.7 billion people affected globally by desertification, practices to increase SOC could address **desertification**, by improving **soil health** and sustainable use of drylands. An estimated 1137 Mha of degraded soils could be targeted. Practices designed to increase SOC have a large potential to address **land degradation** which affects over 1.1 billion ha and over 3.2 billion people globally. Land degradation and food security are intertwined. Both are indeed closely associated with soil organic matter. In addition, soil organic matter is known to **increase water filtration, protect water quality** and increase the overall resilience of landscapes.

Agroforestry practice offers an example of multiple co-benefits related to SOC improvement. Agroforestry is, for instance, a good approach to improve soil carbon, soil health and **soil fertility**. It has positive effects on water quantity and quality, as well as biodiversity, and it can bring economic diversification for farmers (30 to 40% additional income). Agroforestry systems, including their effects on SOC, will be addressed in the Methodology Report titled "2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories".

Key specificities of SOC improvement

Several specificities need to be considered concerning SOC improvement: a) it is a multi-factorial process (e.g. affected by land use and management, climate, soil type) which can be managed at different scales (from plant to landscape); b) it is the result of trade-offs, especially between biomass exports (e.g. food, fodder, fuel from biomass) and organic inputs to soil by vegetation and organic fertilizers; c) SOC storage is reversible and is also affected by processes that degrade soils such as erosion, which implies that avoiding soil carbon losses needs to be considered simultaneously to improve SOC stocks; d) for a given soil depth, the potential of SOC storage is capped. This new equilibrium occurs after 10–100 years, depending on practices, soil type and climate zone, with IPCC using a default saturation time of 20 years; e) the global mean residence time of SOC is depth dependent (i.e. ~4 times higher at 30–100 cm depth); and f) subsoil horizons (30-100 cm depth) have a higher SOC storage potential.

Improvement of SOC via management practices not only encompasses soil carbon related questions, but also governance, sociological, economical and ethical ones.

Enabling environment

Farmers and land managers are generally aware of agricultural and land management practices required to improve SOC and they are also valuable sources of empirical innovations. Optimization of current and contextualized practices requires technical and scientific support. Farmers and land managers have to be at the center of this science/stakeholders dialogue.

The involvement of farmers and land managers is crucial to perpetuate, initiate and then maintain desirable practices for the long term, thus mitigating the risk of reversibility. Moreover, this enabling environment may include direct revenues associated to improved SOC practices, financial support, capacity building and policy incentives, such as payments for ecosystem services. Structural and coherent policies are equally necessary to ensure SOC stock improvement on the medium and long term.

(D) Key documents and papers for consideration at the workshop

FAO and ITPS. (2018). *Global Soil Organic Carbon Map (GSOCmap) Technical Report*. Rome. https://esdac.jrc.ec.europa.eu/content/global-soil-organic-carbon-estimates

Fujisaki, K., Chevallier, T., Chapuis-Lardy, L., Albrecht, A., Razafimbelo, T., Masse, D., … Chotte, J.-L. (2018). *Soil carbon stock changes in tropical croplands are mainly driven by carbon inputs: A synthesis*. *Agriculture, Ecosystems & Environment* (Vol. 259). https://doi.org/10.1016/j.agee.2017.12.008

Fuss, S., Lamb, W. F., Max, W., Nemet, G. F., Callaghan, M. W., Stechow, C. Von, … Minx, J. C. (2018). Negative emissions — Part 2 : Costs , potentials and side effects. *Environ. Res. Lett.* https://doi.org/10.1088/1748-9326/aabf9f

Lal, R. (2018). Digging deeper: A holistic perspective of factors affecting soil organic carbon sequestration in agroecosystems. *Global Change Biology*, *24*(8), 3285–3301. https://doi.org/10.1111/gcb.14054

Rumpel, C., Amiraslani, F., Chenu, C., Garcia Cardenas, M., Kaonga, M., Koutika, L.-S., … Wollenberg, E. (2019). The 4p1000 initiative: Opportunities, limitations and challenges for implementing soil organic carbon sequestration as a sustainable development strategy. *Ambio*. https://doi.org/10.1007/s13280-019-01165-2

Sanz, M. J., de Vente, J., Chotte, J.-L., Bernoux, M., Kust, G., Rulz, I., … Akhtar-Schuster, M. (2017). *Sustainable Land Management contribution to successful landbased climate change adaptation and mitigation. A Report of the Science-Policy Interface.* Bonn: United Nations Convention to Combat Desertification (UNCCD). https://www.unccd.int/sites/default/files/documents/2017-09/UNCCD_Report_SLM.pdf

Soussana, J. F., Lutfalla, S., Ehrhardt, F., Rosenstock, T., Lamanna, C., Havlík, P., … Lal, R. (2017). Matching policy and science: Rationale for the “4 per 1000 - soils for food security and climate”

initiative. *Soil and Tillage Research*, 0–1. https://doi.org/10.1016/j.still.2017.12.002
WOCAT Data base – The global Data base on Sustainable Land Management. https://qcat.wocat.net/en/wocat/

In addition, the forthcoming IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security and greenhouse gas fluxes in terrestrial ecosystems decided by the IPCC Panel at its 43rd session (https://www.ipcc.ch/report/srccl/)

List of signatories

1. **ABDN**, the University of Aberdeen
2. **AU-DCA**, the Danish Center for Food and Agriculture of Aarhus University
3. **CAAS**, the Chinese Academy of Agriculture Sciences
4. **CaSA Network**, the Soil Carbon Network for Sustainable Agriculture in Africa
5. **CATIE**, the Tropical Agricultural Research and Higher Education Center
6. **CCAFS**, the Climate Change, Agriculture and Food Security Research Program of the Consortium of International Agricultural Research Centers (CGIAR)
7. **CEA**, the French Alternative Energies and Atomic Energy Commission
8. **CEIGRAM**, the Research Centre for the Management of Agricultural and Environmental Risks of the Polytechnic University of Madrid
9. **CIAT**, the International Center for Tropical Agriculture
10. **CIMMYT,** the International Maize and Wheat Improvement Center
11. **CIRAD**, the French Agricultural Research Centre for International Development
12. **CNRS**, the French National Centre for Scientific Research
13. **CSIRO**, The Commonwealth Scientific and Industrial Research Organization
14. **CSU**, the Colorado State University
15. **DORAS Center**, the DORAS Center and Kasetsart University (Thailand)
16. **FACCE-JPI**, the Joint Programming Initiative on Agriculture, Food Security and Climate Change
17. **GDA,** the Cambodia General Directorate of Agriculture
18. **GRA**, the Global Research Alliance on Agricultural Greenhouse Gases
19. **ICARDA**, the International Center for Agricultural Research in the Dry Areas
20. **IIASA**, the International Institute for Applied System Analysis
21. **IITA**, the International Institute of Tropical Agriculture
22. **INIA**, the Spanish National Institute for Agricultural and Food Research and Technology
23. **INRA**, the French National Institute for Agricultural Research
24. **IRD**, the French National Research Institute for Sustainable Development
25. **ISRIC**, the International Soil Reference and Information Centre - World Soil Information
26. **MSU**, the Lomonosov Moscow State University
27. **NAFRI,** the National Agriculture and Forestry Research Institute (Laos)
28. **NZAGRC**, the New Zealand Agricultural Greenhouse Gas Research Centre
29. **RUA,** the Royal University of Agriculture (Cambodia)
30. **UNCCD (Sec. & SPI)**, the Secretariat and the Science-Policy Interface of the United Nations Convention to Combat Desertification
31. **University of Antananarivo**
32. **VAAS,** the Vietnam Academy of Agricultural Sciences